EFFECT OF DAYTIME USE OF MOTORCYCLE HEADLIGHTS AND TAILLIGHTS ON MOTORCYCLE NOTICEABILITY

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This paper describes a series of motorcycle noticeability experiments conducted by the Franklin Institute Research Laboratories as part of a study for the National Highway Safety Bureau to determine the effectiveness of using motorcycle headlights and taillights in the daytime for improving motorcycle noticeability. Four front- and three rear-light experiments were conducted. The front-light experiments evaluated motorcycle headlights, both high and low beam, and amber running lights under different and representative traffic conditions. Other stratifications included weather, color of helmet, and number of lanes separating opposing traffic. The rear-light experiments evaluated strandard motorcycle taillight and brake light, raised high-intensity taillight with contrasting background, and dual raised red and amber taillights for two different traffic situations. The results of these experiments indicate that daytime use of motorcycle headlights significantly increases noticeability of the motorcycle by other motorists. However, the relative effectiveness of the headlight is substantially greater in cloudy weather than in clear weather. Use of front amber running lights increases noticeability about half as much as the headlight. The rear-light experiments indicate that red motorcycle taillights, even when modified by intensity, number of lights, mounting height, and contrasting background, do not significantly increase motorcycle noticeability during the daytime. However, dual amber taillights were found to improve noticeability similar to the front running lights.

•THE Franklin Institute Research Laboratories recently completed a study for the National Highway Safety Bureau to determine the efficacy of using motorcycle headlights and taillights during daylight hours as a crash-avoidance technique (1). Two objectives of this study were (a) to determine whether the daytime use of motorcycle headlights and taillights makes drivers of other vehicles more aware of the presence of a motorcycle and (b) to identify those motorcycle lighting parameters such as intensity, color, location, number of lights, and contrast that significantly influence the detectability of the motorcycle by other motorists during the day.

A number of researchers (2 through 6) have found that daytime use of headlights or running lights reduces motor vehicle accidents, increases the perceptibility of motor vehicles, and improves lane position. However, these studies did not consider motorcycles. A survey conducted in Wisconsin (7) indicated that daytime use of motorcycle headlights helped motorists to see motorcyclists better in both urban and rural traffic. Other studies (8 through 17) have suggested that present motor vehicle taillight systems are probably inadequate and that different taillight configurations may be required to increase vehicle noticeability.

Analysis of motorcycle accident data found in the literature has also shown the following:

1. The majority of motorcycle accidents occur in urban areas;
2. Most motorcycle accidents take place at intersections;
3. About 65 to 75 percent of the motorcycle accidents take place in daylight hours;

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4. Collision with other motor vehicles is the predominant type of motorcycle accident;
5. The most common types of motorcycle accidents involving another vehicle are angle and turning collisions at an intersection; and
6. Other important types of motorcycle accidents involving another vehicle are those with vehicles traveling in opposite directions, both moving; in the same direction, both moving; with one vehicle parked or stopped; and with one vehicle entering or leaving an alley or driveway (18 through 26).

These findings were verified through a detailed analysis of motorcycle accident data in four states with daytime motorcycle headlight laws and four control states that did not have daytime headlight laws (1).

The design of the motorcycle noticeability experiments and the selection of the motorcycle lighting and traffic conditions studied was guided by the results of the literature review and the analysis of state accident data described.

Two sets of motorcycle noticeability experiments were conducted during the fall of 1969 and the spring of 1970. They included front-light experiments and rear-light experiments. A description of each of these sets of experiments follows.

FRONT-LIGHT EXPERIMENTS

Four experiments were designed to evaluate the effectiveness of motorcycle headlights and front running lights in increasing the noticeability of motorcycles during daylight hours. The placement of the motorcycle and the choice of motorists questioned were determined by the following preselected traffic conditions: (a) opposite direction, both vehicles moving; (b) angle, right turn (at intersection); and (c) opposite direction, one vehicle turning left and one traveling straight (at intersection). Conditions (b) and (c) are related to the most frequent types of motorcycle accidents.

