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FEEDBACK INTERVENTIONS AND DRIVING SPEED: A PARAMETRIC AND COMPARATIVE ANALYSIS

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Five experiments were conducted to assess the effects of several variables on the efficacy of feedback in reducing driving speed. Experiment 1 systematically varied the criterion used to define speeding, and results showed that the use of a lenient criterion (20 km/hr over the speed limit), which allowed for the posting of high percentages of drivers not speeding, was more effective in reducing speeding than the use of a stringent criterion (10 km/hr over the speed limit). In Experiment 2 an analysis revealed that posting feedback reduced speeding on a limited access highway and the effects persisted to some degree up to 6 km. Experiments 3 and 4 compared the effectiveness of an unmanned parked police vehicle (Experiment 3) and a police air patrol speeding program (Experiment 4) with the feedback sign and determined whether the presence of either of these enforcement variables could potentiate the efficacy of the sign. The results of both experiments demonstrated that although the two enforcement programs initially produced larger effects than the feedback sign, the magnitude of their effect attenuated over time. Experiment 5 compared the effectiveness of a traditional enforcement program with a warning program which included handing out a flier providing feedback on the number and types of accidents occurring on the road during the past year. This experiment demonstrated that the warning program produced a marked reduction in speeding and the traditional enforcement program did not. Furthermore, the warning program and a feedback sign together produced an even greater reduction in speeding than either alone.

DESCRIPTORS: safety, feedback, behavioral community psychology, police, community setting, maintenance

The high societal cost of automobile accidents makes highway safety one of the more important target areas confronting behavioral scientists today. Motor vehicle related trauma in the United States is the primary cause of death between the ages of 1 to 34, injuring an average of 13,000 persons each day, and producing more paraplegia, quadriplegia, and epilepsy than all other causes combined (American Association for Automotive Medicine, Note 1).

One factor related to accident probability is vehicle speed. Data collected on Nova Scotia highways over the past 4 years by the Registry of Motor Vehicles illustrate this point. Although speeding accounted for only 8% of the accidents on provincial highways between 1978 and 1981, it accounted for 16% of all injury acci-

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dents and 32% of all fatalities during the same period.

Other evidence relating excessive speed to fatalities is the marked decline in the fatality rate (the number of deaths per 100 million miles driven) in the United States from 4.11 to 3.52 following the imposition of a national 55 miles per hour (88 km/hr) speed limit ("Higher Speeds," 1978). As average speeds began to increase again several years later, fatalities went up as well.

For these reasons, several techniques have been used to reduce the percentage of vehicles traveling greatly in excess of the speed limit.

One technique that decreases vehicle speed is posting of the percentage of drivers not speeding, along with the best record to date, on a highway sign (Van Houten, Nau, & Marini, 1980; Van Houten & Nau, 1981). This technique reduced serious speeding (85th percentile speeding) by over 50%. Moreover, the effects of the presence of the feedback sign in the original study have persisted for approximately 4 years at the time of this writing.

Van Houten et al. (1980) and Van Houten and Nau (1981) posted the percentage of drivers traveling less than 16 and 14 km/hr over the speed limit, respectively, as not speeding. These criteria for speeding were chosen rather than the posted limit because police authorities did not consider vehicles traveling under these speeds to be significant threats to safety. One result of selecting these limits was that the initial percentages of drivers not speeding following baseline conditions were usually in the high 70's or low 80's. Had the posted speed limit been selected as the criterion in either study the numbers posted at the beginning of posting conditions would have been between 20 and 30%. It is unclear what effect the criterion selected and hence the percentages posted on the sign had on the efficacy of the sign. Therefore, the purpose of the first experiment was to determine the effects of using stringent and lenient criteria (thereby posting low or high percentages not speeding) on the efficacy of the feedback sign.

Although there is considerable evidence that the effects of the feedback sign persist over time (Van Houten et al., 1980; Van Houten & Nau, 1981), there is no evidence to demonstrate how far the effect tends to persist from the sign. One purpose of the second experiment was to determine how far the effects of the feedback sign persisted along a stretch of highway. Since all previous studies have been conducted along urban undivided highways with residential speed limits (Van Houten et al., 1980; Van Houten & Nau, 1981), a second purpose of this study was to determine if the feedback sign would be effective on a limited access divided highway with a high speed limit (100 km/hr).

Another approach used to reduce speeding is parking manned or unmanned police vehicles along the highway. For example, numerous studies have demonstrated that parking an unmanned police vehicle along the roadside reduces the speeds of vehicles below the level obtained when the police vehicles are not present (Dart & Hunter, 1976; Edwards & Brackett, 1978; Galizio, Jackson, & Steele, 1979; Hand & Hills, Note 2; Moncaster & Eagle, Note 3).

Because a large body of literature has demonstrated the efficacy of parked patrol vehicles in reducing speeding behavior, the purpose of the third study was to compare the effectiveness of the feedback sign with that of a parked patrol vehicle.

The aircraft patrol is another enforcement approach commonly used by police to reduce speeding. One advantage of this approach is that it is possible to mark off large sections of highway for aircraft surveillance. Although aircraft patrols are commonly used to reduce speeding on North American limited access highways, little is known about the effectiveness of this technique. One purpose of the fourth experiment was to examine the effects of aircraft patrols used in combination with large signs warning drivers of their use. A second purpose of the fourth

study was to compare the efficacy of the feedback sign alone with the air patrol condition and the feedback sign and air patrol conditions together.

Another approach used to control speeding involves setting up radar check points and charging motorists traveling over the speed limit. However, a number of studies have demonstrated that this traditional method of speed limit enforcement has little effect in reducing the percentage of speeding motorists (Carr, Schnelle, & Kirchner, 1980; Cirillo, 1968; Edwards & Brackett, 1978; Galizio et al., 1979; Van Houten & Nau, 1981). One reason the traditional method of enforcement is not very effective is that the large number of motorists speeding on most roads precludes the charging of all but a small percentage of the total number of violators because of the time required to charge someone with speeding.

One alternative strategy is to issue special warning tickets to all first offenders. This approach saves time in two ways. First, it takes less time to collect information and write a warning ticket than it does to charge a motorist, and second, the issuance of a warning ticket does not require the police constable to appear in court.

Another strategy that has yet to receive attention is providing speeding motorists with specific feedback concerning the accidents and injuries occurring on the road along which they were traveling. Delivering this type of feedback might reduce speeding behavior and would provide the police constable with an excellent rationale for stopping speeding motorists.

The purpose of the fifth experiment was to compare the efficacy of a treatment package consisting of the issuing of warning tickets and feedback fliers to all motorists traveling a designated amount in excess of the speed limit with the traditional method of charging motorists under the motor vehicle act. The second purpose of the sixth study was to examine the effects of combining warning tickets and the feedback flier with the use of the feedback sign.

EXPERIMENT 1

One question that has not received experimental attention is whether the speeding criterion used to determine the numbers posted on the sign can influence the effectiveness of posted feedback. For example, it may be that feedback signs are most effective when the percentage of drivers not speeding posted on the sign is relatively high, such as 70% and above. If this were the case, the choice of a strict posting criterion, such as 55 km/hr in a 50 km/hr zone, could render the feedback sign ineffective, because in many locations the use of such a criterion would result in the posting of numbers well below 50% as not speeding.

The purpose of Experiment 1 was to determine if the choice of different posting criteria can influence the effectiveness of the feedback sign.

METHOD

Subjects and Setting

Subjects of the study were drivers traveling northbound along a two-lane suburban highway outside Dartmouth, Nova Scotia, during daylight hours on weekdays. The highway passed through a mixed industrial and residential neighborhood. The speed limit through the neighborhood was 50 km/hr, but preliminary data collection indicated that a substantial number of speeders could be found at any time.

Apparatus

Speeds of vehicles were measured using a MuniQuip DRS 3 Radar manufactured by Tribar Industries, Weston, Ontario, Canada, used in the same manner as described by Van Houten et al. (1980). Prior to beginning each session the calibration of the unit was checked by switching on the unit and holding a vibrating tuning fork in front of the radar antenna. During these tests the unit read 100 km/hr if it was properly calibrated. On all occasions these new units func-

tioned normally. The units could also be tested by pressing 25 km/hr and 100 km/hr test buttons. This was also done on each session. Again, units all functioned normally.

The digital readout component of the radar was located inside an unmarked automobile parked 15 m from the yellow litter can in a tavern parking lot. Care was taken to park the monitoring vehicle far enough from the roadway to ensure that approaching drivers were unable to see it until after their own vehicles had entered the radar beam, 0.1 km from the litter can.

The feedback sign was similar to the signs used in an earlier study of the effects of posted feedback on speeding (Van Houten & Nau, 1981). However, the present sign displayed only the message "DRIVERS NOT SPEEDING LAST WEEK __%." The message "Best Record __%" was omitted from the sign to avoid the necessity of changing the "Best Record" percentages each time the speeding criterion was changed (i.e., lowering or raising of the "Best Record" each time a stricter or more lenient speeding criterion was chosen, which might have threatened the credibility of the feedback sign).

General Procedure

The speeds of 200 vehicles were sampled each day, Monday through Friday. Sampling was begun at a randomly chosen time between 14:45 and 15:30, and continued for approximately 1.25 hr. Measures of interobserver agreement were calculated in the same manner as described in Van Houten and Nau (1981). Using the digital readout radar, interobserver agreement was always 100%.

Experimental Design

The study used a modified reversal design (A-B-C-A-B-C-B). The order of conditions was: Baseline 1; Posting Strict Speeding Criterion 1; Posting Lenient Speeding Criterion 1; Baseline 2; Posting Strict Speeding Criterion 2; Posting Lenient Speeding Criterion 2; Posting Strict Speeding Criterion 3. The procedures followed during the three major conditions are described below.

Baseline. During Baseline 1 the feedback sign was absent. During the subsequent baseline condition, the face of the feedback sign was covered with a 1.22 m × 3.5 m sheet of black opaque plastic.

Posting strict speeding criterion. The feedback sign was present and uncovered during this condition and the numbers posted on the feedback sign represented the percentage of drivers traveling less than 60 km/hr (less than 10 km/hr or more over the posted limit) on one randomly chosen day during the preceding week. Numbers posted on the sign during this condition never fell below 53% and never exceeded 58%.

Posting lenient speeding criterion. The feedback sign was present and uncovered during this condition. The numbers posted on the sign to indicate "DRIVERS NOT SPEEDING LAST WEEK" represented the percentage of drivers traveling less than 70 km/hr (less than 20 km/hr over the posted limit) on one randomly chosen day during the preceding week. A new number was posted every Monday morning. The numbers posted on the feedback sign ranged from 91% to 96% during this condition.

RESULTS

The results of Experiment 1 are illustrated in Figure 1. The upper curve in the figure represents the percentage of drivers traveling 60 km/hr or more during each session of the experiment. These values were calculated by dividing the numbers of drivers traveling 60 km/hr or more by the total number of drivers sampled during that session and multiplying by 100. The figure also shows a similar curve representing the percentage of drivers traveling 70 km/hr or more each day.

