

## EFFECTS OF MOTORCYCLE AND MOTORCYCLIST'S CONSPICUITY ON DRIVER BEHAVIOR

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Motorcycles have become a popular form of transportation in the United States. Since 1961, motorcycle registrations have increased at nearly four times the rate of all other vehicles. In 1977, motorcycle registrations in this country passed five million. In the same year about 500,000 motorcycles were involved in accidents, resulting in about 4,000 deaths and 400,000 injuries (1).

Motorcycles offer much less protection to their riders than do automobiles. As a result, when a collision occurs, the motorcyclist is far more likely to suffer injury. Unfortunately, barring major changes to the vehicle itself, this problem cannot be easily solved. Thus, the principal means of improving motorcycle safety seems to be reducing the incidence of crashes.

Motorcycle accident data offer some insights into how motorcycle safety might be improved. In a review of these data (2) the authors point out that motorcycle accidents are characterized by a substantial over-representation of a type of crash in which a straight-traveling motorcycle runs into a car attempting to cross its path. This information, combined with reports from motorcyclists and law enforcement officials, has led to an assumption that motorcycles are not sufficiently conspicuous.

The conspicuity hypothesis has resulted in a number of studies seeking ways to improve motorcycle/motorcyclist conspicuity. A review of this work is provided in (2). Many of the techniques suggested were included in the current investigation.

## METHOD

### Introduction

The purpose of this study was to determine whether the conspicuity of motorcycles/motorcyclists could be improved to reduce multivehicle motorcycle crashes. Various conspicuity-increasing treatments were fabricated and tested, using a realistic driving situation and measuring the response of naive drivers.

### Dependent Variable

A gap acceptance measure was employed in this investigation. A typical situation and the terminology used are shown in Figure 1. The method requires creating a gap in the traffic stream between one or more lead vehicles and a test vehicle. The driver of the subject vehicle may "accept" the gap—that is, merge with or cross the traffic stream—or "reject" the gap (remain stopped). The assumption is that changing the conspicuity of the motorcycle and/or motorcyclist will modify the behavior of other motorists in a way which will reduce the likelihood of short gaps being accepted.

Note that both the lead and subject vehicles in this study were part of the normal traffic at the test site. Their drivers did not know they were participating in a test.

### Equipment

The required data were the gap size (in time),

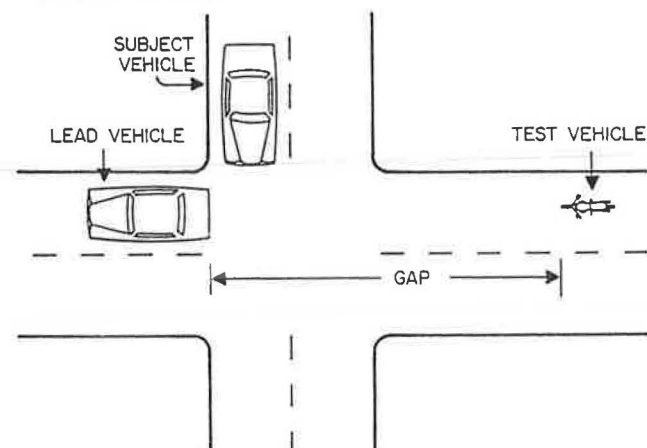
whether the subject vehicle accepted or rejected the gap, and the type of maneuver the subject driver executed or planned to execute. A simple instrumentation package was developed which was carried on the back of the motorcycle. It provided a continuous record of time, distance (wheel revolutions), and speed. The motorcyclist coded other required information by pressing buttons which were positioned conveniently on the handlebars.