Motorcycle lighting conditions included high- and low-beam headlight and amber running lights. Other stratifications included weather, color of helmet, and number of lanes separating opposing traffic.

Experiments were run in the fall of 1969 and in the spring of 1970. An experienced, helmeted motorcycle driver was used at all times.

Two experimental sites were used for all front-light experiments: (a) the Benjamin Franklin Bridge between Philadelphia, Pennsylvania, and Camden, New Jersey, and the New Jersey approaches to the bridge and (b) the section between 19th and 21st Streets on Spring Garden Street in Philadelphia. Arrangements were made with the Delaware River Port Authority and the Philadelphia Police Department respectively to use these sites and to assist in conducting the experiments.

All experiments were conducted during nonpeak hours (normally between 9:30 a.m. and 3:30 p.m.).

Experiment 1: Opposite Direction, Both Vehicles Moving

Experiment 1 was run on the Benjamin Franklin Bridge between Philadelphia and Camden. Data were collected on weekdays between 10:00 a.m. and 3:00 p.m. and on Sunday mornings during September 1969. The objective of this experiment was to determine the effect of a motorcycle headlight operating during daylight hours on motorcycle noticeability as perceived by oncoming vehicles.

Design—Three motorcycle headlight conditions—no light, low beam, and high beam—were considered. Data were collected for each of these headlight conditions. Pre- and post-stratification of the data enabled the researchers to determine noticeability as a function of (a) motorcycle light condition, (b) weather (cloudy or clear), (c) color of helmet (white or black), and (d) number of lanes separating the opposing traffic (one or two lanes closed to traffic). The results also provided some indication of the effect of traffic volume on noticeability.

Data were also collected with no motorcycle present as a statistical control for bias. No motorists responded positively when there was no motorcycle present.

Procedure—The motorcycle started at point P_0 on the Benjamin Franklin Bridge (Fig. 1) and traveled west over the bridge toward Pennsylvania in the lane closest to

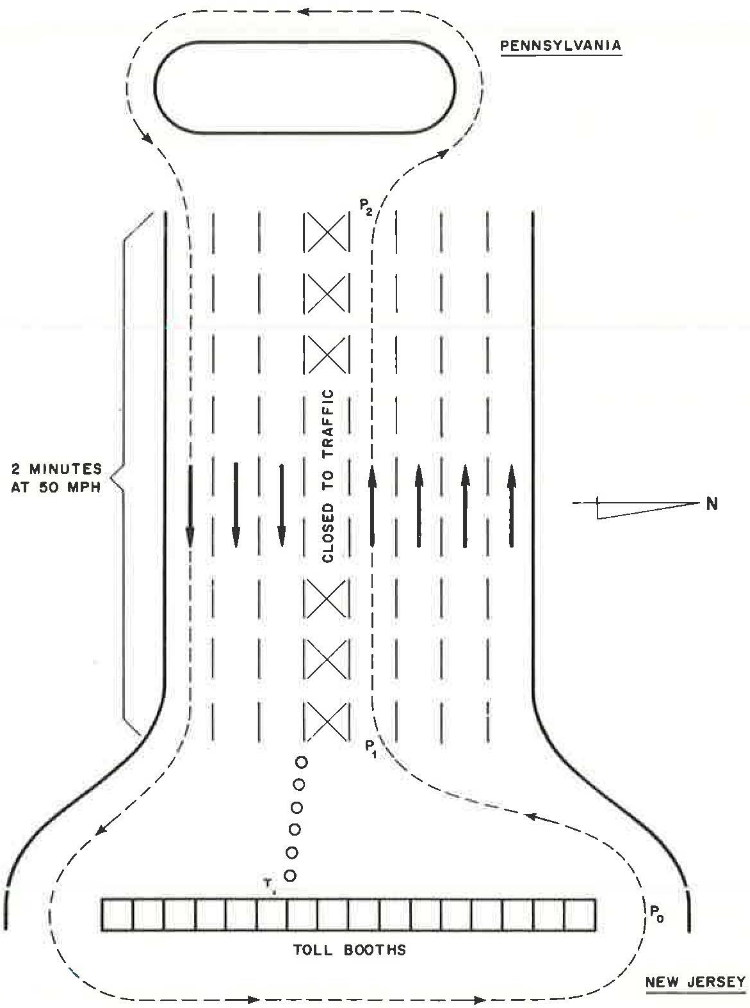

Figure 1. Site for experiment 1, Benjamin Franklin Bridge.