The introduction of the sign with the stringent criterion led to reductions in the percentage of drivers traveling at or over 60 km/hr and 70 km/hr from baseline levels of 48.2% and 9.3% to 43.1% and 7.4%, respectively. The first introduction of the posting lenient speeding

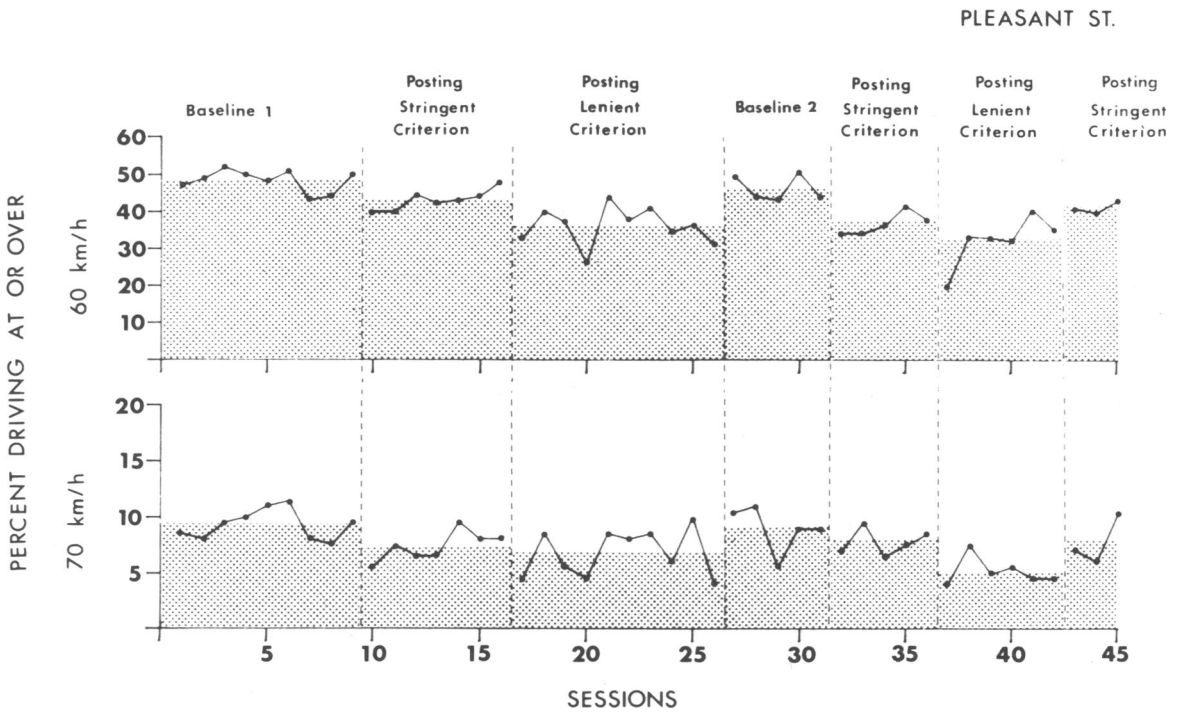

Fig. 1. The percentage of drivers traveling at or over 70 and 60 km/hr during each session of Experiment 1. The shaded bars represent the mean percentages during each condition.

criterion condition led to a further decline to 36.1% and 6.9%, respectively. Reintroduction of the baseline condition led to an increase to original baseline levels.

The second introduction of the posting stringent speeding criterion condition led to a decrease in the percentage of drivers traveling at or over 60 km/hr and 70 km/hr from Baseline 2 levels of 46.3% and 9.0% to 36.7% and 7.8%. The second introduction of the posting lenient speeding criterion led to a further decline in these percentages to 32.4% and 5.1%. The change back to the posting stringent speeding criterion condition produced an increase in these percentages to 41.3% and 7.7%, respectively.

Discussion

The results of Experiment 1 demonstrated that the posting of feedback about the percentage of drivers speeding during the preceding week was most effective in reducing speeding when a relatively lenient criterion of 70 km/hr was used, and hence, when numbers posted on the feedback sign were 91% or above. Although the use of a stricter 60 km/hr criterion and hence the posting of numbers between 53% and 58% also reduced speeding, the reductions produced during this condition were less than those that were produced when the 70 km/hr criterion was used. The inferiority of a stringent criterion was evident both when it was preceded by the posting of high numbers and when it was preceded by a period during which the feedback sign was absent. This finding partially rules out an interpretation of these results in terms of a simple order of treatment effect, although it is still possible that the use of a lenient criterion may not have been as effective if it had not been preceded by the use of a stringent criterion.

This result of this study indicates that in order to achieve maximum benefit from the feedback sign, users should choose a speeding criterion that will result in the posting of high numbers. It is suggested that users of the feedback sign will achieve best results by choosing a posting

criterion that leads to the classification of 80% to 90% of drivers as "Not Speeding" when baseline data are posted. Typically, such a limit will most often coincide with the *enforced* limit (speed limit plus a cushion), rather than with the *legal* limit.

It is unclear precisely why the posting of high numbers is more effective than the posting of low numbers. For example, it may be that the sign serves as a prompt for not speeding, and that the prompting effect is strongest when the sign indicates that a high percentage of drivers are obeying the limit. A related notion is that the feedback sign derives some of its effectiveness from the police surveillance that it implies. It may be that drivers are more likely to reduce speed in the presence of high percentages because they fear that, with most drivers obeying the limit, speeders will be more easily detected.

EXPERIMENT 2

In previous research the feedback sign has always been used at the beginning of residential or business sections at a location where the posted speed limit has been reduced (Van Houten, Nau, & Marini, 1980; Van Houten & Nau, 1981). These studies have demonstrated that posted feedback can be effective in increasing compliance with a change in speed limit.

Another situation where speeding is often a problem is on highways with a constant speed limit. In one study, Dart and Hunter (1976) compared the effects of a visual speed indicator, which automatically provided each vehicle's speed ("YOUR SPEED IS —") and displayed the message "SLOW DOWN" whenever a car was exceeding the 55 mph (88.5 km/hr) speed limit, with the effects of various police enforcement strategies. They found that the sign alone had little or no effect on vehicle speeds but that the presence of a police vehicle reduced speeding for a distance of up to approximately 3 km. They also found that the enforcement strategy reduced the speeds of cars traveling under the speed limit.

In another study, Moncaster and Southgate (Note 4) reported that an automated sign which displayed the message "POLICE—YOU ARE SPEEDING" whenever a vehicle exceeding a 30 mph (50 km/hr) speed limit approached it, reduced the percentage of cars traveling over 35 mph (56 km/hr) from 47% to 24% in an urban area. Unfortunately, there was no indication of how far beyond the sign this effect persisted. One reason that the sign in the Moncaster and Southgate (Note 4) study was effective whereas the sign in the Dart and Hunter (1976) study was not, may have been related to the different speed limits on the roads involved. It may be easier to get people to comply with an urban speed limit than to get them to comply with the speed limit on a high speed highway because the level of enforcement on urban roads is typically higher. Another possible explanation for the differing results may involve the wording of the sign. A sign worded "POLICE—YOU ARE SPEEDING" may imply a greater degree of police surveillance than one which simply provides feedback. In this regard it is noteworthy that the weekly feedback sign used by Van Houten et al. (1980) and Van Houten and Nau (1981) also implied police surveillance because the sign was not automated and therefore the posted numbers were obviously based on human measurement. For this reason, one might expect that the weekly feedback sign might also reduce speeding on a highway with a constant speed limit.

Therefore, one purpose of Experiment 2 was to determine whether the weekly feedback sign could reduce speeding on a limited access highway with a constant 100 km/hr speed limit (62.5 mph). The second purpose was to determine how far beyond the sign any effects would persist.

METHOD

Subjects and Setting

The subjects of this study were drivers traveling southbound on a 6-km section of Highway 102 in the province of Nova Scotia between

9:00 a.m. and 12:00 p.m. Monday through Friday. Highway 102 is a 100-km long, four-lane divided highway with a 100 km/hr speed limit. The nearest exit was located 9 km beyond the site selected for erection of the feedback sign.

Apparatus

Vehicle speeds were measured using a Tribar Industries T-3 MuniQuip digital hand-held radar. The observer measured vehicles' speeds by aiming the radar out the rear window of an unmarked automobile parked on the shoulder of the highway. Because of the design of the highway, it was not possible to conceal the measurement vehicle in this study. However, it is relatively common to see vehicles parked along this highway. While monitoring speeds, the observer sat as low as possible to maximize concealment and to reduce the likelihood of being detected.

The observer always began taking speed measurements at the 1 km site. After a sample of 200 vehicles had been recorded, the observer moved to each of the remaining sites in sequence and repeated the recording procedure. Before beginning a speed sample the observer first tested the radar unit by pressing the 25 km/hr and 100 km/hr test buttons and holding a tuning fork in front of the antenna. If the radar unit was working properly the unit read 25 km/hr and 100 km/hr when the respective test buttons were depressed and 100 km/hr when the tuning fork was held in front of the antenna. The radar unit used in this study was a new device and always tested out perfectly. The observers were trained in the proper use of the radar device by the authors who had been trained by the Traffic Division of the Dartmouth Police Department.

Measures were taken at four sites along the highway. The first site was located 1 km past the sign on a level grade, the second site was 2 km past the sign on a slightly uphill grade, the third site was located 4 km past the sign on a level grade, and the last site was located 6 km past the sign on a downhill grade.

The feedback sign used in this study was constructed in the same manner as those used in the Van Houten and Nau (1981) study and read "DRIVERS NOT SPEEDING LAST WEEK —%, BEST RECORD —%."

General Procedure

Vehicles' speeds were sampled daily at each of the four sites between 9:00 a.m. and 12:00 p.m. No measurements were taken on rainy or foggy mornings because preliminary data revealed that little speeding occurred on the highway under these conditions.

Police patrolling and ticketing were carried out by the Royal Canadian Mounted Police (RCMP), who patrolled these roads according to their normal schedule throughout the entire experiment.

Measures of interobserver agreement were calculated in the same manner as described by Van Houten and Nau (1981). Interobserver agreement was always 100%.

Experimental Design

A reversal design was used in this study. The sequence of conditions was: Baseline 1; Weekly Posting 1; Baseline 2; Weekly Posting 2. The two major conditions used in this study are described below.

Baseline. During this condition, vehicles' speeds were recorded according to the procedure outlined above. Prior to the first baseline condition the feedback sign was erected and covered with a large sheet of opaque black plastic. During both baseline conditions the signs were covered with this plastic. The first and second baseline conditions lasted six and five sessions, respectively.

Weekly posting. During this condition the feedback sign was uncovered and the percentage of drivers traveling at 109 km/hr or less was posted on the sign as well as the highest percentage recorded to date. Although the speed limit was 100 km/hr, 110 km/hr was chosen as the cutoff point because the Royal Canadian Mounted Police (RCMP) tend to charge motorists over this speed under normal driving conditions.

New weekly percentages were posted on the sign every Monday and represented the results obtained at site 1 on one randomly selected day during the preceding week. The first and second weekly posting conditions were in effect for five and six sessions, respectively.

Results

The data presented in Table 1 show the mean percentage of drivers traveling at or over 105 km/hr and 115 km/hr at each of the four distances from the sign site during each of the experimental conditions. It can be seen that with one exception (the percentage of vehicles traveling over 105 km/hr at the 6 km site) each introduction of the sign reduced the percentage of motorists traveling within each speed category when compared with the preceding baseline condition. In addition, session-by-session graphs of these data (not presented) show little overlap at 1 km from the sign and a large degree of overlap at a distance of 6 km from the sign.

