EFFECTS OF INCREASED ENFORCEMENT AT URBAN INTERSECTIONS ON DRIVER BEHAVIOR AND SAFETY

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The study described in this paper was initiated in 1972 in an attempt to define the nature and magnitude of the effects on driver behavior and safety resulting from increased levels of enforcement of traffic laws. A major purpose of the study was to investigate the increased benefits to be obtained from higher enforcement levels to determine how police can be cost effectively employed. The results of the study indicated that visible police presence at an urban intersection can significantly reduce the incidence of traffic violations. This effect appeared to be restricted to the time of actual police presence; it disappeared almost immediately after the police left. Traffic conflicts were recorded as representing a measure of safety, but, although their effects were similar to those on violations, results were not judged significant. Based on effectiveness in reducing violations the most significant improvement occurred in employing a single policeman for a period of 1 h/day. Further increases in effort did not produce appreciable further improvement.

•ALTHOUGH the effects of enforcement practices on driver behavior have not been exhaustively researched, the literature contains many references to studies in this field. Most of the studies relate to speed control (4, 6). Unfortunately, many of the studies lacked adequate design or control, but an overall pattern of behavior can be deduced from them. In general, the evidence points to the ability of visible enforcement symbols, which are related in the driver's mind to punishment, to produce a temporary modification of driver behavior within a restricted distance or time frame.

In terms of safety benefits resulting from long-term application of enforcement practices, the situation also is not clear-cut. A number of studies have reported accident reductions over periods ranging from a few weeks to several years, but there is disagreement on the significance and nature of the effects achieved (6). Where accident reductions were reported, there was no real consistency about the relative effects of enforcement on severe and minor accidents except that in most cases a significant distinction between them was noted.

Very few of the past studies were oriented specifically toward assisting police forces in evaluating their enforcement programs and providing them with information that could be employed to increase their effectiveness. So, during the fall of 1972, the Road Safety Branch of the Canada Ministry of Transport conducted a research study to investigate the effects of increased enforcement on driver performance and safety to make recommendations on more efficient use of the police force.

DESIGN OF THE STUDY

The investigation was designed and conducted with the cooperation of the Toronto police force. Wherever possible, the major characteristics of the study were kept consistent with existing enforcement methods and practices.

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Police motorcycle officers were employed as the basic enforcement symbol; the number of officers stationed at an intersection at any given time was limited to a maximum of 2. The police were instructed to be highly visible at all times and to maintain their normal function of issuing warnings or tickets to offending drivers.

The 2 independent variables chosen for study were duration of enforcement (3 levels) and magnitude of effort (1 or 2 officers per location).

Seven intersections were chosen for observation in Toronto. Six were study locations, and 1 was a control location (Figure 1). Each study location received a different combination of duration and magnitude of enforcement. Each was signalized to make it easier to define vehicle maneuvers and violations, and each was chosen on the basis of similar characteristics including geometric design, traffic volume, number and type of traffic control devices, pedestrian flow, and environmental factors such as abutting land use. In addition, each intersection was studied in terms of the ratio of repeating (daily commuters) to nonrepeating drivers because it was considered that learned behavior might be involved. This ratio was the basis of the selection of the 7 locations. Levels of existing enforcement were noted and, in all cases, were found to be relatively inconsequential when compared with the higher levels contemplated for the study.

To select time durations for enforcement activity, we constructed a statistical model that considered various combinations of sampling schemes and traffic compositions. Analysis of this model led to the selection of time periods of 60, 120, and 180 min/day to represent a cost-benefit optimum based on efficiency of driver exposure to enforcement at the point where added returns became marginal. Through this same analysis, we determined that there should be 20 days of increased enforcement (4 weeks minus weekends). The study thus consisted of 2 weeks of base data collection under prestudy conditions, 4 weeks of increased enforcement levels, and 2 weeks when levels were reduced to their original state.

Enforcement schedules for each intersection were set up through consultation with the police. These schedules were designed to ensure that the total daily time spent at each intersection remained constant; the period of enforcement was changed systematically, however, so that all hours of major traffic flow were covered. Care was taken to ensure that police personnel were rotated among the various locations. Table 1 gives the enforcement schedule.