the oncoming traffic. It took slightly over 2 min to cross the bridge (P_1 to P_2). The motorcycle then continued around the circle, recrossed the bridge, and returned to the starting position P_0.

Data were collected at the eastern (New Jersey) end of the bridge at toll booth T_1. This toll booth was chosen to maximize the probability of questioning drivers traveling closest to the oncoming motorcycle. When the motorcycle reached P_1, a stopwatch was started by the data collector. The next car to pass P_1 traveling east and stopping at T_1 was the first car to be questioned. Each subsequent car stopping at T_1 was questioned, and questioning continued for 4 min. (After 2 min the motorcycle would be at point P_2, and any car at P_2 traveling toward New Jersey would take slightly over 2 min to reach T_1.)

The motorcycle traveled at 45 to 50 mph, the speed of traffic (speed limit 45 mph), always staying in the southernmost lane toward Philadelphia and always attempting not to tailgate.

The complete cycle (across bridge and return) took about 7 to 8 min. Under typical traffic conditions, about 15 vehicles passed through T_1 during the 4-min interval.

No traffic delays were caused by the questions at the toll booths, even when queues of five or six cars occurred.

Motorists were asked the following question: "Did you notice (see) a motorcycle traveling toward Philadelphia (going in the opposite direction) while you were on the bridge?" If the driver answered "yes," to clarify his response he was also asked if he noticed the headlight or if he noticed anything special about the motorcycle.

TABLE 1

EFFECT OF HEADLIGHT CONDITION ON NOTICEABILITY: EXPERIMENT 1, OPPOSITE DIRECTION

Motorcycle Light Condition	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	455	41	9.0
Low beam	432	82	19.0
High beam	482	105	21.8

Results—The experiment was prestratified by motorcycle light condition and color of helmet and post-stratified by weather and number of lanes separating the opposing traffic.

Motorcycle Headlight—The data, stratified by motorcycle headlight condition only, are given in Table 1. A "t" test on the distribution of the difference of the proportions (27) reveals a significant difference between no light and either of the two light conditions but no significant difference between the two light conditions. The low beam provides a 111 percent improvement in noticeability over the no-light condition, whereas the high beam increases noticeability by 142 percent.

Weather—Stratifying the data in Table 1 by weather yields the data given in Table 2. There are significant differences between either of the motorcycle light-on conditions and the no-headlight condition, but the difference between cloudy and clear weather is not statistically significant. With high-beam headlights, noticeability increases by 115 percent in clear weather and by 273 percent in cloudy weather. However, for the no-light condition, there is a sizable difference between cloudy and clear weather in the percentage of noticeability; hence the relative effectiveness of the headlight is increased during cloudy weather.

Helmet—There were no significant differences between the white and black helmets, although the black helmet caused a slightly higher percentage of noticeability when the motorcycle light was on. Table 3 gives the results of this portion of the experiment.

Number of Lanes Separating Opposing Traffic—With only one lane separating the opposing traffic, there is a significant increase in noticeability caused by the headlight; with two lanes separating traffic, this difference disappears. This may have been partially caused by the lower traffic volume when the two center lanes on the bridge were closed on Sunday mornings. The traffic volume on Sundays was 2,000 to 2,200 vehicles per hour (vph) as compared to 3,000 to 3,200 vph during weekdays.