The relationship between speed reduction and distance from the sign is summarized in Figure 2, which displays the mean percentage of motorists driving at or over 105 and 115 km/hr during both baseline conditions and both posting conditions. Examining the baseline data at each distance from the sign, it is apparent that the percentage of drivers traveling at or over 105 and 115 km/hr was higher at the 6 km site (situated on a downgrade) than at the other three sites and that the percentage of drivers within the two categories at the three remaining sites did not differ much from each other. Although the overall percentage of drivers traveling at or over 105 km/hr changed more than the overall percentage of drivers traveling at or over 115 km/hr the percentage reduction was largest for the at or over 115 km/hr category (a 50% reduction at 1 km from the sign, versus a 10% reduction in the 105 km/hr category). Lastly, the effects of the posting condition on the percentage of drivers traveling at or over 105 km/hr almost disappeared at 6 km past the sign whereas a considerable effect was still apparent in the percentage of drivers traveling at or over 115 km/hr at this site.

Table 1

Mean percentage of vehicles at or over 105 km/hr and 115 km/hr at each of the four distances from the sign site during each experimental condition of Experiment 2.

	Distance from sign site			
Condition	*1 km*	*2 km*	*4 km*	*6 km*
	at or over 105 km/hr			
Baseline 1	34.4	38.0	35.7	41.8
Posting 1	28.5	34.0	32.3	41.5
Baseline 2	40.3	39.0	43.6	45.4
Posting 2	31.8	32.5	34.0	41.3
	at or over 115 km/hr			
Baseline 1	7.8	6.6	6.3	8.6
Posting 1	3.2	5.5	5.0	6.7
Baseline 2	6.5	7.2	7.9	8.8
Posting 2	3.8	3.6	4.3	6.1

Discussion

The results of this experiment demonstrated that the feedback sign was effective in reducing speeding on a section of limited-access highway with a constant speed limit and that the effects of the sign deteriorated with increasing distance beyond the sign. Furthermore, the effects of the sign persisted to some degree up to a distance of at least 6 km past the sign. As in previous studies (Van Houten et al., 1980; Van Houten & Nau, 1981) the sign produced a larger percentage reduction in the higher speed drivers than it did in the lower speed drivers.

Because the sign exercised considerable effectiveness for a distance of 1 km, and retained some effectiveness for at least 6 km, the results of Experiment 2 would support the use of the sign in reducing speeds along short dangerous stretches of highway that are associated with high frequencies of accidents. However, if one's purpose is to reduce speeding along an extended

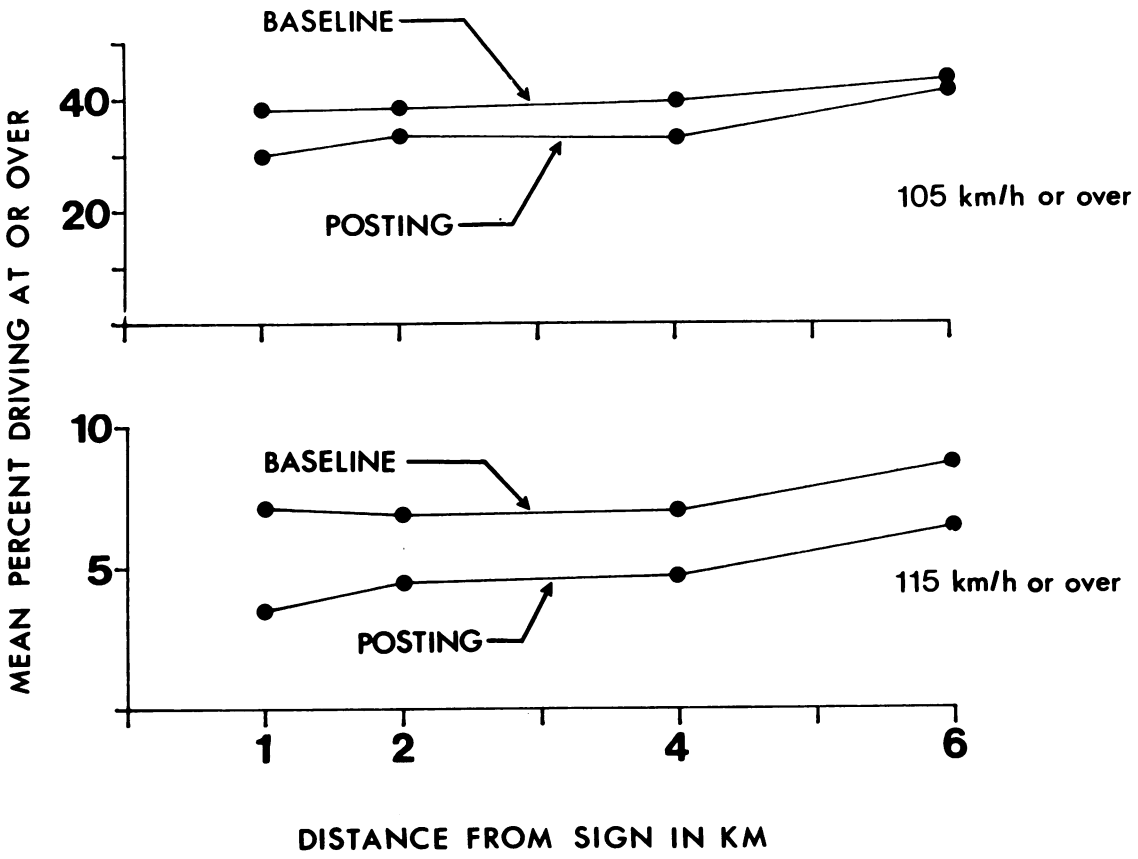

Fig. 2. The mean percentage of drivers traveling at or over 115 and 105 km/hr at distances of 1, 2, 4, and 6 km past the feedback sign during the posting and baseline conditions in Experiment 2.

section of highway it is not likely that the sign alone would prove to be a useful tecehnique.

EXPERIMENT 3

Previous research has shown that when a marked, unmanned police vehicle is present at the roadside, the speeds of passing drivers are lower than when the vehicle is not present (Dart & Hunter, 1976; Edwards & Brackett, 1978; Galizio et al., 1979; Hand & Hills, Note 2). Experiment 3 was designed to compare the use of this technique with the use of posted feedback to determine which is more effective in reducing speeding. A second purpose of Experiment 3 was to determine whether the simultaneous application of both techniques is more effective than the application of either technique alone.

METHOD

Subejcts and Setting

Subjects were drivers traveling southbound along a two-way street composed of one traffic lane in each direction and located in a business district that included a small shopping center. The speed limit on this street was 50 km/hr. A great deal of cross traffic made the area somewhat dangerous and many accidents had occurred there. Preliminary data collection indicated that a high percentage of the drivers traveled through the area at speeds 20 km/hr or more in excess of the posted limit.

The city police had conducted only a minimal number of radar and ticketing patrols prior to the beginning of the study, and the frequency

of these patrols remained constant once the study began.

Apparatus

Speeds of vehicles were measured according to the procedure described in Experiment 1. An attempt was made to conceal the vehicle's true function by parking it in a line of unoccupied vehicles with its front end facing away from the street. The observer occupied the driver's seat of the monitoring vehicle, and watched approaching traffic over his shoulder with the vehicle's rear view mirror.

The police vehicle used during certain phases of the study was a blue and white Ford LTD. The car bore the standard markings of the Dartmouth City Police Department and carried a standard red and blue flashing light bar on its roof. These lights were never illuminated during the experiment. The vehicle was one assigned to the Traffic Division and the message "TRAFFIC DIVISION, DRIVE CAREFULLY," printed in white block letters on the vehicle's trunk was visible to drivers approaching the vehicle from the rear. No radar antenna was mounted in this vehicle.

General Procedure

The speeds of vehicles were sampled for 45 min each day, Monday through Friday. The sampling period always began between 9:00 and 11:00 a.m. The exact sampling time varied from day to day to make the sampling routine less predictable to passing drivers. The number of vehicles sampled during the 45-min periods varied from day to day, averaging 175 vehicles per day and never falling below 150 vehicles per day. Sampling sessions were terminated at the end of 45 min to minimize the likelihood that the presence of the observer would be detected and to reduce the likelihood that any vehicle would be sampled more than once during a given session.

Measures of interobserver agreement were calculated in the same manner as described in Van Houten and Nau (1981). Interobserver agreement was always 100%.

Experimental Design

The study used a modified reversal design. The sequence of conditions was: Baseline 1; Marked Police Vehicle 1; Baseline 2; Marked Police Vehicle 2; Baseline 3; Marked Police Vehicle 3; Baseline 4; Posting 1; Baseline 5; Posting 2; Posting plus Marked Police Vehicle 1; Posting 3; Posting plus Marked Vehicle 2; Marked Police Vehicle 4; Posting plus Marked Police Vehicle 3; Marked Police Vehicle 5; Posting plus Marked Police Vehicle 4; Marked Police Vehicle 6. The procedures following during the four major conditions (baseline, marked police vehicle, posting, and posting plus marked police vehicle) are desecribed in detail below.

Baseline. During Baseline 1 through 4 the feedback sign was absent. However, once the sign was erected for the first posting condition it was covered with a large sheet of black opaque plastic during all subsequent baseline conditions. The marked police vehicle was never present during baseline conditions.

Marked police vehicle. During the marked police vehicle condition, the Traffic Division's patrol car was parked along the shoulder of the street, 0.2 km in front of the radar can and immediately adjacent to the feedback sign's location whenever the car was available. The police vehicle was parked facing the monitoring vehicle so that the "Drive Safely" message on the vehicle's rear was visible to drivers approaching the radar. The police vehicle was parked at the site before each sampling session began and was left unoccupied for at least one hour. In most cases the patrol car was removed immediately after this one-hour period, but in some cases it remained at the site for several hours. Data were not collected during this condition on days when the police vehicle was unavailable. During the initial replications of this condition, the feedback sign was absent. However, during the marked police vehicle 4 through marked police

vehicle 6 conditions, the feedback sign was present but was covered with a large sheet of black opaque plastic.

Posting. During this condition, the feedback sign was erected 0.2 km from the radar can. The sign indicated the percentage of drivers traveling 64 km/hr or less during the preceding week and the highest percentage yet recorded. New weekly percentages were posted on the sign every Monday morning and represented the results obtained on a randomly chosen day from the preceding week. The marked police vehicle was never present during this condition.

Posting plus marked police vehicle. During this condition the feedback sign was present and uncovered and the feedback numbers were changed each week according to the schedule described above. In addition, prior to each daily session the marked police vehicle was parked along the shoulder of the road immediately adjacent to the feedback sign. The patrol car remained there, unoccupied, until the termination of the day's session.

Results

The results of the experiment are shown in Figure 3. The topmost curve in the figure represents the percentage of drivers traveling 60 km/hr or more (10 km/hr or more over the speed limit) during each session of each experimental condition. The lower curve shows the percentage of drivers traveling 70 km/hr or more.