### Test Treatments

The following daytime treatments were evaluated:

1. Car control. A 1969 Maroon Plymouth station wagon was used.
2. Motorcycle control. A normal motorcycle with no lights was used. The driver wore dark clothing and either a white or dark colored helmet.
3. Orange fluorescent fairing. The bike was equipped with a fairing to increase the frontal area. An orange fluorescent fabric was stretched over the entire fairing, including the headlight aperture.
4. Green fluorescent fairing. Same as item 3, except for the color of the fabric.
5. Headlamp on. The bike ran with low beam on.
6. Modulating headlamp. The high-beam filament was modulated from low to full intensity at about 3 Hz. Low beam filament was off.
7. Reduced brightness headlamp. A neutral density filter reduced the intensity of the low beam to one-tenth normal.
8. Orange fluorescent outfit. The same material as used in treatment 3 was made into a vest and helmet cover to be worn by the rider.

FIGURE 1: Schematic of typical gap situation employed in test.



9. Green fluorescent outfit. Same as treatment 8, using the green material.

10. Orange vest. Just the vest from treatment 8 was used.

11. Orange cap. Just the helmet cover from treatment 8 was used.

The following night treatments were evaluated (note that low-beam headlamps were used in all cases):

1. Car control. The same vehicle was used as in the day condition.

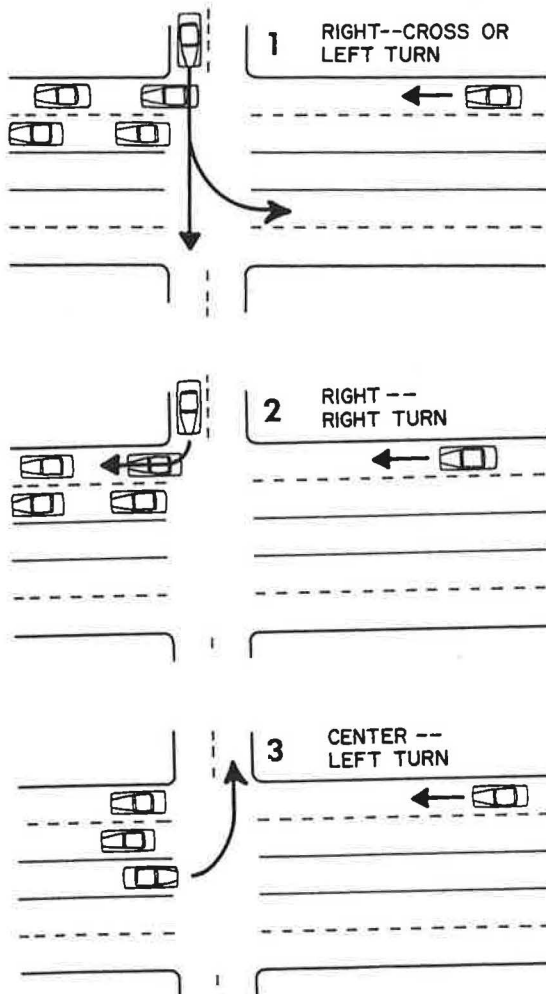
2. Motorcycle control. This was the same bike as was used in the day condition.

3. Retroreflective fairing. The fairing was covered with a retroreflective fabric, leaving the headlamp aperture open.

4. Retroreflective outfit. The same material described in treatment 3 was used to make a vest and helmet cover.

5. Running lights. The turn signal lamps were on full-time (not flashing).

FIGURE 2: Schematics of the three maneuvers investigated.



## Maneuvers

Measurements were taken on three maneuvers. These are shown schematically in Figure 2. Note that only maneuvers 1 and 3 show up as particularly troublesome in the accident data literature (2). Data were taken on the "right--right turn" maneuver because it could not be separated before the fact from the "right--cross or left turn" maneuver.

## Test Site

A site was sought which had a high volume of vehicles attempting the maneuvers of interest. A reasonable volume of parallel traffic was required as well to provide lead vehicles for the front end of the gap. The site used for the day data collection was a major thoroughfare near the city of Ann Arbor, Michigan. The street is five lanes wide (center lane for left turns) and lined for most of its length with various small businesses. Speed limits were 70 km/h for most of its length, 55 km/h for the rest. There were three stop lights in the 6.5 km test section.

Most night data were collected during the winter months in the city of Gainesville, Florida. A major thoroughfare having many of the characteristics of the northern site was used. Data taken on the same configurations at both sites did not differ statistically.