CONDUCT OF THE STUDY

To assess the possible effects of enforcement on driver behavior, we selected number and type of traffic violations as the dependent variables. We decided to record violations in the following categories: turns to or from the wrong lane, prohibited turns, failure to signal turns, and infractions at traffic signals. We based our decision on a previous Canada Ministry of Transport study in which violations at intersections were investigated and on an analysis of past accident records at the 7 study locations.

We also decided to record the number of traffic conflicts at each intersection. Conflicts have been researched widely in recent years and have been shown to be significantly related to traffic accidents. By considering conflicts, we eliminated the necessity for a long-term investigation because the frequency of conflicts is several thousand times that of accidents. A conflict was defined as any abnormal deceleration, lane change, or to avoid collision. Weave, left-turn, right-turn, cross-traffic and rear-end conflict categories were considered (Figure 2).

During the study a record of all violations, conflicts, and violations that directly resulted in conflicts was kept and summarized at hourly intervals. Traffic volumes also were monitored closely both as an exposure statistic that considered all traffic movements and as a check to ensure that prestudy travel patterns established by a preliminary license plate survey were not changing. A number of permanent, traffic-counting stations in the area proved useful in providing day-to-day traffic volume fluctuations.

The observers used in the study for counting traffic volumes, violations, and conflicts were given a comprehensive training course and some field practice to ensure

Figure 1. Study area and locations.

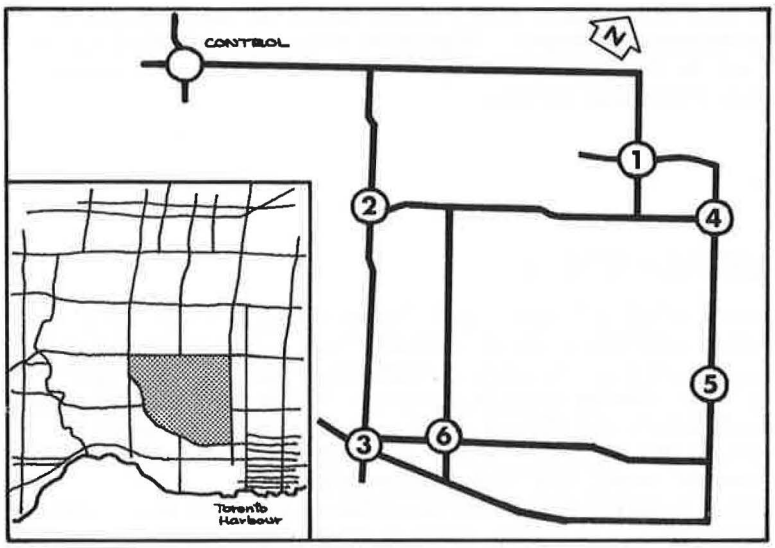
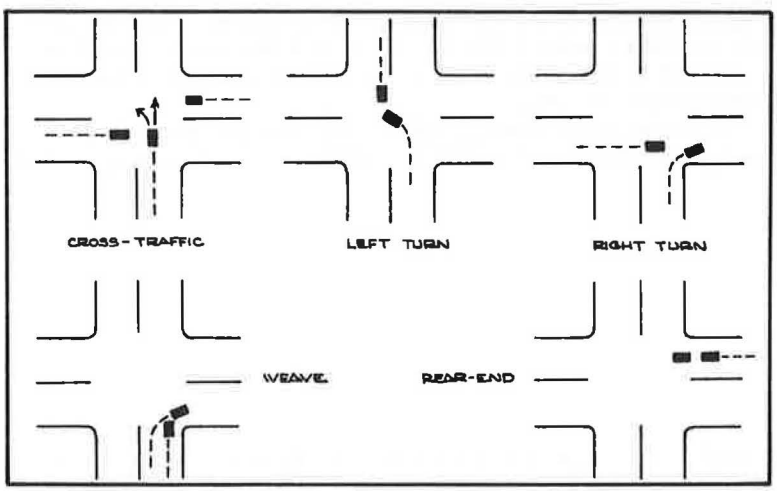


Table 1. Enforcement schedule.

Study Location	Number of Officers	Enforcement Duration (min/day)
1	1	60
2	1	120
3	1	180
4	2	60
5	2	120
6	2	180

Figure 2. Traffic conflict categories.



that they were familiar with the new concepts, especially that of conflicts, that were involved. Four observers were stationed at each intersection (1 for each approach) and all data were recorded on separate forms. Observers were supervised closely in the field and were rotated among the intersection approaches to minimize the effects of any systematic counting or recording errors.