The first, second, and third introductions of the marked police vehicle condition ("Police Car" on the figure) each led to a marked reduction in the percentage of motorists traveling at or over 60 and 70 km/hr. However, two things are apparent from the data. First, the magnitude of the reduction declined somewhat in the 60 km/hr and over category with each intervention of the marked police vehicle condition. For example, the percentage of motorists traveling at or over 60 km/hr during the first three marked police vehicle conditions increased from 7.6% during the first condition to 9% and 13.5% during the second and third conditions, respectively. It should be noted that this increase did not occur in the percentage of motorists traveling at or over 70 km/hr during the first three marked police vehicle conditions (0.6%, 0.8%, and 0.8%, respectively). Second, the original baseline levels of performance were not recovered during baseline 2 following the first marked police vehicle condition, but were slowly

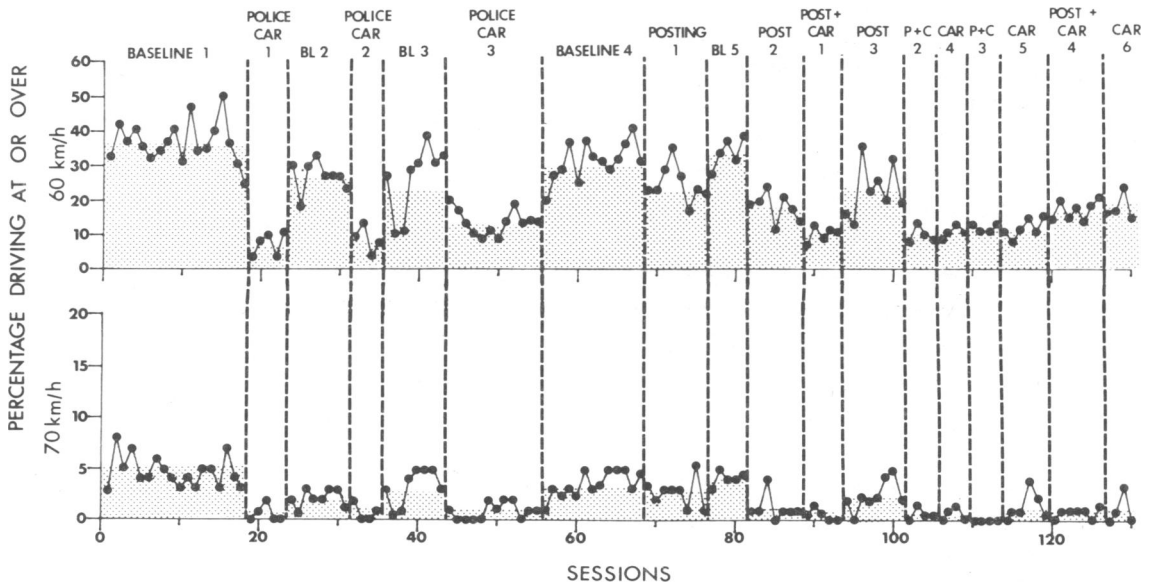

Fig. 3. The percentage of drivers traveling at or over 70 and 60 km/hr during each session of Experiment 3.

recovered following the second marked police vehicle condition and were immediately recovered following the third marked police vehicle condition.

The introduction of Posting 1 led to a small decline in the percentage of drivers traveling at or over 60 and 70 km/hr, although these reductions were not nearly as large as those produced by the marked police vehicle condition. However, Posting 2 led to a larger reduction in the percentage of motorists traveling at or over 60 and 70 km/hr than did Posting 1. The reductions produced by Posting 2 were nearly as large as those produced by the third marked police vehicle condition.

The first posting plus marked police vehicle condition resulted in reductions in speeding to levels below those obtained during the preceding posting 2 condition.

The results of the third posting condition were similar to results obtained during Posting 1 and the results of the second posting plus marked police vehicle condition were very similar to the results obtained during the first posting plus marked police vehicle condition.

When the feedback sign was covered during the fourth marked police vehicle condition, the percentages of drivers in all three speed categories were similar to the percentages obtained during the preceding posting plus marked police vehicle 2 condition. Results of the marked police vehicle 4 condition were also similar to results of the earlier marked police vehicle conditions.

The results of the third posting plus marked police vehicle condition were similar to those obtained during the second posting plus marked police vehicle condition. The only exception was the percentage of drivers traveling at 70 km/hr or more, which remained at zero throughout the condition. The results obtained during the fifth marked police vehicle condition were similar to those obtained during the marked police vehicle 4 condition. However, during later sessions there was a tendency for the percentages to increase in both speed categories. Drivers traveling 60 km/hr or more and 70 km/hr or more averaged 12.2% and 1.5%, respectively, during this condition.

The results of the final posting plus marked police vehicle condition and marked police vehicle condition were similar to each other and higher than those obtained during the preceding posting plus marked police vehicle and marked police vehicle conditions.

Distribution of Drivers' Speeds

Figure 4 illustrates the mean distribution of drivers' speeds during four selected conditions of the experiment: Baseline 1, Marked Police Vehicle 1, Posting 2, and Baseline 5.

The figure shows that during Baseline 1 most drivers were traveling at speeds equal to or greater than the speed limit. The distribution was a very symmetrical one, the peak occurring in the 55 to 59 km/hr category. Baseline 5 produced a distribution very similar in shape to the distribution produced during Baseline 1.

The marked police vehicle 1 condition produced a skewed distribution with large decreases in the mean percentages of drivers traveling in higher speed categories and large increases in the mean percentages of drivers traveling in categories below the speed limit. Indeed, relative to Baseline 1, the mean percentage of drivers traveling between 45 and 49 km/hr more than doubled during the marked police vehicle 1 condition whereas the mean percentage of drivers traveling between 40 and 45 km/hr increased almost eightfold.

In addition, the peak of the distribution was shifted to the left, occurring in the 50-54 km/hr category during this condition.

The posting 2 condition also produced a distribution different from those of the baseline conditions. In particular, Posting 2 produced decreases in the percentages of drivers in the 60 to 64 km/hr, 65 to 69 km/hr, 70 to 74 km/hr, and 75 to 79 km/hr categories. These decreases were accompanied by increases in the 50 to 54 km/hr and the 55 to 59 km/hr categories. However, it is most important to note that the posting 2 condition led to only small increases

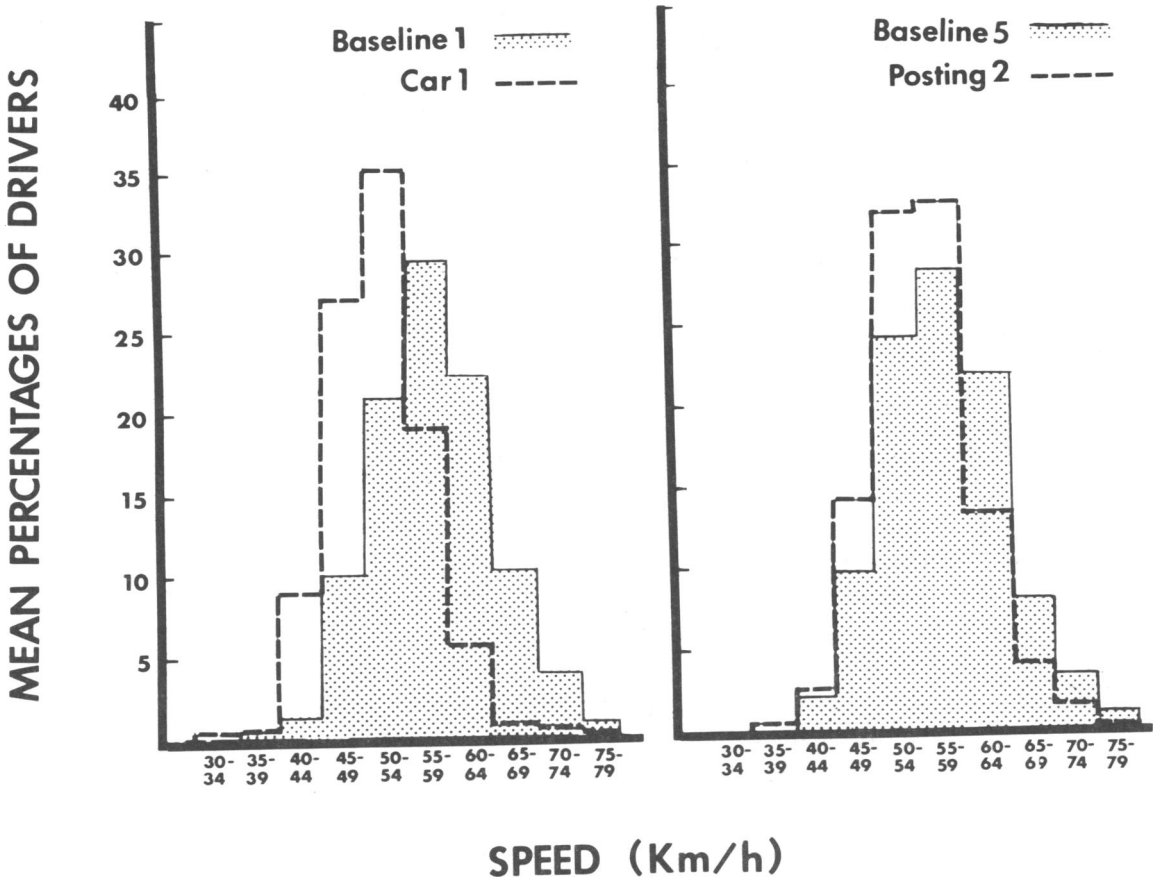

Fig. 4. The mean percentage of drivers traveling within each of 10 different 5 km/hr speed categories during the baseline 1, marked police vehicle 2, baseline 5, and posting 2 conditions of Experiment 3.

in drivers traveling in the categories below the 50 km/hr speed limit. In this respect, the results of Posting 2 were very different from the results of the marked police vehicle 1 condition in which there were large increases in categories below the speed limit. Moreover, the peak of the posting distribution occurred in the 55 to 59 km/hr category and not in the 50 to 54 km/hr category as it did in the marked police vehicle 1 condition. Thus, although the marked police vehicle condition resulted in a skewing of the speed distribution, the posting condition merely resulted in a narrowing of the speed distribution.

Distributions obtained during all other baseline, marked police vehicle, and posting conditions were similar to the distributions presented here, although there was some tendency for distributions obtained from later marked police vehicle conditions to resemble those of the posting conditions. This confirmed the earlier tendency for the effectiveness of the marked police vehicle condition to diminish with repeated application. Distributions obtained from the posting plus marked police vehicle condition were very similar to those of the marked police vehicle conditions.

Discussion

The results of this experiment confirmed that parking a marked, unmanned police vehicle along a roadside can reduce the speeding of

passing drivers by a substantial amount. This result is in agreement with similar results reported by Dart and Hunter (1976), Edwards and Brackett (1978), and Galizio et al. (1979).

The results of the present experiment also provide an additional confirmation of the effectiveness of posted feedback for the reduction of speeding (Van Houten et al., 1980; Van Houten & Nau, 1981).

A comparison of results from the two conditions revealed that the parked, unmanned police vehicle reduced speeding to a greater extent than did posting. Indeed, the effectiveness of the police vehicle was so great that, when posting was combined with the unmanned police vehicle, no greater reduction in speeding was apparent than when the police vehicle was present alone.

However, several considerations suggest that parked police vehicle may not represent an optimal technique for the control of speeding. First, the allocation of a fully equipped police vehicle to serve as a stationary speed control is much more expensive than is the use of a feedback sign. On the basis of manpower requirements alone the police vehicle was the most expensive tecehnique, requiring two patrolmen to devote approximately 40 min per day to transporting the patrol vehicle to and from the site. By contrast, maintenance of a feedback sign would require the presence of a single observer for as little as 45 to 60 min per week (Van Houten & Nau, 1981). Furthermore, the use of a patrol vehicle in this manner precludes its use for other tasks such as patrolling and answering calls.

One further problem associated with the use of the marked, unmanned police vehicle was its tendency to produce increases in the percentage of drivers traveling below the speed limit. This phenomenon has been reported by other researchers and has been termed the "overreaction" effect (Dart & Hunter, 1976; Galizio et al., 1979). Previous research has suggested that the probability of traffic accidents increases with increased departures above or *below* the mean speed. Thus, although the marked police vehicle did produce substantial reductions in the percentage of drivers traveling in excess of the limit, the substantial increases in the percentage of drivers traveling below the limit that were also produced during this condition may have meant that the probability of traffic accidents was unchanged. On the other hand, the use of posted feedback is less subject to this criticism because posting produced only slight increases in the percentage of drivers traveling below the speed limit.