In addition, there is a significant difference between a one-lane separation and a two-lane separation for the high-beam condition but not for the low-beam or no-light condition. These data are given in Table 4.

Traffic Volume—Traffic counts by hour and direction were obtained from the Delaware River Port Authority for each day during which the experiments were run. In

TABLE 2

EFFECT OF HEADLIGHT CONDITION ON NOTICEABILITY STRATIFIED BY WEATHER: EXPERIMENT 1, OPPOSITE DIRECTION

Motorcycle Light Condition	Clear Weather			Cloudy Weather		
	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	337	34	10.1	118	7	5.9
Low beam	349	67	19.2	83	15	18.1
High beam	355	77	21.7	127	28	22.0

TABLE 3

EFFECT OF HEADLIGHT CONDITION ON NOTICEABILITY STRATIFIED BY COLOR OF HELMET: EXPERIMENT 1, OPPOSITE DIRECTION

Motorcycle Light Condition	White Helmet			Black Helmet		
	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	325	29	8.9	130	12	9.2
Low beam	308 (232)	53 (42)	17.2 (18.1)[a]	124	29	23.3
High beam	352 (243)	69 (55)	19.6 (22.6)[a]	130	36	27.7

[a]If the data collected when two lanes separated the opposing traffic are removed (only appearing in the white helmet condition), the differences between the white and black helmet conditions become smaller.

Figure 2, noticeability without a headlight on is compared to noticeability with a headlight on (high beam). No significant conclusions can be drawn from these data, except possibly a slight increase in noticeability caused by the headlight as traffic volume increases.

Experiment 2: Angle, Right Turn

Experiment 2 was conducted on the New Jersey approaches to the Benjamin Franklin Bridge (Fig. 3). Data were collected on weekdays between 10:00 a.m. and 3:00 p.m. during the first 2 weeks of October 1969. The experiment was run to determine the effect of motorcycle headlights operating during daylight on motorcycle noticeability as perceived by drivers passing an intersection at right angles to the motorcycle.

Design—Because there was no significant difference between high and low beams in the first experiment, only the high-beam and no-light conditions were tested in this experiment. The no-motorcycle condition was also tested to determine statistical bias. The data were also post-stratified by weather condition.

Procedure—The motorcycle was positioned at P_1 (Fig. 3) at all times and appeared to be stopped at the traffic light at the corner of 7th and Linden Streets in Camden, one block from the toll booths, waiting to make a right turn. The direction of the motorcycle headlight was perpendicular to the traffic being questioned.

A data collector was placed at T_1 (either the third or fourth toll booth from the north side of the bridge). Because the first two toll booths handle a large percentage of trucks and buses, they were avoided. The data collector was careful to question only motor-

TABLE 4

EFFECT OF HEADLIGHT CONDITION ON NOTICEABILITY STRATIFIED BY NUMBER OF LANES SEPARATING OPPOSING TRAFFIC: EXPERIMENT 1, OPPOSITE DIRECTION

Motorcycle Light Condition	One-Lane Separation			Two-Lane Separation		
	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	339	28	8.3	116	13	11.2
Low beam	356	71	19.9	76	11	14.5
High beam	373 (348)	91 (81)	24.4 (23.3)[a]	109	14	12.8

[a]A small amount of data were collected with no lanes separating opposing traffic. If these data are removed, the difference between one- and two-lane separation with the high-beam condition becomes smaller.

ists passing the motorcycle at right angles (not those coming from P_2, P_3, or P_4). When the data collector's visibility was blocked by traffic, he stopped questioning motorists until he was certain they came from the proper direction.

Motorists were asked the following question: "Did you notice the motorcycle as you passed through the last intersection?" If the driver answered "yes," to clarify his response he was also asked if he noticed the headlight or if he noticed anything special about the motorcycle.

The rate of data collection varied from 100 to 200 vph, depending on the number of heavy trucks and buses (which blocked visibility, thus causing delays).