RESULTS OF THE STUDY

Effects of Enforcement on Violation Behavior

Figure 3 shows the variation in total violations counted over the study period at 1 of the locations. Volume fluctuations over the same period are shown above the violation plot.

To discover what, if any, effect was produced by increased exposure to the enforcement symbol, we analyzed the results by through route at each intersection. This analysis indicated that those routes having the highest proportion of repeating drivers displayed the greatest reduction in violations during the enforcement phase. These routes were used in the data analysis to quantify the enforcement effects.

Because there was evidence from the literature that enforcement may have different effects on different classes of accident severity, the data collected were used to assess the probability of the arising of accidents and conflicts as a direct result of traffic violations. Details of this analysis can be found elsewhere (10). It was found that the violations monitored during the study could be classed as either hazardous or nonhazardous. Those of the latter type were turns to the wrong lane, prohibited turns, and failure to signal turns. Turns from the wrong lane and traffic signal infractions were shown to have a higher-than-chance probability of resulting in conflicts or accidents.

The number of violations occurring each day then were separated into these 2 groups and replotted so that possible reductions could be assessed in this new form. Figure 4 shows an example of this that is typical of the results obtained for all the locations because hazardous violations, when considered alone, were considerably less affected by increased enforcement than were total violations. Hence it can be surmised that, in this study at least, enforcement may have a more salutary effect on the less critical violations.

Although fewer violations occurred during the enforcement period, these decreases had to be tested for significance. An attempt to quantify in some manner the overall effects of the different levels of enforcement also had to be undertaken. This was difficult because a considerable variation occurred from day to day throughout the study. The effects of this natural fluctuation had to be separated from the changes occurring as a result of the introduction of enforcement.

To test for significance, we constructed a series of the differences among daily totals that covered the period of increased enforcement. This series can be represented by the following:

$$\Delta_{11} = Y_{1+1} - Y_1$$

$$\Delta_{12} = Y_{1+2} - Y_1$$

$$\Delta_{13} = Y_{1+3} - Y_1$$

and so on where Y_i = total number of violations occurring at an intersection on day i.

To test the null hypothesis that enforcement had no effect on violation rates, we calculated the limits of this series for each location and compared them with the values of differences between days before and after introducing enforcement by using a 95 percent level of confidence. Details of this test are discussed elsewhere (10). As we ex-

Figure 3. Typical pattern of violation occurrences.

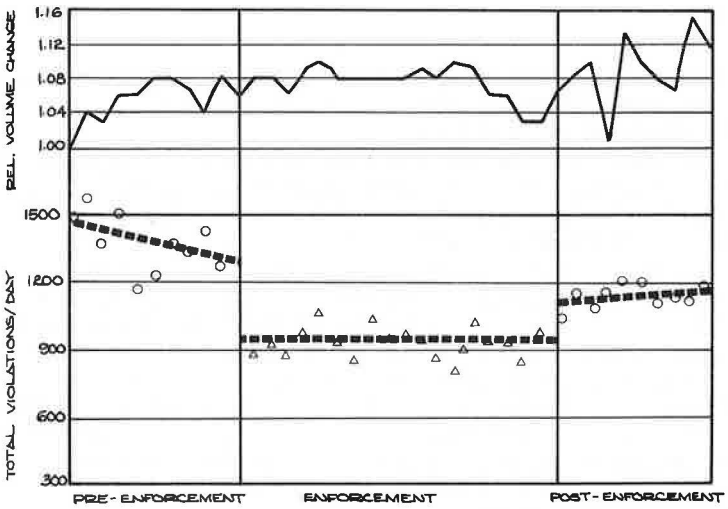


Figure 4. Effect of enforcement on hazardous violations.