It may be of interest to note that Galizio et al. (1979) also reported that a speed limit sign failed to reduce speeding in their study. This is surprising because numerous other researchers have shown the use of speed limit signs to be an effective speed control technique (Department of Scientific Research, Roard Research Laboratory, 1963). An explanation of this discrepancy may lie in the overreaction effect and in the fact that, during the Galizio et al. (1979) control condition, most drivers were already traveling under the posted limit. Thus, the large reductions produced by the patrol car in the Galizio et al. (1979) study were attributable mostly to the overreaction effect. By the same token, it is quite likely that posting the speed limit did not produce a reduction in mean speed because it did not produce an overreaction effect. This interpretation is supported by the lack of a strong overreaction effect when the feedback sign was used in the present study because a speed limit sign would be expected to be even less likely to produce an overreaction effect than would the feedback sign used here.

Lastly, and perhaps most important, the narrowing of the distribution of drivers' speeds produced by both the presence of a police car and the feedback sign is an important finding in light of the relationship between deviation from mean vehicle speed and accident probability. Cirillo (1968) and West and Dunn (1971) reported accident rate increases with increased deviation from mean vehicle speed.

EXPERIMENT 4

The results of the previous experiment demonstrated that a stationary marked police vehicle could reduce speeding behavior. Although large reductions in speeding were initially produced, the results suggested that the effects of the parked police car gradually decreased over time. Another way of signaling police presence is to mark highways for aircraft speed enforcement. This type of approach is used in many North American communities to reduce speeding. The purpose of the present experiment was to examine the effectiveness of police aircraft patrols in reducing speeding and to compare this technique with the feedback sign.

METHOD

Subjects and Setting

The subjects were drivers traveling along a 5-km segment of Highway 111, a four-lane divided highway with a speed limit of 80 km/hr. This highway cuts through the City of Dartmouth, Nova Scotia, and is bounded by a bridge on the north and a rotary, or traffic circle, on the south. This section of highway was selected for study for two reasons: first, preliminary analysis indicated that there was a considerable amout of speeding on the highway; second, there had been numerous, and six fatal, accidents on this highway during the preceding several years.

Speed measurements were taken at four sites along the highway. Two of these sites (the Burnside sites) were located at a point 2 km from the bridgehead near the entrance ramps where traffic from Burnside Drive joined Highway 111. The remaining two sampling sites (the MicMac sites) were located 1 km from the traffic rotary near the point where MicMac Boulevard joined Highway 111. The MicMac sites were located 2 km from the Burnside sites. Because of the large amount of variability in speeds on a crowded high speed highway, daily measures at each site were averaged over 2-day blocks.

Apparatus

Vehicles' speeds were measured using a Tribar Industries T3 digital radar. The feedback signs were in all respects the same as those used in Experiment 2. Air patrol warning signs bore the message "SPEED LIMIT ENFORCED BY POLICE AIRCRAFT," measured 3.15 m long × 1.00 m high, and were made of the same material as the feedback signs. Letters on these signs were also 20.3 cm in height.

To guarantee that all vehicles passing any speed monitoring site had already passed or were within sight of both types of sign, two pairs of signs were located along the northbound lanes and two pairs of signs were located along the southbound lanes. The feedback sign and air patrol warning sign within a given pair were separated by a distance of 40 m.

General Procedure

The speeds of 200 vehicles were sampled daily at each of the four sites, Monday through Friday, commencing between 9:00 a.m. and 1:00 p.m. Due to the design of the highway it was impossible to conceal the measurement vehicle. Therefore, as was the case in Experiment 2, the observer measured vehicles' speeds by aiming the radar through the rear window of an unmarked automobile parked along the shoulder of the highway. Once the daily sampling session was completed at a given site, the observer drove the monitoring vehicle to the next site, and commenced sampling there. No measurements were taken on rainy or foggy days because preliminary investigation revealed that less speeding occurred under these conditions.

Experimental Design

A reversal design was used in this study. The sequence of conditions was: Baseline 1, Posted Feedback 1, Baseline 2, Posted Feedback 2, Baseline 3, Air Patrol 1, Baseline 4, Air Patrol 2, Air Patrol plus Posted Feedback 1, Air Pa-

trol 3, Air Patrol plus Posted Feedback 2, Air Patrol 4, and Air Patrol plus Posted Feedback 3.

Baseline conditions. During the first baseline condition no signs were present at the four sites. During subsequent baseline conditions all signs were covered with black opaque plastic.

Posted feedback conditions. At the beginning of each of the weekly posting conditions four feedback signs were either erected or uncovered. These signs, which indicated the percentage of drivers traveling at 94 km/hr or less during the preceding week and the highest percentage recorded to date, were placed in the following locations: one northbound sign located approximately 0.5 km north of the rotary, a second northbound sign approximately 2 km north of the first sign and 1 km before the Burnside exit, one southbound sign located approximately 1 km from the bridgehead and about 1 km before the Burnside exit, a second southbound sign situated just before the MicMac exit. Although the speed limit was 80 km/hr, 94 km/hr was selected as the cutoff point because local highway and police officials did not consider vehicles traveling less than 95 km/hr as a serious threat to highway safety. Police patrolling procedures remained as during baseline.

New weekly percentages were posted on the sign every Monday morning and represented the average percentage obtained from the two Burnside sites on one randomly chosen day during the preceding week. The Burnside sites were selected because most of the speeding occurred there.

Air patrol conditions. Prior to beginning the first air patrol condition the road was surveyed for the placement of "T" bars to allow for the aerial calculation of vehicles' speeds. At the beginning of this condition, six "T" bars were painted on each side of the highway at 0.5-km intervals, dividing it into five zones. In addition, the four air patrol warning signs were erected at the commencement of this condition. Each sign, which read "SPEED LIMIT ENFORCED BY POLICE AIRCRAFT," was erected in close proximity to one of the feedback signs. The feedback signs remained covered during this condition and all subsequent air patrol conditions.

The police flew two 2-hour patrols between 10:00 a.m. and 3:00 p.m. during the first air patrol condition, a single 2-hour patrol during the second and third air patrol conditions, and no patrol during the fourth air patrol condition. The helicopter, either a Bell Jet Ranger or a Hughes 369, was flown in such a manner as to make it highly visible because the focus of this study was to deter rather than to catch speeders.

A police constable, seated in the front passenger seat of the helicopter, used a special clipboard with calibrated stopwatches mounted on it to record the amount of time that it took selected vehicles to travel through several T-bar zones. When a speeding vehicle was observed, the constable radioed one of two patrol cars parked at either end of the highway. The constables in the patrol car then stopped the offending vehicle and either warned or charged the driver with speeding. The data collected by the police constable in the helicopter were used for enforcement purposes only. All experimental data were collected in the usual manner by observers on the ground.

Air patrol plus posted feedback conditions. The air patrol warning signs remained uncovered during this condition. In addition, the feedback signs were also uncovered and percentages were posted. Hence, all the signs were uncovered during this condition. The helicopter patrol was flown for 2 hours during the second air patrol plus posted feedback condition.

RESULTS

Because there was little or no difference in the percentages of drivers traveling 90 and 100 km/hr or more at each of the two Burnside sites, the data obtained at these two sites were combined. For the same reason the data obtained at each of the two MicMac sites were also combined. The percentage of vehicles traveling at or over 90 and 100 km/hr at the Burnside and

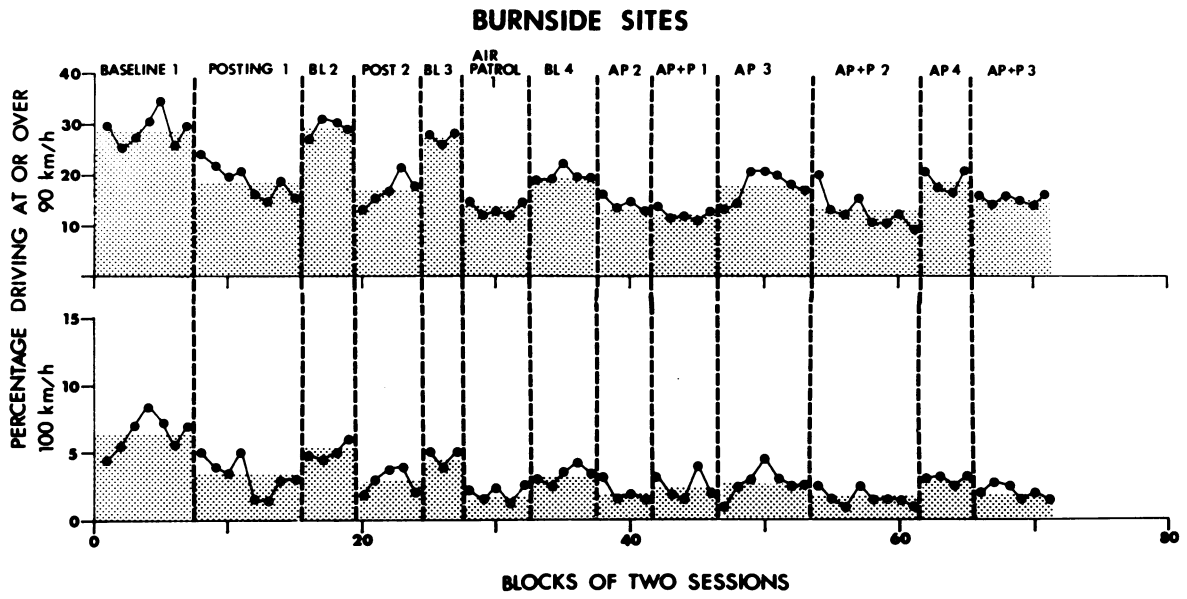

Fig. 5. The mean percentage of drivers traveling 90 and 100 km/hr or more at both Burnside sites during each condition averaged over two-session periods in Experiment 4.

MicMac sites are presented in Figures 5 and 6, respectively.

The first introduction of the posted feedback condition led to a decline in the percentage of drivers traveling at or over 90 and 100 km/hr at both the Burnside and MicMac sites. Performance returned to Baseline 1 levels for both speed categories at both sites during the baseline 2 condition and declined again to Posting 1 levels for both speeds at both sites during Posting 2.