## RESULTS

### Daytime Treatments

"Right--cross or left turn." Figure 3 shows the results of the daytime treatments for this maneuver. The figure shows the percent of gaps of three seconds or less which were rejected for the control motorcycle (dark vertical bar) as compared with all of the various treatments. For example, in this instance for the control motorcycle, 94% of those short gaps were rejected. Anything which appears to the right of the control motorcycle bar constitutes an improvement. In the case of this maneuver, all of the tested treatments and the car control were better than the control motorcycle, many of them significantly better (statistical significance is shown by the small numbers on the right ends of the bars; 01 means 0.01, and 05 means .05).

"Center--left turn." Figure 4 shows the same combination of treatments for this maneuver. In

FIGURE 3: Daytime Treatment: Right--cross or left turn: Percent of gaps of 3 seconds or less rejected.

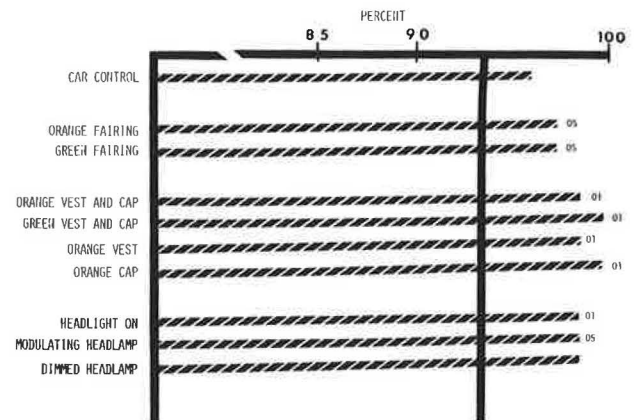
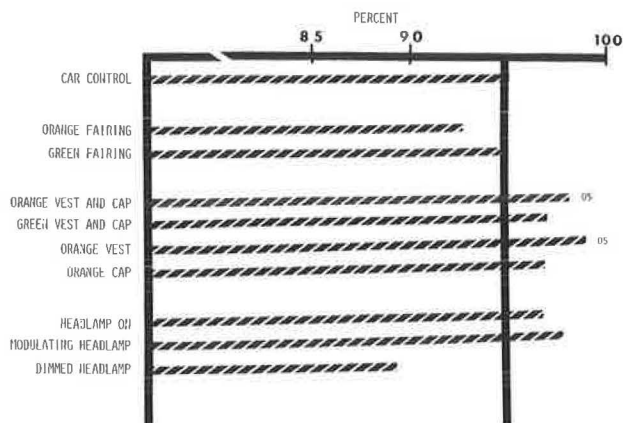


FIGURE 4: Daytime Treatments: Right--right turn: Percent of gaps of 3 seconds or less rejected.



this case, 95% of the short gaps were rejected for the control motorcycle. However, the picture for the various conspicuity treatments is somewhat different for this maneuver than for the "right--cross or left turn." Only the orange fluorescent fabrics worn by the rider appear to be significantly better than the control motorcycle. None of the lighting treatments differ significantly from the control, although the modulating headlamp is just short of significance at the 0.05 level.

"Right--right turn." Figure 5 shows the same treatment combinations for this maneuver. It will be immediately apparent that there is a rather substantial change in the situation confronted by the rider of the control motorcycle, in that 98% of the short gaps were rejected. Because of this, there was little room for improvement, and none of the tested conditions are significantly better than the control motorcycle.

It will note that the right--right turn maneuver does not show up as particularly dangerous in the accident statistics. The explanation may be indicated by the findings of this study, which indicate that potentially encroaching drivers are somewhat more conservative, i.e., more reluctant to accept a short gap, when making a right--right turn maneuver.

#### Nighttime Treatment

"Right--cross or left turn." Figure 6 summarizes the results for this maneuver at night. None of the differences are significant, although the running lights condition approaches significance at the 0.05 level. While a reflective fairing seems to be equally effective in terms of percent gaps rejected, this percentage is based on a relatively small number of cases and hence is not significant. It should be noted that, because of the initial right-angle orientation of the test motorcycle and subject vehicle, the use of retroreflective treatments would not be expected to be effective.