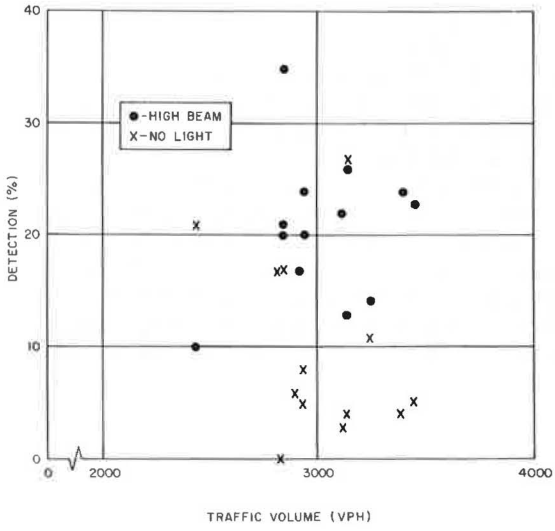

Figure 2. Percentage of detection versus traffic volume.

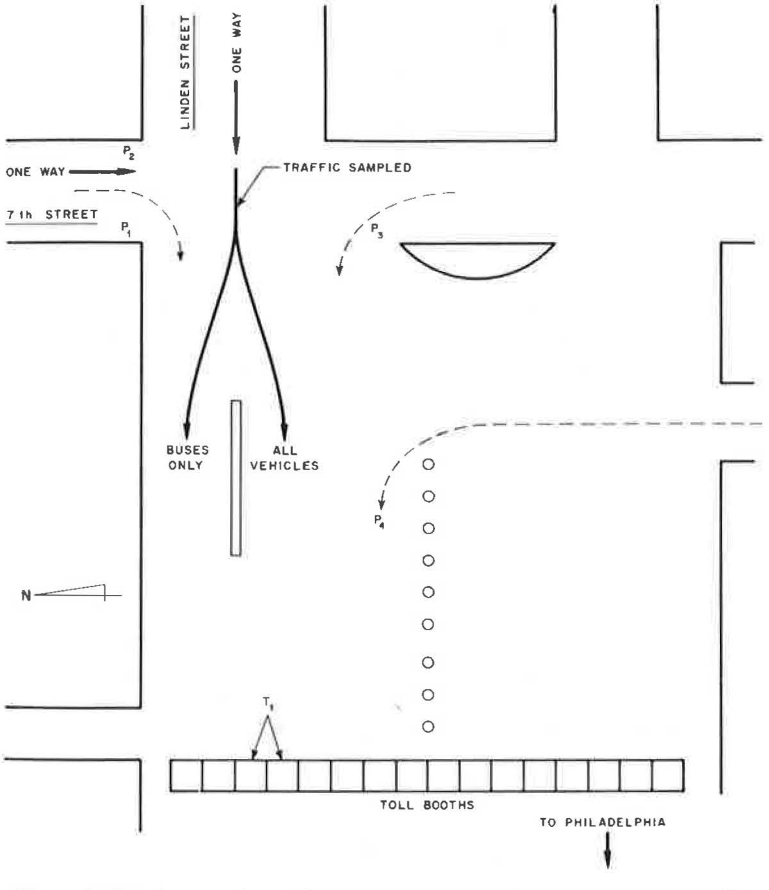

Figure 3. Site for experiment 2, New Jersey approaches to Benjamin Franklin Bridge.

Results

No Light Versus High Beam—Table 5 gives the effects of high beams on noticeability. As shown, noticeability is increased by 108 percent and is significant at the 0.01 level.