Baseline 1 levels were again recovered at both sites in both speed categories during Baseline 3. The introduction of the first air patrol condition led to reductions in the percentage of motorists

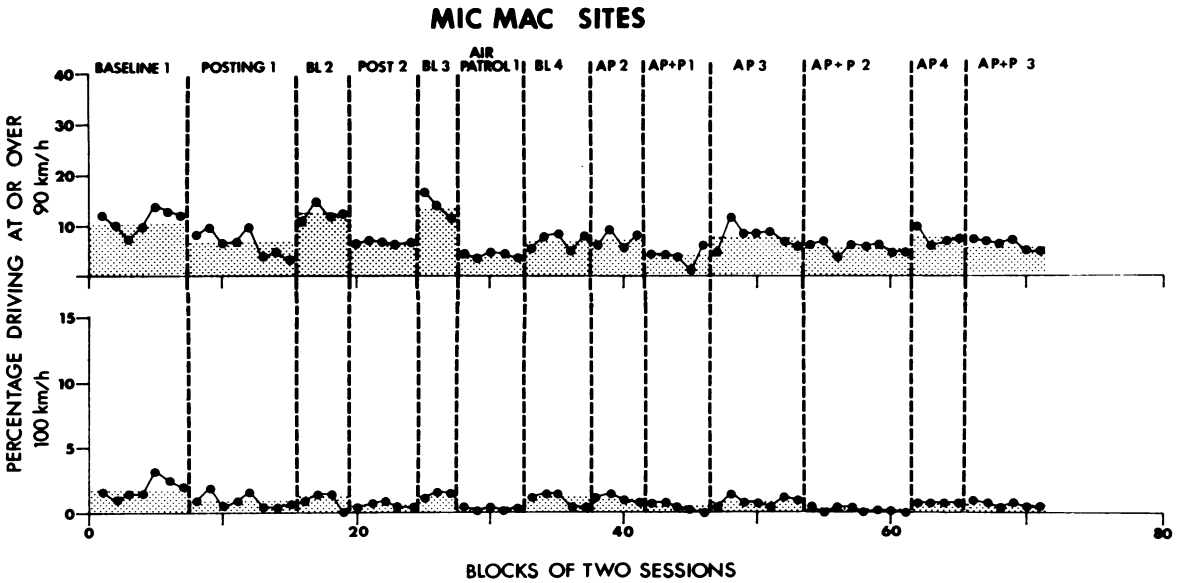

Fig. 6. The mean percentage of drivers traveling 90 and 100 km/hr or more at both MicMac sites averaged over two-session periods in Experiment 4.

traveling within both speed categories, at both sites, that were very similar to those produced by the two posting conditions. The data obtained from both sites also show that Baseline 1 levels were never fully recovered following the introduction of the first air patrol condition and that the air patrol plus posting conditions typically produced larger reductions in speeding for both speed categories at both sites than the air patrol condition alone. Furthermore, the reductions produced by the air patrol plus posting condition were also greater than those produced by the posting conditions alone at the Burnside site.

Discussion

The results of this experiment demonstrated that the posted feedback and air patrol conditions both reduced speeding below baseline levels. These results were obtained at both the Burnside and MicMac sites.

The combination of the posted feedback and air patrol conditions was more effective than posted feedback alone and more effective than the later air patrol condition at the Burnside site. These results suggest that the feedback sign and air patrol conditions may potentiate each other under some conditions.

Another finding was the failure to recover the original baseline levels of performance completely following the first air patrol condition. One reason the effects of the air patrol condition may have persisted was that the highly discriminable T-bars painted on the road were still present during that condition. It is likely that many Nova Scotians know the purpose of these T-bars since the RCMP have widely publicized this fact over recent years.

Although the air patrol was flown only infrequently in this study, the weekly minutes of air time per kilometer patrolled in the latter portion of the present study compare quite well to that used by the RCMP in the air patrols over interprovincial highways—12 min/km in the present study versus 2 min/km by the RCMP. However, it is possible that the reduced number of hours flown could have been responsible for the reduction in the effectiveness of the air patrol conditions. Lastly, it is also possible that the results of the experiment may have been influenced by the order in which the various treatments were introduced. Unfortunately, it would have been difficult to begin with an air patrol condition because of the difficulty in recovering baseline in the presence of the T-bars painted on the pavement.

EXPERIMENT 5

The results of Experiments 3 and 4 suggest that the presence of stimuli associated with police enforcement of speeding, such as a parked police vehicle or signs indicating the presence of police aircraft patrols may gradually lose their effectiveness over a period of time. One way of maintaining these stimuli as effective discriminative stimuli for police enforcement is to pair them frequently with enforcement activity. However, the results of a study reported by Van Houten and Nau (1981) suggest that this approach may not be entirely effective. The results of this study demonstrated that traditional methods of police enforcement (stationary radar patrols and charging motorists with speeding violations) failed to reduce the percentage of speeding motorists once the enforcement patrols were no longer present at the scene.

One reason traditional methods are not very effective may be that only a small percentage of people who speed ever make contact with the ticketing contingency. For example, Van Houten and Nau (1981) reported that police were able to charge only a few motorists during a 60-min surveillance period even though 40% of the motorists were traveling 10 km or more over the speed limit (approximately 120 motorists per hour). McCoy, Mohaddes, and Haden (1981) reported similar rates of charging.

One reason police charge such a small percentage of the motorists exceeding the speed limit is that each motorist charged must be detained for up to 10 min, while information is

gathered and the required forms are filled out. Another reason may be the reluctance of police to charge too many people because of the time involved in court appearances. Finally, charging a high percentage of speeding drivers would not contribute to good police-community relations.

An alternative approach to charging speeding motorists is to issue them a warning ticket. This approach offers several advantages over the traditional approach. First, it requires less time to issue a warning ticket because only the operator's master number needs to be recorded. Second, police need not be concerned about time lost in court appearances if they issue only a warning. Third, it should be possible to issue a large number of warning tickets without harming police-community relations. If a record of warnings is maintained it is also possible to charge individuals caught speeding a second time.

Another approach which has received little attention is providing information to speeding motorists in the form of a flier. For example, it would be easy to retrieve from the police department's computer a record of accidents on a particular problem street over the preceding year. From these data it would be easy to prepare a flier that provided information on the number, type, and costs of accidents occurring on the selected road. This flier could then be handed to each motorist being warned on that street in order to emphasize the seriousness of the problem. Such a positive approach might also involve having the police officers ask motorists for their cooperation in making their streets safer places.

The purpose of the present study was to compare the efficacy of a treatment package consisting of the issuing of warning tickets and feedback fliers to speeding motorists traveling a designated amount in excess of the speed limit with the traditional method of charging motorists under the motor vehicle act. A second purpose of this study was to examine the effects of combining warning tickets and the feedback flier with the use of the feedback sign.

METHOD

Subjects and Setting

The subjects were drivers traveling on three roads in Dartmouth, Nova Scotia. The first road, Mount Edward Road, was a two-lane, 3-km long suburban feeder road linking numerous small suburban streets with shopping areas and primary urban highways. The speed limit on this residential road was 50 km/hr and most of the traffic consisted of local vehicles. This road was selected for inclusion in this study because local residents had made frequent complaints to the police about speeding and because preliminary measurements with radar indicated that there was a large amount of speeding there. In addition, there were numerous schools in this area and children could be seen along the street during most of the day. All speed measurements on this road were taken on weekdays between 10:00 and 11:00 a.m. Only traffic headed downtown (southbound) was studied.

The second road, Portland Street, was a four-lane, undivided highway that linked the outskirts of the city with business and residential areas. This was one of the two streets reported in the Van Houten and Nau (1981) experiment and had a feedback sign located where the speed limit changed from 70 km/hr to 50 km/hr. Speed measurements were taken on weekdays between 9:00 and 10:00 a.m. Only traffic entering the city was studied.

The third road, Raymond Street, was a 0.5-km long residential street with a 50 km/hr speed limit that was used by many drivers as a shortcut during rush hour. This road was selected because residents frequently compained to police and aldermen about speeding during evening rush hour and because preexperimental speed measurements supported the validity of these complaints. All speed measurements on this road were taken during the weekday evening rush hour, between 4:00 and 5:00 p.m. Although the majority of traffic was headed southbound, the speeds of vehicles headed in either direction were measured.

Apparatus

The speeds of vehicles on Mount Edward Road and Portland Street were measured using a Tribar Industries DRS 3 radar placed inside a large yellow litter can. Vehicle speeds were recorded in the same manner as described in Experiments 1 and 3. The speeds of vehicles on Raymond Street were measured using a Tribar Industries T-3 hand-held radar used in the same manner as described in Experiments 2 and 4. When using the hand-held radar the observer sat in a private, unmarked car parked along the curb of the road. The observer aimed the radar through the front window of the vehicle while sitting as low as possible in order to maximize concealment and reduce the likelihood of being detected.

General Procedure

Samples were taken on each of the three roads on three randomly selected days each week. Speeds were sampled during one-hour observation periods on Mount Edward Roard and Raymond Street and a 200-car sample was taken on Portland Street because of the higher traffic volume on this road (22,400 cars per day). On Mount Edward Road and Raymond Street approximately 80 cars were sampled each one-hour observation period. At the end of each week the mean percentages of motorists traveling at or over 60 and 70 km/hr were calculated for the week on Mount Edward Road and Raymond Street and the mean percentages of motorists traveling at or over 60, 70, and 75 km/hr were calculated for Portland Street.

Measures of interobserver agreement were calculated in the same manner as described in Van Houten and Nau (1981). Interobserver agreement was always 100%.

Experimental Design

In this study two variables, a brief warning plus information feedback program and a standard enforcement program, were each introduced according to a multiple-baseline design. Following the baseline condition (baseline on Portland Street included the presence of a feedback sign), the warning plus informational feedback program was introduced across all three roads. The warning plus informational feedback program was first introduced on Mount Edward Road, then on Portland Street, and finally on Raymond Street. This program was in effect for 4 days on Mount Edward Road and Portland Street and for 1 day on Raymond Street. Prior to implementing the warning plus feedback program on Portland and Raymond streets a standard enforcement program was introduced on these streets according to a multiple-baseline design with the program first being introduced on Portland Street and later on Raymond Street. The standard enforcement program lasted 4 days on Portland Street and 1 day on Raymond Street. Therefore, the warning plus informational feedback program and the standard enforcement condition lasted the same number of days on each street.

Finally, after the warning plus informational feedback program had been implemented on Portland Street, the feedback sign located there was covered and uncovered several times. This was done to determine whether the effects of the feedback sign potentiated the efficacy of the warning program.

Baseline. During this condition police patrolling and ticketing were carried out according to the police department's normal schedule.

Warning and informational feedback program. This program lasted for 4 consecutive weekdays between 10:00 a.m. and 3:00 p.m. on Mount Edward Road and Portland Street and for 1 day between the hours of 3:00 and 5:30 p.m. on Raymond Street. Prior to beginning the program each day a brown, unmarked police van was parked in a concealed location along the street. While seated in the van a police radar operator from the traffic division measured speeds of all passing vehicles. On Mount Edward Road the police van was parked in a driveway approximately 200 m past the yellow drum used by the experimental team to measure vehicles'

speeds. On Portland Street the van was parked in a driveway shielded by a woodlot approximately 30 m ahead of the yellow drum used by members of the experimental team. On Raymond Street the van was parked alongside the road. Two motorcycle officers from the traffic division served to stop speeding vehicles and deliver warnings. On Mount Edward Road and Portland Street, these officers were located approximately 0.3 km beyond the van, their motorcycles parked off the road and out of sight of approaching traffic. On Raymond Street one officer was stationed at each end of the street so that vehicles traveling in either direction could be stopped. The radar operator communicated with the two motorcycle officers via a VHF radio tuned to a police frequency.

Whenever a motorist exceeded the 50-km speed limit at any of these sites by 10 km or more the radar operator identified the vehicle and alerted the motorcycle officer. After confirming that the correct vehicle had been stopped, an officer approached the vehicle and explained to the driver that he or she had been traveling in excess of the speed limit. If both officers were already busy with two motorists, additional motorists were instructed to pull over and wait until the officers were finished with the earlier vehicles. No more than five vehicles were pulled over at any one time. This rule was used to ensure that the number of cars stopped along the roadside did not interfere with the flow of traffic and because more than five vehicles would be too many for two constables to handle easily.