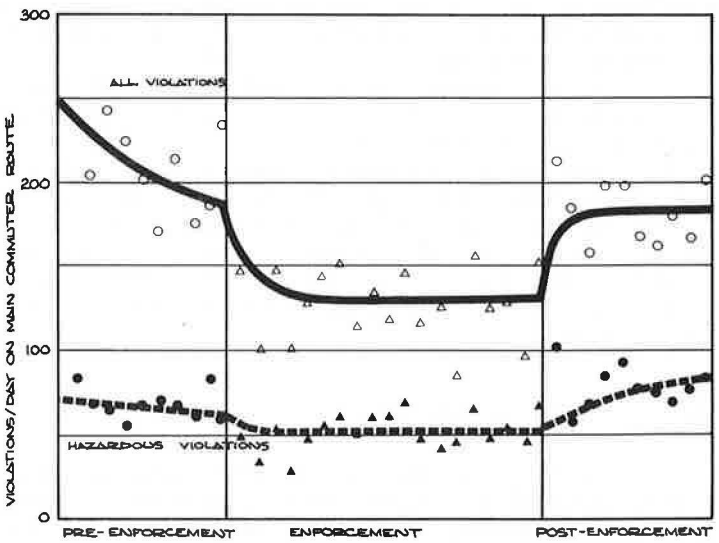
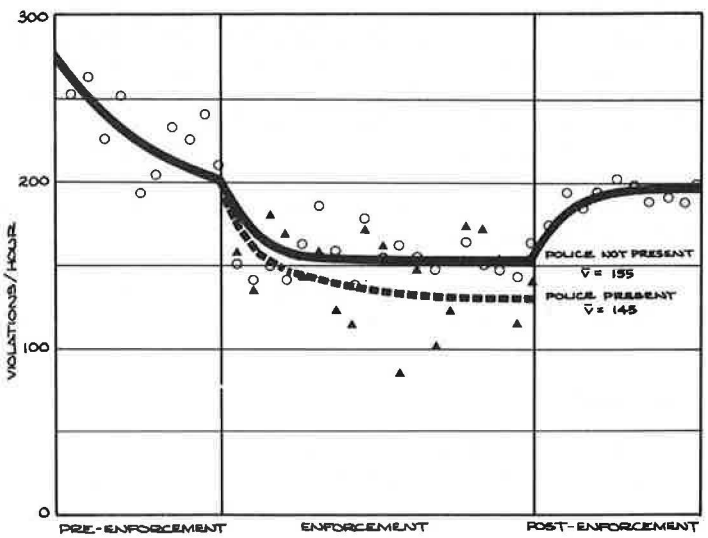


Figure 5. Effect of police presence on violation rate.



pected, the control location showed no change but of the 6 other study locations (where there was at least visual evidence of decreases) only 3 gave results that could be judged significant at the 0.05 level.

Similar tests also were run on the number of violations occurring after the extra enforcement was removed. Most locations showed an increase over the enforcement period but only 3 of the 6 proved significant. These 3 were, however, the same locations that had shown a significant decrease during enforcement.

Perhaps the most interesting observation concerns the nature of the decreases and subsequent increases in violation behavior. The changes appeared immediately on institution and relaxation of the enforcement effort and showed little or no transitional characteristics that would be typical of a learning process. This suggested that the phenomenon was an instinctive and immediate reaction to a visual symbol with no thought of long-term implications. To verify this we made a further separation within the data. Violations occurring during actual police presence were separated from violations occurring on the same day but when the police were absent. The figures were adjusted to a common base for comparison and plotted as shown in Figure 5. These plots show that the level of violation reduction was greater during actual police presence than when they were not there. Thus the hypothesis presented on the nature of driver reaction is strengthened. These differences were tested for significance by means of a t-test for paired samples. At half of the locations the difference between violation behavior with and without police presence was significant.

Although there appeared to be no descernible pattern in effects on different classes of violations, those of a hazardous nature were more often below average than above average in violation reduction.

To quantify those reductions that proved significant, we used regression analysis to fit curves to each of the 3 phases of the study. Best fit relationships were selected from among linear, polynomial, and power curves; the maximums and minimums were compared to establish the value of the reductions. Figure 6 shows these values as a function of level of police enforcement and indicates that, although an initial low-order level may produce significant improvement in driver behavior, subsequent increases may be of little additional value.

Effects of Enforcement on Safety

A serious problem was encountered in the attempt to relate enforcement increases to changes in recorded conflicts. Despite the training provided, observers took longer to attain a stable counting performance than the amount of time alloted. Thus, as shown in Figure 7, the initial tendency to drastically overcount during the first week of data collection produced a sharply decreasing trend that extended across the base-enforcement interface and had the effect of masking any possible decreases that would have been due to the police efforts. This occurred with violations but not to the same extent. We used the same procedure to test for significance as was employed with the violation data, and the results were, in most cases, negative. Two locations were marginal and possibly could be considered significant but this would be a presumption. In terms of conflict reduction during police presence versus conflict reduction when police were absent, the results were uniformly negative both visually and statistically. But when the data were reduced in this format, the graphs of conflict rates showed definite reductions and subsequent increases similar to those found in the case of violations (Figure 8).