"Center--left turn." Figure 7 summarizes the results of this maneuver at night. The probability of short gaps being rejected for the control motorcycle drops to .92 in this instance, and both the car control and the two retroreflective treatments show significant improvements.

Because the two vehicles are initially facing towards one another, this is the only one of the three maneuvers where the retroreflective treat-

FIGURE 5: Daytime Treatments: Right--right turn: Percent of gaps of 3 seconds or less rejected.

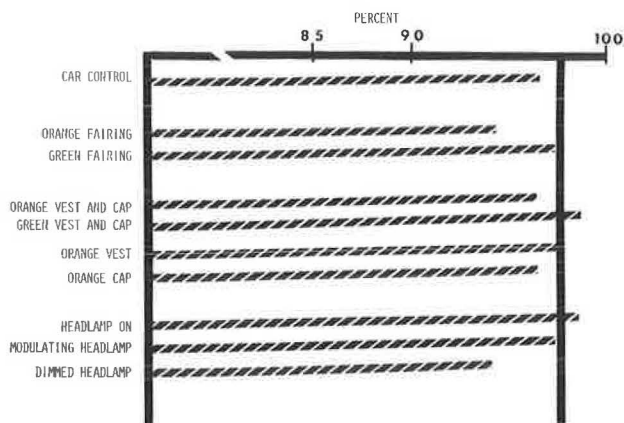
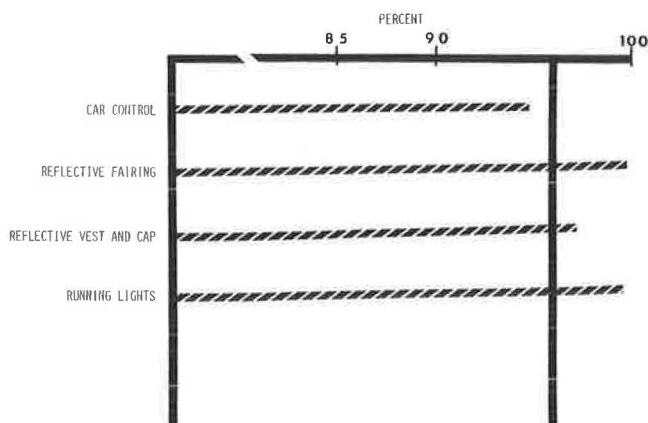


FIGURE 6: Nighttime Treatments: Right--right turn: Percent of gaps 3 seconds or less rejected.



ments would be expected to show any measurable effect.

"Right--right turn." Figure 8 summarizes the results for this maneuver at night. The car control is significantly better than the motorcycle at the 0.01 level. The reflective fairing shows a marginally significant difference, but the initial orientation of the vehicle is such that differences would not be expected. Hence, the difference is probably spurious. The running lights and reflective vest and cap do not show significant differences in comparison to the motorcycle control.

#### DISCUSSION

##### Methodology

In general, the gap-acceptance procedure was quite successful in the current application. The data seem meaningful (i.e., intuitively related to the likelihood of accidents) and can be collected quickly, economically, and with relatively simple instrumentation.

This experience suggests that approximately one thousand data points are required per treatment to ensure reliable results. This assumes approximately equal distribution across three maneuvers, or about 300-350 data points per maneuver. It further assumes that the data are

FIGURE 7: Nighttime Treatments: Center--left turn:  
Percent of gaps of 3 seconds or less rejected.