After informing the driver of the violation the officer filled out a special warning ticket which included information on the driver's master number and the car's license plate number. The motorist was then handed the ticket and a special information flier which described the number and types of accidents occurring on that particular road during the previous year. The flier used on Mount Edward Road is illustrated in Figure 7. The flier was printed with black letters and the Dartmouth Police Department crest was screened over in blue ink. The cost of printing 500 fliers for each of the streets was $30 CAN ($26 US). It took the second author approximately 2 hr to collect and organize the data used in each flier. The text of this flier began by providing information on the total number of accidents occurring during the previous year (the previous 12 months) followed by a breakdown of accidents according to type. Following this, the total cost of damage to vehicles in dollars was noted. (This figure was an underestimate because the cost of many accidents were reported as "over $200." In these cases, the estimate was taken as $200.)

Next, the flier featured information about a particular danger associated with the road in question. For example, in the Mount Edward Road flier, the danger to young pedestrians was emphasized; in the Portland Street flier, crosswalk accidents were featured, and in the Raymond Street one, the death of a young pedestrian was emphasized. Finally, each of the fliers pointed out the risks associated with speeding. The police constable ended the interaction by asking the motorist to cooperate with the program and help make the community a safer place to live. The maintenance of the brief program was monitored for an additional 39 weeks on Mount Edward Road, 28 weeks on Portland Street, and 23 weeks on Raymond Street.

Standard Enforcement Program

The standard enforcement program was conducted for 4 consecutive weekdays between 10:00 a.m. and 3:00 p.m. on Portland Street and for 1 day between 3:00 and 5:30 p.m. on Raymond Street. Hence, on each street the standard program remained in effect for the same amount of time as the warning program. Prior to beginning the program each day a brown, unmarked police van and two motorcycle officers were parked in concealed locations along the street. A police radar operator from the traffic division measured speeds from the van. On each street the radar operator and motor cycle officers were positioned in exactly the same

IT DOESN'T MAKE SENSE TO SPEED ON MOUNT EDWARD ROAD

THERE WERE 20 TRAFFIC ACCIDENTS ON MOUNT EDWARD ROAD LAST YEAR

2 children were struck by vehicles

1 vehicle was struck from behind

2 vehicles lost control while turning

4 vehicles were struck while turning in front of other vehicles

3 vehicles were struck while entering from side streets

3 vehicles were struck while passing other vehicles

2 vehicles were struck while parked on the street

3 miscellaneous

DAMAGE TO VEHICLES WAS WORTH OVER $14,175.

THE TWO PEDESTRIANS INJURED ON MOUNT EDWARD ROAD LAST YEAR WERE CHILDREN

There are six schools in this area with a total enrollment of 4,687 students. Every morning, noon hour and afternoon, the sidewalks and crosswalks along Mount Edward Road are full of children on their way to and from school. Yet - at these same times, drivers on Mount Edward Road have been clocked as high as 80 km/hr. THINK AGAIN. AT YOUR SPEED YOU MIGHT NOT HAVE BEEN ABLE TO STOP IF AN INATTENTIVE CHILD HAD RUN OUT IN FRONT OF YOU.

AT THE SPEED YOU WERE GOING

You might not have been able to stop if an unpredictable driver tried to turn left in front of you. You might not have been able to stop if a car in front of you stopped suddenly. You might not have been able to stop if a car emerged suddenly from a side street.

SO FAR, NONE OF THE CHILDREN WALKING NEAR MOUNT EDWARD ROAD HAS BEEN KILLED

IF DRIVERS DON'T SLOW DOWN, IT WILL PROBABLY BE JUST A MATTER OF TIME BEFORE ONE IS

WE ARE TRYING TO MAKE YOUR STREETS SAFER FOR YOU. PLEASE CO-OPERATE

SLOW DOWN

Dartmouth Police Force

Fig. 7. A picture of the feedback flier used on Mount Edward Road in Experiment 5.

locations as during the warning program. The radar operator communicated with the two motorcycle officers via a VHF radio tuned to a police frequency.

Because it was not possible to charge all speeding motorists during this condition, the police charged only the fastest violators. The radar operator identified the vehicle to be stopped by the motorcycle officers. After confirming that the correct vehicle had been stopped, an officer approached the vehicle and explained to the driver that he or she had been exceeding the speed limit and was going to be given a summary offense ticket for speeding. Next the officer wrote out a ticket, including all the information that was required.

In filling out a standard summary offense ticket, officers were required to supply information in response to no less than 30 questions, including questions regarding the motorist's identity, the vehicle's identity, the statute violated, the court date, and the officer's identity. As a consequence it took as long as 10 min to deliver each speeding charge. As was the case during the warning feedback program, no more than five vehicles were stopped at any one time. Additional vehicles were not stopped until one of the five vehicles left the site. The maintenance of any effects produced by this treatment was then monitored for 6 weeks on Portland Street and 7 weeks on Raymond Street.

Feedback sign covered. The feedback sign covered condition was only used on Portland Street because this was the only street along which a feedback sign was in place during this experiment. This condition was in effect on this street on two occasions after the warning plus informational feedback condition had been used. On each occasion the sign was covered with a sheet of black opaque plastic.

RESULTS

The results of the experiment appear in Figure 8. This figure shows the mean percentage of drivers traveling 60 and 70 km/hr or more on Mount Edward Road, Portland Street, and Raymond Street during each week of the experiment. An additional graph in the figure shows the mean percentage of drivers traveling 75 km/hr or more on Portland Street during each week of the experiment. Each data point represents an average of the percentages obtained during three randomly scheduled measurement sessions that took place during the week. The horizontal shaded area on each graph indicates the range of percentages obtained during the baseline condition.

Mount Edward Road

As Figure 8 shows, percentages were high and stable during baseline on Mount Edward Road. The mean percentages of drivers traveling 60 and 70 km/hr or more averaged 42.8% and 5% respectively, during this condition. The introduction of the warning plus informational feedback condition led to an immediate decrease in the mean percentages in both speed categories. The figure also shows that the mean percentages in these categories remained at the lower levels for the succeeding 40 weeks. It should be noted that the warning plus informational feedback condition was in effect for only one week and hence only coincided with the first weekly data point on the figure. The remaining data illustrate the persistence of the effects produced by this program. By referring to the shaded areas of the graphs, it can be seen that percentages obtained following the warning and information program only rarely overlapped percentages obtained during baseline. The mean percentages of drivers traveling 60 and 70 km/hr or more during this condition averaged 26.7% and 2.7%, respectively. Relative to baseline, these represented reductions of 37.6% and 46%. Police delivered 474 warnings and 33 charges during this condition. Thus, charges amounted to only 6.5% of the tickets issued.

Portland Street

Percentages obtained on Portland Street during baseline were stable, averaging 34.3% of drivers traveling 60 km/hr or more, 5.8%

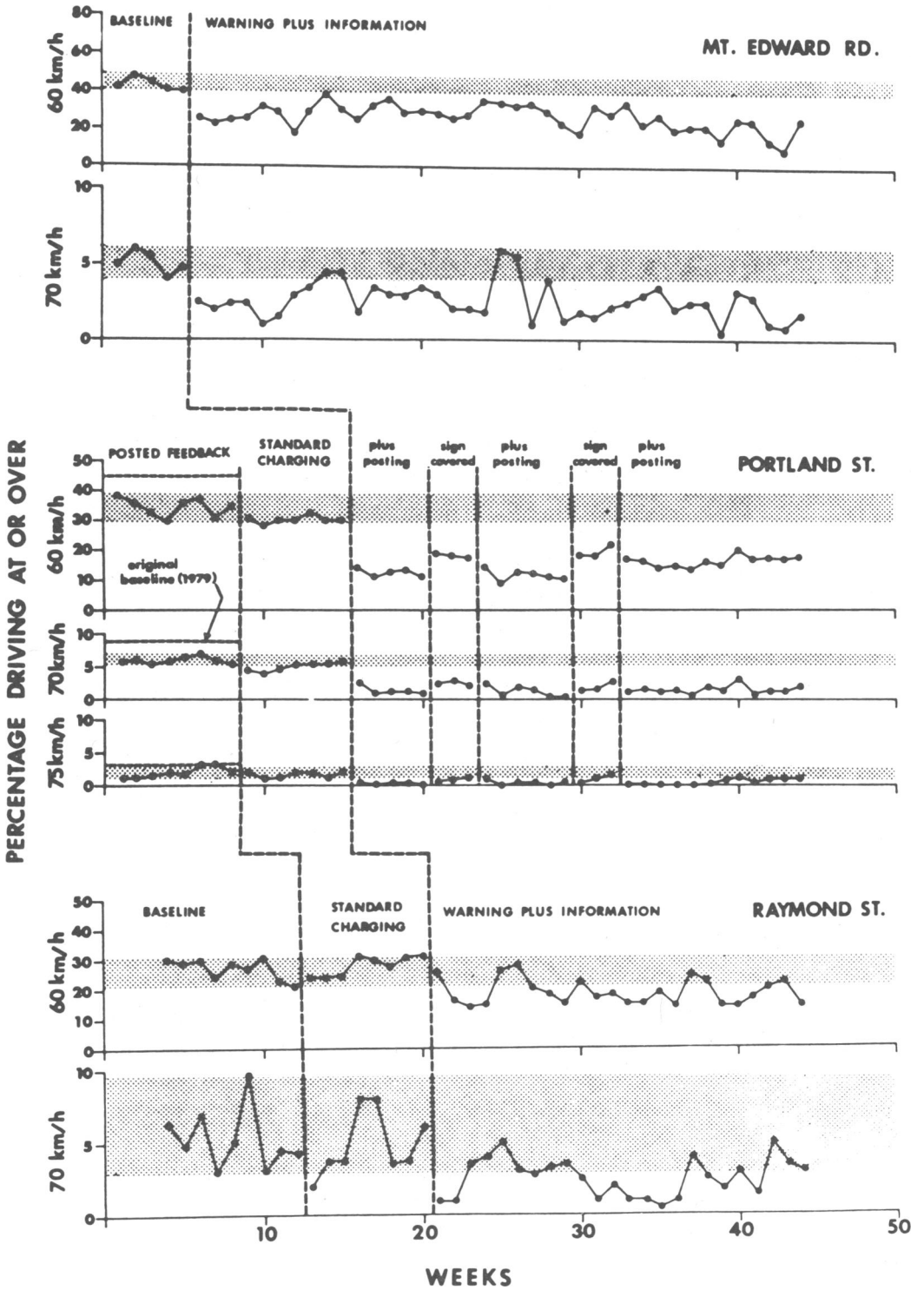

Fig. 8. The percentage of drivers traveling at or over 70 and 60 km/hr during each condition of Experiment 5 on each street. The horizontal dashed lines in the baseline condition on Portland Street represent the means during the original baseline two years earlier. The shaded area indicates the range of performance during the baseline condition on each street.

traveling 70 km/hr or more, and 2% traveling 75 km/hr or more. The horizontal dashed lines on the Portland Street graphs represent the mean percentages obtained during the original baseline that was obtained 2 years earlier, before the feedback sign was ereceted. These data show that the sign had maintained its effectiveness.

The introduction of the standard enforcement program had little effect on the percentage of motorists traveling within each of the speed categories. As shown in Figure 8, percentages were only marginally lower following implementation of the standard enforcement program. In addition, there was a considerable amount of overlap between percentages obtained following the standard enforcement program and those obtained during baseline. The mean percentages of drivers traveling 60, 70, and 75 km/hr or more during the standard enforcement program averaged 30.3%, 5.1%, and 1.8%, respectively. During this condition the police delivered a total of 68 charges and no warnings.

The introduction of the warning plus informational feedback condition produced marked reductions in the percentage of vehicles traveling in all speed categories and, as the figure shows, there was no overlap with the results obtained during the preceding two conditions. The mean percentage of drivers traveling 60, 70, and 75 km/hr or more averaged 12.5%, 1.4%, and 0.4%, respectively, during this condition. Relative to baseline, these represented reductions of 63.6%, 75.9%, and 80%.