Cloudy Versus Clear Weather—Table 6 compares noticeability for the no-light and high-beam conditions stratified by weather condition. For both cloudy and clear weather, there is a significant difference between the no-light and high-beam conditions (0.05 level). As compared to the

TABLE 5

EFFECT OF NO LIGHT VERSUS HIGH BEAM ON NOTICEABILITY: EXPERIMENT 2, ANGLE, RIGHT TURN

Motorcycle Light Condition	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	350	26	7.4
High beam	350	54	15.4

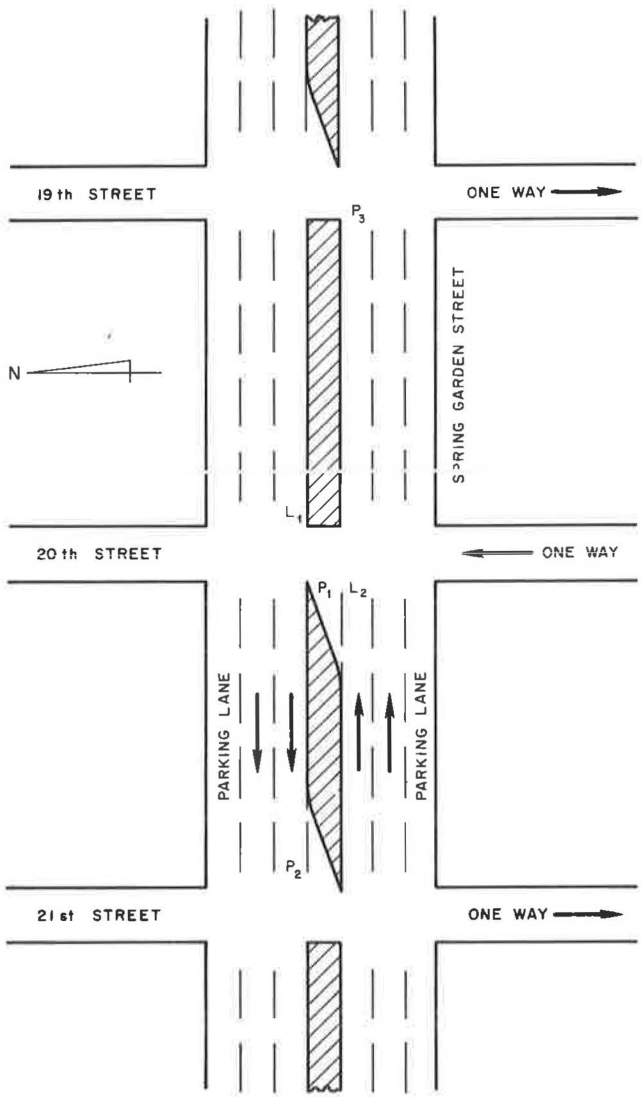

Figure 4. Site for experiments 3, 4, 5, and 6, Spring Garden Street.

TABLE 6

EFFECT OF NO LIGHT VERSUS HIGH BEAM ON NOTICEABILITY STRATIFIED BY WEATHER: EXPERIMENT 2, ANGLE, RIGHT TURN

Motorcycle Light Condition	Clear Weather			Cloudy Weather		
	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	200	17	8.5	150	9	6.0
High beam	200	31	15.5	150	23	15.3

no-light condition, noticeability is increased by 82 percent in clear weather and 155 percent in cloudy weather. However, there is no significant difference between the no-light, cloudy versus clear weather condition or the high-beam, cloudy versus clear weather condition.

Experiment 3: Left Turn, Headlight

The location selected for experiment 3 was between 19th and 21st Streets on Spring Garden Street in Philadelphia. The experiment was conducted on weekdays during non-peak hours in October 1969. During all data collection, a Philadelphia police officer provided assistance by stopping traffic or controlling the traffic signal. The purpose of the experiment was to determine the effect of motorcycle headlights operating during the daylight on motorcycle noticeability as perceived by oncoming drivers while a motorcycle was waiting at an intersection to make a left turn.

Design—The data were pre-stratified by motorcycle headlight condition (no light or high beam) and post-stratified by weather (clear or cloudy). Data were collected at the rate of approximately 100 vehicles per day.

Procedure—The motorcycle was positioned on Spring Garden Street at 20th Street at P_1 (Fig. 4), as if waiting to make a left turn. The data collector and the police officer were positioned on Spring Garden Street at 21st Street at P_2. Traffic signals were at both intersections.

