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REVIEW OF RESEARCH EVIDENCE BEARING ON THE DESIRABILITY
OF USING RETROREFLECTIVE LICENSE PLATES IN MICHIGAN

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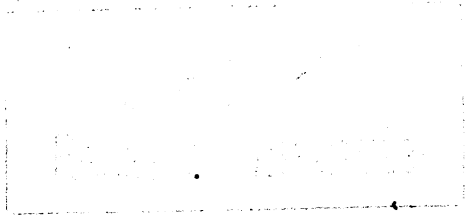
ABSTRACT

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This paper reviews research evidence concerning the safety benefits of retroreflective license plates. A substantial number of studies have been carried out to date. In almost all cases the results show reductions in nighttime crash rates with the use of retroreflective license plates. However, there are serious problems with many of these studies. The few which seem methodologically sound show small differences and, in one case, no differences at all.

A discussion is provided of the problems involved in experimentally demonstrating the value of retroreflective license plates in Michigan. Although the expected effect is small, it could still be cost-beneficial. However, to conduct a really adequate study would require a sample of vehicles much larger than used in any controlled study reported to date.



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INTRODUCTION

This review shall be concerned primarily with two questions:

1. Of what value are retroreflective license plates?
2. What would be required to demonstrate their safety potential (assuming the available evidence is not conclusive)?

At the start it is important to point out that there are two recent, comprehensive reviews of this subject matter written by highly qualified individuals (Cook, 1975; Hulbert and Burg, 1975). It would be pointless to duplicate these efforts. Rather this paper shall briefly review the available material pertaining to the points mentioned above with particular emphasis to the situation in Michigan, where such a distinction seems pertinent. Persons interested in a more complete discussion may wish to consult the documents referenced.

DEFINITION

The term "reflectorized license plate" although in common use, is a misnomer. The proper term is "retroreflective." All objects reflect light to a greater or lesser extent. A retroreflector appears much brighter than a conventional surface because it has optical properties which cause most of the light impinging upon it to be reflected back toward the source. Thus the observer's eye must be close to the source for the retroreflective object to appear bright. The angular separation between a driver's eyes and the headlamps is small enough so that retroreflectors are quite effective at reasonable distances. For an observer not in a car, a retroreflective plate would appear no different than a normal plate, unless it is viewed with a flashlight held close to the eye, or some such arrangement. This is an important point, since, as will be noted, improved legibility is an argument used for retroreflective plates. This "improved

legibility" applies only for favorable viewing conditions (normally from a car).

CLAIMED ADVANTAGES OF RETROREFLECTIVE PLATES

A substantial number of arguments have been raised to support the use of retroreflective license plates. Since the license plate functions as an additional marker on the car if it is given a retroreflective treatment, most of these points are visibility (hence safety) related.

1. It improves the likelihood that a car will be seen by an approaching driver. If the normal vehicle lights are on and operating properly, this is a dubious argument. If the lights are not operating for some reason or are very dim due to internal dirt accumulation or electrical problems, then the plate may significantly improve the likelihood of the vehicle being seen or the distance at which it is seen.
2. It aids in identifying the orientation of vehicles having a light or lights inoperative on one side.
3. It aids in making judgments of separation distance. This argument was advanced by Cook (1975). In the opinion of the present authors, it is a questionable point. The apparent size of a retroreflective plate depends on its luminance, which depends in turn on the aim and intensity of the lamps being used by the approaching car and the reflective efficiency of the plate itself (which can be markedly affected by dirt or damage to its surface).
4. It is a back-up vehicle marker which is less easily damaged than the standard retroreflectors and is regularly renewed.
5. It improves the legibility of the license plate. This is a valid argument. If the plate is clean and in good shape, legibility of both the front and rear plates will be dramatically improved over a non-retroreflective plate. However, in Michigan, which uses retroreflective legends,

the improvement would be minimal. It is a matter of comparing the legibility of a white legend (as in Michigan) to a black legend as would be the case if fully retro-reflective plates were adopted. Recent research (Olson and Bernstein, 1977) suggests there is no difference in legibility when both are in good condition. However, the exposed bead system used in Michigan is harder to keep clean than enclosed lens materials which might be used in a fully retroreflective system, so a greater reduction in legend reflectivity over time could be expected, together with a reduction in legibility.

SAFETY

Accident Studies. The key selling point for reflectorized plates is safety. If they are at all effective as a safety measure they should produce a decrease in accidents. This has been a point of principle concern, in part perhaps because the safety benefits, if any, are more readily quantified than some other benefits.

A substantial number of studies have been reported which have sought to demonstrate changes in accident rates associated with the use of retroreflective license plates. These shall now be briefly reviewed.