Covering the feedback sign resulted in an increase in the percentage of drivers traveling in all three speed categories. However, in no case did the percentages return to the levels obtained before the warning plus informational feedback program was initiated. Indeed, as the figure shows, results obtained during the sign covered condition did not overlap with results obtained during the baseline, standard enforcement or the warning conditions. When the sign was uncovered the results obtained were similar to those obtained during the initial warning plus informational feedback condition. Covering and uncovering the signs produced data replicating these results.

Raymond Street

During baseline the weekly mean percentage of drivers traveling 60 and 70 km/hr averaged 27.3% and 5.3%, respectively. During the standard enforcement program police delivered six charges and no warnings. Figure 8 shows that the weekly mean percentages remained essentially unchanged during this condition. There was some indication that the standard procedure did produce a transitory decrease in the percentages of drivers in the 70 km/hr or more category. However, by the second week following the implementation of the program, results had returned to baseline levels.

The introduction of the warning plus informational feedback condition was followed by an immediate and substantial decrease in the percentages of drivers in both the speed categories. Moreover, these percentages remained low throughout the remainder of the experiment and, as the shaded areas in Figure 8 show, results of this condition only occasionally overlapped results of the two preceding conditions. The mean percentages of drivers traveling 60 and 70 km/hr or more during this condition averaged 18.6% and 2.6%, respectively. These represent reductions of 31.9% and 50.9%. The police delivered 46 warnings and 3 charges during this condition. Thus charges constituted only 6.1% of the tickets delivered.

DISCUSSION

The results of this experiment demonstrate that the warning ticket plus informational feedback program was effective in reducing speeding. Substantial reductions were noted in all speed categories and on all three streets on which the program was used. The effectiveness of the warning plus informational feedback program was evident both when it was first preceded by the standard enforcement program, and when it was not, as was the case on Mount Edward Road. Thus, previous implementation of the

standard program was not necessary for the warning program to be effective. Moreover, in all cases the effects of the warning program persisted long after the program itself had been terminated. For example, on Mount Edward Road, effects persisted for at least 39 weeks following termination of the program.

One possible explanation for these results is that faster driving motorists changed their travel routes in order to avoid the streets where the warning program was applied. However, this interpretation of these results is highly unlikely for two reasons. First, it would be very difficult for motorists to avoid traveling on Mount Edward Road or Portland Street without greatly increasing their travel time. Second, and more important, there was no change in traffic volumes on these streets following the implementation of the warning program as measured by the rate at which observers collected their data each day.

The results demonstrating that the standard enforcement program was ineffective in reducing drivers' speeds were consistent with previous studies (Cirillo, 1968; Van Houten & Nau, 1981). This ineffectiveness was evident on both of the roads on which the standard enforcement program was implemented and occurred despite the fact that, in both cases, the standard program was in effect for approximately the same amount of time as the warning plus informational feedback program. Thus, the results of the experiment demonstrate clearly that the warning plus informational feedback program was more effective in reducing speeding than was the standard enforcement program.

It bears emphasis that the results presented here do not contradict results presented by Moncaster and Southgate (Note 4) indicating that delivery of a charge has more effect on an individual driver than does delivery of a warning. Such may have been the case in the present experiment as well. However, in the present experiment delivery of charges alone had little effect on the population as a whole.

Although the warning plus informational feedback program condition was successful in reducing speeding during the times that the police were present at the street (i.e., during the morning and afternoon hours) it is not known whether the effects of this treatment persisted at times during which the program was never applied (i.e., evening hours). Future research is needed to determine whether the effects of this program generalize to untreated times.

There are a number of reasons that could explain why the warning plus informational feedback program reduced speeding whereas the standard enforcement program did not. First, the number of vehicles stopped during the warning program was in each case considerably larger than during the corresponding standard enforcement program. For example, the number of drivers stopped on Portland Street during the warning program was 6.7 times greater than the number of drivers stopped during the standard enforcement program. Thus, during the warning program, police officers were able to make personal contact with a much larger percentage of drivers than during the standard procedure.

A related factor may have been the number of drivers of passing vehicles that had the opportunity to view the program being implemented. Van Houten, Nau, MacKenzie-Keating, Sameoto, and Colaveccia (1982) have demonstrated that the delivery of reprimands to a misbehaving student can reduce the misbehavior of nonreprimanded students seated nearby. It may have been that the delivery of a warning ticket was a discriminative stimulus for punishment in this experiment as well. During implementation of the warning program, vehicles were stopped and ticketed on a nearly continuous basis. For example, during the warning program on Portland Street, police stopped an average of 31.75 drivers per hour. As a result, almost every driver official charge of speeding could be made meant that the police often had to wait long periods of time before they could stop a driver and deliver a charge.

The other major difference between the two programs was the delivery of the informational flier to all drivers stopped during the warning plus informational feedback program. This flier detailed the risks associated with speeding on each street by providing information about the number, types, and cost of accidents and by indication of how excessive speed may have contributed to each accident's occurrence. It may have been that this information was responsible for some of the reduction in speeding that took place. It is also possible that drivers who received informational fliers were more likely to respond to the police's request to slow down because they saw these requests as being made in the best interest of the community and felt that the police were clearly not "just out to make money." Several drivers, who were interviewed informally, stated that they did not mind having been stopped and felt that the police were doing a good job on behalf of the community as a whole. Indeed, in this regard, several traffic officers commented that they found the warning program more pleasant to administer than the standard enforcement program because motorists argued with them less often and occasionally complimented them for the job they were doing.

Interestingly, analysis of the tickets delivered on Mount Edward Road during the warning procedure indicates that only one driver was ticketed for a repeat offense during the course of the program. Although not conclusive, this result suggests that the warning tickets and fliers were effective in reducing the speeds traveled by drivers who were ticketed. One would expect that, under normal circumstances, these drivers would have been speeding through the area regularly because analysis of their addresses indicated that most were residents of the neighborhoods adjoining Mount Edward Road. Unfortunately, the warning tickets issued on Portland and Raymond streets were lost before an analysis of repeat offenders on these two streets could be made.

Although the standard enforcement program condition was less effective in reducing the speeding behavior of the population of drivers using the three streets it should be noted that a history of police charging speeding motorists may be a necessary condition for the warning program to produce large reductions in speeding. For example, if police never charged motorists with speeding in the City of Dartmouth, the results of this experiment may have been quite different.

The results obtained on Portland Street indicated that the combination of a speeding feedback sign and warning program was more effective than either technique alone. It may have been that the feedback sign potentiated the efficacy of the warning program because the sign served as a discriminative stimulus for the presence of the police and the warning ticket contingency. Alternatively, it may have been that the feedback sign and the warning program affected two different populations of drivers. Determining which of these factors is responsible for this effect is somewhat important. For example, a discriminative stimulus function for the feedback sign would suggest that the most effective procedure would be to erect the sign and initiate the warning simultaneously because such a procedure would maximize the development of stimulus control by the feedback sign. If, however, the sign and warning program affect different populations, the sequence of introduction should make little difference. Whatever the reason, the results of this experiment do suggest that a combination of the two techniques may be an effective solution whenever practitioners observe decreases in the effectiveness of the feedback sign alone or of the warning program alone at a particular site.

GENERAL DISCUSSION

The experiments reported here provide repeated demonstration of the efficacy of a feed-

who passed by during the warning program would have been able to see another driver in the process of receiving a ticket from the police.

Such was not the case during the standard enforcement program. At these times, the higher speeding criterion that was required before an back sign in reducing speeding and in so doing replicate the results of previous research (Van Houten et al., 1980; Van Houten & Nau, 1981). In addition, these experiments provide valuable information about the optimal methods of using the feedback sign.

The results of the first experiment indicated that the feedback sign was more effective when a lenient criterion for speeding was used, leading to the posting of high percentages of drivers not speeding, than when a stringent criterion was used, leading to the posting of low percentages of drivers not speeding. These results suggest it would be wise first to establish a baseline distribution of speeds on a roadway and select a criterion that results in the posting of high percentages (above 80%). This rationale is in close accord with the practice of traffic engineers who are primarily concerned with reducing the difference between the 85th percentile speed and the posted speed limit. Indeed, it is common practice for highway engineers to set posted speed limits at a value equal to the 85th percentile of the free flow speed whenever reasonable. Hence there is good reason for selecting the 85th percentile speed obtained during baseline as the posting criterion. This approach results in the posting of serious speeding rather than technical speeding.

It is still not clear why the feedback sign is effective in reducing the speeds of vehicles traveling over the speed limit, although the results of certain of the experiments reported here may favor some explanations over others. For example, the results of Experiment 1 suggest that the sign is effective because it serves as a model for appropriate behavior. However, other explanations of this result are possible. For example, it may be that the posting of high percentages is most effective because drivers presume that, with most drivers traveling the speed limit, speeding will be more easily detected. This would suggest that posted feedback derives its power from the implication of surveillance by police. Perhaps a survey of motorists who had passed the sign would help to resolve this issue. In any case, such a survey might provide useful interpretations that could be tested in subsequent experiments.

The results of Experiment 2 demonstrated that the feedback sign can be effective in reducing speeding on a section of high speed divided highway with a constant speed limit. This study also provided some information on how far the effects of the sign can persist on this type of roadway.

The results of the last three studies examined the interaction of the feedback sign and three enforcement techniques. In the third experiment the efficacy of a stationary, marked, unmanned police car was compared to the feedback sign alone and the feedback sign and the unmanned police car together. Results indicated that the presence of the unmanned police car initially reduced speeding to a greater extent than did the feedback sign. Furthermore, the police car and feedback sign in combination were no more effective than the presence of the police car alone. The results also indicated that the effectiveness of the police vehicle gradually declined as the experiment progressed. Another interesting result of this experiment was the increase in the percentage of drivers traveling considerably below the speed limit when the police vehicle was present. Because the frequency of traffic accidents is a function of departure from mean speed, the presence of this effect is not desirable.

The results of Experiment 4 demonstrated that the effects of a police air patrol declined over time. This result parallels the gradual weakening of the parked patrol vehicle in Experiment 3. The combination of posted feedback and the air patrol condition was more effective than both the air patrol alone and feedback sign alone conditions near the end of the study.

The results of Experiment 5 demonstrated that a brief enforcement program that involved giving warning tickets and informational feedback produced a marked and sustained reduc-

tion in speeding where a traditional enforcement program did not. Further, the combination of the feedback sign and warning enforcement program produced such a marked reduction in speeding that serious speeding was almost completely suppressed. Therefore, communities wishing to decrease the level of speeding would be well advised to combine the feedback sign technology with the warning program in order to produce large and enduring speed reductions. It would then be feasible to deal more severely with the small percentage of motorists who did not respond to either the sign or the warning program.

This partial solution to the problem of speeding suggests a hierarchical community approach which might be successfully applied to solving other serious problems. The first step in such a program is to reduce the frequency of a problem behavior to manageable levels through the use of wide-reaching community interventions such as the use of the feedback sign. Once the incidence of the problem behavior is reduced in this way, emphasis is placed on developing solutions on a slightly more molecular level such as the warning enforcement program. Finally, when the number of remaining individuals decreases to manageable levels it is possible to apply one-on-one procedures such as speeding charges, point loss, license suspensions, and community service orders for speeding. One advantage of this approach is that only those drivers who do not respond to less severe measures are dealt with more severely.

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