Figure 5 shows the motorcycle at the experimental site with headlight on and headlight off. Traffic in the nearest opposing lane to the motorcycle (L_1) could easily be observed by the data collector and stopped at 21st Street for questioning. A total of 406 drivers was questioned.

Motorists were asked the following question: "Did you notice a motorcycle as you passed through the last intersection?" Motorists who answered "yes" were also asked: "Did you pass this intersection and were you questioned on a previous day?" (If so, the driver was omitted since there was an obvious learning curve;

Figure 5. Test motorcycle with headlight on and off.

TABLE 7

SUMMARY OF EXPERIMENT 3 RESULTS: LEFT TURN, HEADLIGHT

Motorcycle Light Condition	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	194	57	29
High beam	212	112	53

TABLE 8

SUMMARY OF EXPERIMENT 3 RESULTS STRATIFIED BY WEATHER: LEFT TURN, HEADLIGHT

Motorcycle Light Condition	Clear Weather			Cloudy Weather		
	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	55	19	35	139	38	27
High beam	60	29	48	152	83	55

drivers almost always noticed the motorcycle once they had been questioned previously.) and "Where was the motorcycle located?" (This was to verify that the driver actually saw our motorcycle, not another possible in the vicinity at the time.)

Results—Table 7 gives the results of this experiment. Some 29 percent of the oncoming motorists (nearest opposing lane) noticed the motorcycle with no headlight on, and 53 percent noticed it with a headlight on. This is an 83 percent increase in noticeability and is significant at the 0.01 level.

Table 8 gives the results of this experiment stratified by weather. In cloudy weather, 27 percent noticed the motorcycle without a headlight on and 55 percent noticed it with a headlight on. This is slightly over a 100 percent increase and is significant at the 0.01 level. During clear weather, noticeability increased by 37 percent over the no-light condition (35 percent versus 48 percent), but it was not significant even at the 0.1 level. (This may be partially due to the smaller sample—115 vehicles during clear weather and 291 vehicles during cloudy weather.)

Experiment 4: Left Turn, Running Lights

Previous noticeability experiments have shown that significant increases in noticeability can be achieved by using a motorcycle headlight during the day. However, operating the headlight requires a significant amount of electrical power and may have detrimental effects on the motorcycle's electrical system. Many of the newer motorcycles are being equipped with turn signals (amber in front and red or amber in the rear) that can be readily adapted to running lights. An evaluation of their effectiveness, in terms of increasing noticeability, was therefore felt to be important. In addition, running lights require far less electrical power than does the headlight and have negligible detrimental effects on the motorcycle's electrical system. The amber front running lights were evaluated in experiment 4. (The dual taillights are considered later in this paper.) The experiment was run to determine the effect of motorcycle running lights operating during the daylight on motorcycle noticeability as perceived by oncoming drivers while a motorcycle was waiting at an intersection to make a left turn.

Design and Procedure—The design and procedure were the same as in experiment 3, except that stratification was only by the following motorcycle light conditions: (a) no light; (b) standard high-beam headlight; and (c) amber running lights (two 21-cp lights each).

All experiments were conducted in clear weather. Data were collected during April 1970 from 786 motorists at the Spring Garden Street location.

Results—Table 9 gives the results of experiment 4. With no light, 39.6 percent of the drivers traveling in the opposite direction in the nearest lane saw the motorcycle. The figure was 49.0 percent for running lights and 57.1 percent for the

TABLE 9

SUMMARY OF EXPERIMENT 4 RESULTS: LEFT TURN, RUNNING LIGHTS

Motorcycle Light Condition	Total Number of Vehicles	Number of Motorists Noticing Motorcycle	Percentage of Motorists Noticing Motorcycle
No light	270	170	39.6
Running lights	353	173	49.0
Headlight (high beam)	163	93	57.1

headlight. This represents a 44 percent increase in noticeability for the headlight and a 24 percent improvement for the running lights over the no-light condition. The differences are significant at the 10 percent level for the running lights and at the 1 percent level for the headlight.