Minnesota (Baerwald, Karmeier, and Herrington, 1960)

This study compared accident data for 1955, which was prior to the introduction of retroreflective license plates, and 1957, after they had come into use. In general, it was found that various classes of accidents increased during the day and decreased during the night. While these trends are consistent with what would be expected if retroreflective plates are beneficial, the "before and after" design used confounds the variable of interest with any other changes which may have occurred in the same time period.

Maine (Maine State Police, 1963)

This study compared accident data for 1945-49, which was prior to the introduction of retroreflective license plates and 1950-63, after they had come into use. On the average, rural collisions with parked vehicles declined by nearly 60% in the years after the retroreflective plates had been introduced. All other categories of rural accidents increased by an average of more than 100%.

Like the Minnesota study, this was a "before and after" design and the same cautions apply to interpretation of the results.

Iowa, Polk County (Iowa Department of Public Safety, 1960)

This study involved about 100,000 vehicles in 1959. A total of 60,000 retroreflective plates were issued to the first persons to apply that year. The rest of the county residents received normal plates. The data indicate that the population of vehicles with retroreflective plates were struck far less often while parked at night than vehicles with regular plates. The discrepancy was greater for unlighted areas, although the number involved is quite small.

Again, the data support the use of retroreflective plates, but in this case there is a question as to whether early license plate applicants are similar to those who apply later. If not, then the issue is the extent to which the results reflect group differences.

North Carolina (Campbell and Rouse, 1968)

This study compared the accident experience of cars with and without retroreflective license plates for a six week period in early 1967 while both types were on the road during the annual change. The data indicate a relatively modest change in rear end collisions favoring cars with retroreflective license plates. The difference was statistically significant.

Given the difficulties under which this study was carried out (short time period, limited sample) it was well done. It does suffer from the problem of early and late applicants which plagued the Polk

County effort. The authors noted that other collision categories did not change in comparing the two groups, which may indicate that "safety consciousness" on the part of the early license applicants was not a factor. More than any earlier study, this one suggests that the safety claims of retroreflective license plate advocates may be real.

Virginia (Stoke, 1974)

In this study 200,000 vehicles were involved for a period of 13 months. Half were issued retroreflective plates, half regular plates. Care was taken to try to make the distribution truly random. In the test period 497 of the non-retroreflective vehicles and 475 of the retroreflective vehicles were struck in the rear at night. While the difference is in a direction favoring retroreflective plates, it is not large enough to be "statistically significant."

The Virginia study has been criticized on at least two occasions (Kleinknecht and Hicks, 1975; Ericson, 1976). The thrust of each of these critical reviews was to the effect that the Virginia study lacked statistical "power." A brief explanation of this concept is in order.

Inferential statistics, as used by Stoke for example, are a tool which allow the investigator to make a statement concerning the probability that an observed difference could have come about purely by chance. If the probability is small enough (normally 0.05 or 0.01 are used) the difference is said to be "statistically significant." If the probability is too high to permit a judgment of "statistically significant" then a problem arises. Clearly, it is possible for two conditions to differ, but a study, through poor design or whatever, may fail to demonstrate statistically acceptable levels. The probability of two or more conditions actually being different and producing statistically acceptable differences is known as "power." The power levels in the Virginia study are quite low, about 0.16. Phrased another way, the probability of real differences of the size noted being judged significant in the Virginia study was 0.16, or about 1 in 6.

Australia (Australian Road Federation, 1972)

This report contains brief mention of accident statistics from Tasmania for the years 1969-70, prior to, and 1970-72, subsequent to the introduction of retroreflective license plates. While vehicle registration increased from about 156,000 to 171,000 in that period, accidents declined from 1,413 to 1,371, an effective improvement of 13.4%.

The Tasmania data, like those from some other studies cited, represent raw accident data which did not result from a planned investigation. It is a "before and after" situation and suffers from lack of control over other events which may have influenced the accident rate.

Australian Capital Territory (Vaughan and Wood, 1975)

Retroreflective license plates were introduced into the Australian Capital Territory starting in September, 1968. Due to the vehicle licensing system used there, the transition period until all cars were so equipped was nearly a year. The investigators used the same logic as the North Carolina study. It was found that the number of instances where cars without retroreflective plates struck cars with the retroreflective plates was virtually identical to the number of instances where both the striking and struck vehicles had retroreflective plates (175 and 174 respectively).

Although the sample of vehicles is fairly small, this study was carefully done and, together with the North Carolina and Virginia studies, probably provides the best available data as to the value of retroreflective license plates.

Conclusions from Accident Studies. Clearly, a substantial effort has gone into evaluating the safety benefits of retroreflective license plates. Three main points should be noted:

1. Most studies show differences in accident rates consistent with the hypothesis that retroreflective license

plates are a significant safety item. In some instances the differences in accident rates are very large indeed.