A major influencing factor in considering the results of the conflict investigation is that numbers of conflicts, when compared to violations, are uniformly low and thus are greatly affected by extraneous factors such as counting variability.

CONCLUSIONS

The study indicated that increased enforcement may bring about a reduction in the number of violations committed by motorists. It also indicated that this reduction occurs

Figure 6. Effect of varying enforcement level on violation rate.

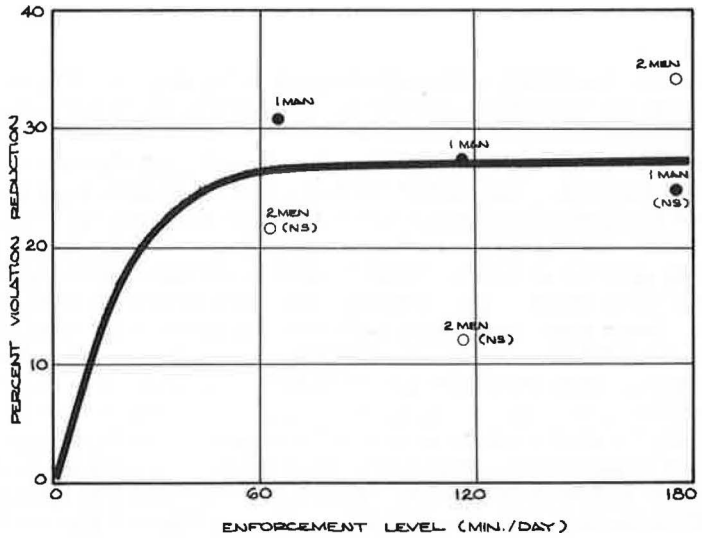


Figure 7. Typical pattern of conflict occurrences.

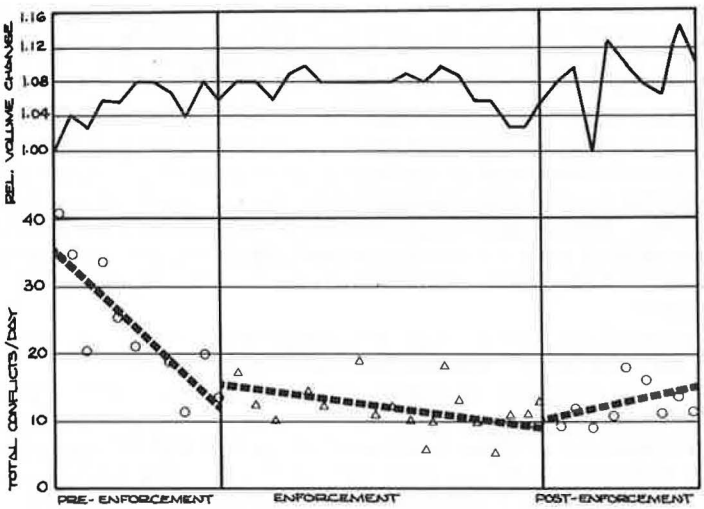
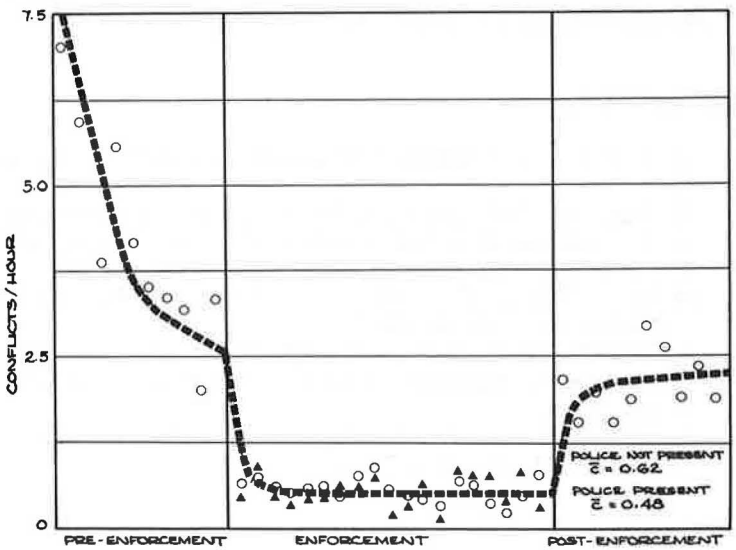


Figure 8. Effect of police presence on conflict rate.



almost immediately after enforcement is increased. The reduction seems to be related more to an instinctive reaction to visual evidence of enforcement than to a typical learning process.