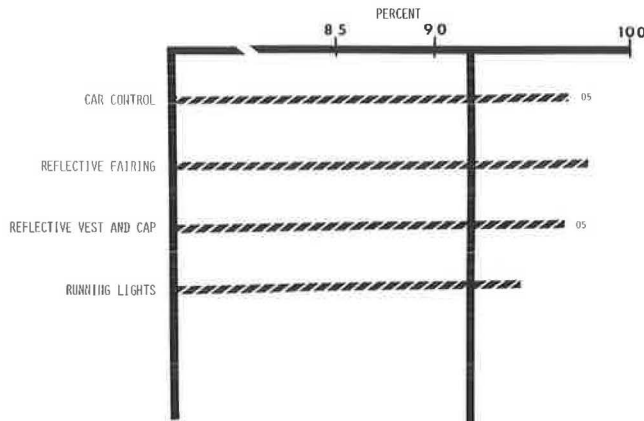
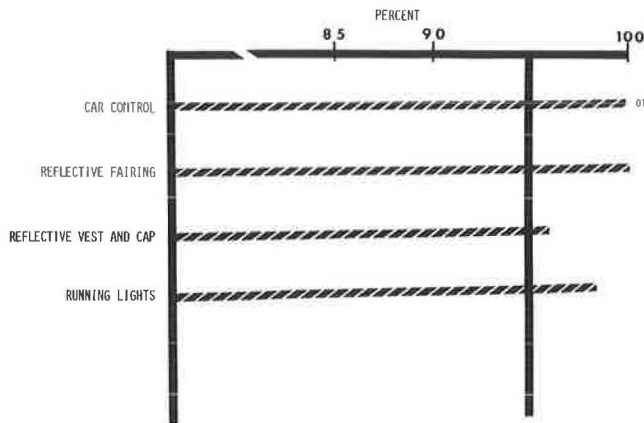


FIGURE 8: Nighttime Treatments: Right--right turn:  
Percent of gaps of 3 seconds or less rejected.



concentrated in the short gap region, i.e., below a gap-acceptance probability of 0.5.

Two points should be made regarding the validity of the gap-acceptance method in this application. First, the relationship of gap acceptance and accidents is largely unknown at this time. Riding with headlights on seems to be an effective accident countermeasure, as was noted in the literature review section. That the headlamp-on treatment was effective as measured by gap-acceptance in this study is encouraging evidence of validity. However, further validation data would be desirable.

The second point concerns a limitation of the method. It can measure only a fairly general response characteristic of automobile drivers. The fact that differences were found in this study does not mean that other, less general, responses cannot account for a significant portion of the problem. If this is the case, different countermeasures may be appropriate.

Finally, a word about safety. The investigators were very concerned about safety since our riders were being asked to deliberately recreate pre-crash configurations known to be overrepresented in the crash statistics. It was hoped that

the high level of attention required to be able to take data would reduce the risk. In the more than 20,000 miles accumulated during the tests, the riders experienced one minor crash and a few near misses. Interestingly, none of these occurred while collecting data, but all involved pre-crash configurations of the classic type described earlier in this paper. Based on this experience, the method seems to pose no special dangers to the motorcycle riders.

#### Means for Improving Conspicuity

It appears that there are a number of ways to improve daytime motorcycle/motorcyclist conspicuity that should have a meaningful effect on the behavior of car drivers. The simplest is to drive with the headlamp on at all times. The modulating headlamp may be somewhat more effective, but does require some investment on the part of the motorcyclist. High-visibility materials seem quite effective as well, but work better when worn by the rider than when fitted to the bike.

The latter finding is somewhat surprising. In the opinion of the investigators, the fluorescent fairing treatment was a more effective attention getter than the fluorescent vest or helmet cover. Yet the field test data indicate the opposite. This suggests that laboratory studies of motorcycle conspicuity can produce misleading results. However, it is not clear why the results came about. One possible explanation is that effectiveness is improved by height. Another is that by emphasizing the rider, speed-spacing judgments are facilitated. This might happen because apparent size is an important distance cue. However, it is based on knowledge of actual size. Most drivers know less about the size of motorcycles, especially motorcycle fairings, than they do about people.

For nighttime riding conditions there may be value in wearing retroreflective garments and using running lights. Retroreflective treatments applied to the bike seem less effective, but may be of help. There are combination fluorescent/retroreflective materials available which can provide day and night conspicuity in one package. It is also possible to treat ordinary fabric with beads and make it retroreflective without changing its appearance under normal viewing conditions. This may have potential for other vehicles with conspicuity problems as well.

#### ACKNOWLEDGMENTS

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