2. In general, the studies which had the more rigorous experimental controls report the smallest differences and, in one instance, no difference at all. This suggests (but does not prove) that the methods of some of the earlier studies were seriously flawed and the results, as a consequence, wrong or at least optimistic.
3. Despite the effort expended and the relatively consistent results, the issue cannot fairly be described as settled. Proponents of retroreflective license plates are fond of pointing to the many studies available and the generally consistent direction of the results. However, one cannot draw conclusions from bad research. In the opinion of the present authors, there are only three studies which used reasonably sound procedures (North Carolina, Virginia, and the Australian Capital Territory). One of these shows a modest difference that is statistically significant favoring retroreflective license plates, another shows a similarly modest difference that is not statistically significant, and the third shows no differences.

REQUIREMENTS FOR DEMONSTRATING THE VALUE OF RETROREFLECTIVE LICENSE PLATES.

If it is agreed that the present data are not entirely satisfactory to justify the use of retroreflective license plates as a cost-beneficial safety measure, the question then becomes one of deciding what sort of investigation would be required to provide adequate data.

There are two questions which must be addressed in this regard:

1. What are the expected benefits?

- a. Frequency of accidents in categories likely to be affected by the use of retroreflective license plates.
 - b. Size of reduction in accident rate required for the treatment to be cost-beneficial.
2. How large a study is required to demonstrate significant differences at the cost-beneficial level while maintaining adequate statistical power?

These points will now be considered in somewhat greater detail.

Expected Benefits of Retroreflective License Plates

Although retroreflective license plates may be of occasional benefit in instances where vehicles are in motion, it seems clear that the largest single category of accidents likely to be affected by their use is nighttime collisions with parked cars. In the 1975 Michigan Traffic Accident Facts, collisions with parked motor vehicles are one of the largest categories listed, more than 38,000 incidents, about 11% of the total. However, the Michigan statistics (as well as those compiled by the National Safety Council) do not provide a day-night breakdown. Some efforts have been made to estimate the day-night split. One such study analyzed 890 parked car crashes in Washtenaw County, Michigan in the period from 1968 to 1971 (Mortimer and Post, 1972). Slightly over half occurred at night. If these data can be generalized to the entire state, the population of accidents most likely to be affected by the introduction of reflectorized license plate accounts for 5-6% of the total, or about 20,000 cases annually.

At this point even rough statistics must give way to speculation. Obviously, not all nighttime collisions with parked cars are attributable to "failure to see," and not all of those which are, would be prevented by the addition of another retroreflector (most cars have retroreflectors). For purpose of illustration, assume that the class "preventable with use of retroreflective license plates" accounts for 10% of nighttime collisions with parked cars. For Michigan, this is

about 2,000 accidents, 2 deaths and 300 injuries annually. Given the relatively low cost of introducing reflectorized plates, they may well be cost-beneficial at these levels. However, this judgment requires a rather careful analysis.

Required Study Size. Unfortunately, the smaller the change one seeks to document experimentally, the larger the required research effort. The problem can reach the point where the study is so costly, that it too should be considered in the cost-benefit calculations. The authors are not suggesting that this case necessarily pertains here, but, as shall be indicated shortly, a very large experimental effort is indicated.

There is a further complication applicable to the Michigan situation. The studies which have been reported to date have compared fully retroreflective with non-retroreflective plates. Michigan uses a process where the legend and border of the plate are retroreflective. The benefits of retroreflective treatment may be linearly related to the extent of retroreflection, or they may not, but the fact that a study conducted in Michigan would be seeking to compare full benefits with whatever partial benefits are now provided would make it even more difficult to demonstrate the value of the various options.

Once a decision has been made concerning the size of the reduction in accident rates required for the treatment to be acceptable, it is possible to approximate the size of the sample required to meet the dual criteria of demonstrating statistical significance while maintaining reasonable power levels. Not knowing what the minimum change in accident rates deemed acceptable will turn out to be makes it impossible to specify at this time the size of study required. For purposes of illustration however, assume that a change like that found in Virginia is of interest. Based on their data it appears that about 1.7 million cars would be required in both experimental and control groups to achieve a power level of 0.90; a total experimental example of 3.4 million vehicles. The study would involve over half of the 6 million vehicles registered in Michigan. Clearly, this would be a

very expensive study to carry out. And, even at this level of effort, it can fairly be predicted that critics will remain and, at least for some persons, the issue will still be clouded.

CONCLUSIONS

A substantial amount of research work has been carried out which makes it appear that retroreflective license plates may be an effective way to reduce certain types of accidents. However, it also appears that the gains to be expected through the use of retroreflective license plates are very modest relative to the total problem of traffic accidents. If the expected gains are small, the problem of demonstrating them experimentally is formidable. Given the problems of using an accident criterion, it would be very difficult and expensive to carry out a study which will satisfy all or even most critics. However, if benefits cannot be unequivocally established, cost-benefits remain tenuous and debatable. This is the situation we are in today with regard to retroreflective license plates. It is a dilemma from which no easy escape seems possible.

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