Driver behavior tends to revert to its original characteristic after increased enforcement ends. The nature of this subsequent rise suggests that drivers quickly observe the lack of police presence and relapse to preenforcement violation behavior.

These conclusions are reinforced by the fact that adherence to traffic laws was higher during periods of police presence than when police were absent even though the program was still in effect. The intersections were not covered by police at the same times each day. Therefore, many motorists who did not commit violations while under police observation did so when their commuting schedule did not coincide with the enforcement schedule. This effect did not change significantly over the entire enforcement period. Therefore, no evidence of learning behavior could be found. In apparent contradiction to this, greater reductions generally occurred on the approach legs representing the higher proportion of repeaters. This might be explained by drivers' greater familiarity with the intersection and thus heightened sensitivity to change.

Enforcement did not uniformly influence driver behavior for all types of violations. The violations most affected were those that tend to be less hazardous possibly because the more severe or hazardous classes of violations are not as likely to be premeditated. For instance, a decision to run a red light or speed up to catch an amber signal may be a spur-of-the-moment decision influenced more by factors other than police presence. On the other hand, not signalling turns seems to be a characteristic of some motorists who, when they observe the police, realize the legal requirement and decide to use their indicator to be on the safe side.

The significant information that was obtained on the relative effects of different levels of enforcement on violation rates indicated that the returns to be expected in employing a saturation program may be marginal when compared to more modest procedures. Assigning 1 policeman to an intersection for 1 h/day produced a significant improvement over a no-enforcement situation, but increasing this coverage to 2 policemen for 3 h/day reduced violation occurrence only slightly above the first level of increase.

Although the conflict data did not produce significant results, trends in the data support the conclusions reached on violation behavior.

A number of factors undoubtedly combined to reduce the efficiency and enthusiasm of the traffic observers. Among these were adverse weather conditions and boredom. To a major extent these are unavoidable and will be encountered during any such study. What this does point up, however, is the problem associated with using human observers who are subject to psychological influences and performance decrements from a variety of uncontrollable factors. A study specifically designed to identify and quantify such effects might provide useful findings that could be applied to the results of many investigations involving human observation.

REFERENCES

1. P. J. Cooper. Predicting Intersection Accidents. Canada Ministry of Transport, 1973.
2. K. Hanawa. Relationship Between Accident Involvement Rate and Patrol Density. Rept., National Research Institute of Police Science, Vol. 13, No. 1, Tokyo, 1972.
3. A. D. Little. The State of the Art of Traffic Safety: A Critical Review and Analysis of the Technical Information on Factors Affecting Traffic Safety. Automobile Manufacturers Association, 1966.
4. T. Murata and M. Kobuyaski. Effects of Police Enforcement in Terms of Vehicle Speed. Rept., National Research Institute of Police Science, Vol. 13, No. 1, Tokyo, 1972.
5. R. Myrick and L. E. Schiesinger. Driver Improvement or System Improvement? Traffic Quarterly, Vol. 18, 1964.

6. The Effects of Enforcement of Legislation on Driver Behaviour and Traffic Accidents. Organization for Economic Cooperation and Development, Research Group S6, Paris, Interim Rept., 1973.
7. J. Slavin. Problems of Law Enforcement. Proc., 13th Annual Canadian Highway Safety Council Conference, Quebec City, May 1967.
8. Expert Group on Safety. The Road Accident Situation in Australia—A National Review. Canberra Act Australian Government Publishing Service, 1972, pp. 20-24.
9. The Police in Traffic Safety Work. Department of Traffic Safety, Institute of Transport Economy, Oslo, Norway, Research on Traffic Safety Information Leaflet 1, March 1973.
10. P. J. Cooper. Effectiveness of Traffic Law Enforcement. Canada Ministry of Transport, Aug. 1974.