The results indicate that approximately half of the increase in noticeability obtained by using a headlight can be achieved by using two 21-cp amber running lights instead of the headlight. There may be some value in using running lights in lieu of headlights.

The no-light and high-beam data, 40 and 57 percent respectively, do not agree totally with the results of 29 and 53 percent in experiment 3. However, the warmer weather, different sun position, different motorcycle, and frequency of other motorcycles all had some effect on the data. Only the relative nature of the data is used to determine significant differences.

Summary of Front-Light Experiments

When motorcycles operate with their headlights on during the daylight hours, their noticeability is increased by between 44 and 142 percent (without stratification by weather or other conditions) depending on traffic condition. The absolute percent differences without stratification by weather or other conditions range from 8 to 24 percent. When stratified by weather conditions, the relative effectiveness of the headlight is considerably greater in cloudy weather than in clear weather.

The running light experiment revealed that approximately half of the increase in noticeability resulting from headlights can be obtained by using only two amber running lights (21 cp each).

Thus, motorcycle headlights or front running lights appear to be valuable as a cue for alerting motorists to the presence of a motorcycle during the daytime.

REAR-LIGHT EXPERIMENTS

Three experiments were designed to evaluate the effectiveness of motorcycle taillights operating during the daylight in increasing noticeability.

Two traffic conditions were studied: (a) same direction, one vehicle stopped making a left turn and one traveling straight and (b) same direction, one vehicle stopped and one bearing left.

The taillight conditions included (a) standard taillight (3 cp), (b) standard brake light (21 cp), (c) raised (12 to 15 in.), high-intensity (100 cp) taillight with contrasting background, and (d) dual raised taillights (21 cp each).

Experiments were run in the fall of 1969 and in the spring of 1970. An experienced, helmeted motorcyclist was used at all times.

Two experimental sites were used: (a) between 19th and 21st Streets on Spring Garden Street and (b) 20th and Race Streets in Philadelphia. All experiments were conducted during nonpeak weekday hours. The Philadelphia Police Department assisted in carrying out these experiments.

Experiment 5: Standard Taillight and Brake Light

Experiment 5 was conducted on Spring Garden Street between 19th and 21st Streets during November 1969. The motorcycle was positioned on Spring Garden Street at the intersection with 20th Street waiting to make a left turn (Fig. 4). Stratification was by motorcycle taillight condition only and included the following conditions: (a) light off, (b) standard taillight (3 cp), and (c) standard brake light (21 cp). Motorists traveling on Spring Garden Street who passed the motorcycle while traveling in the same direction in the nearest adjacent lane were stopped and questioned at the intersection of 19th and Spring Garden Streets. A total of 226 drivers was questioned.

The results of this experiment revealed that no significant differences between any of the three taillight conditions exist and that present motorcycle taillight systems do not increase noticeability during daylight hours.

Experiment 6: Raised, High-Intensity Taillight With Contrasting Background

Originally, four independent taillight variables were considered: (a) intensity, (b) mounting height, (c) contrasting background, and (d) multiple lights.

However, before testing any of the first three variables separately or in pairs, a test of the maximum configuration was felt to be most important because the preceding taillight experiment showed no increase in noticeability. This was a wise choice, because motorcycle noticeability did not increase in this experiment when all three variables were maximized. These variables were therefore not tested further.

The experimental design and procedure of experiment 6 were identical to experiment 5 except that the stratification by motorcycle taillight condition included (a) light off and (b) raised (12 to 15 in. above the standard position), high-intensity (100 cp) taillight with a 4-in. contrasting black border. The experiment was conducted during March and April 1970. A total of 633 drivers was questioned.

No significant difference was found between the two conditions.

Experiment 7: Dual Raised Taillights

Experiment 7 was conducted at 20th and Race Streets in Philadelphia during June 1970. Stratification was by taillight condition only and included (a) light off, (b) dual

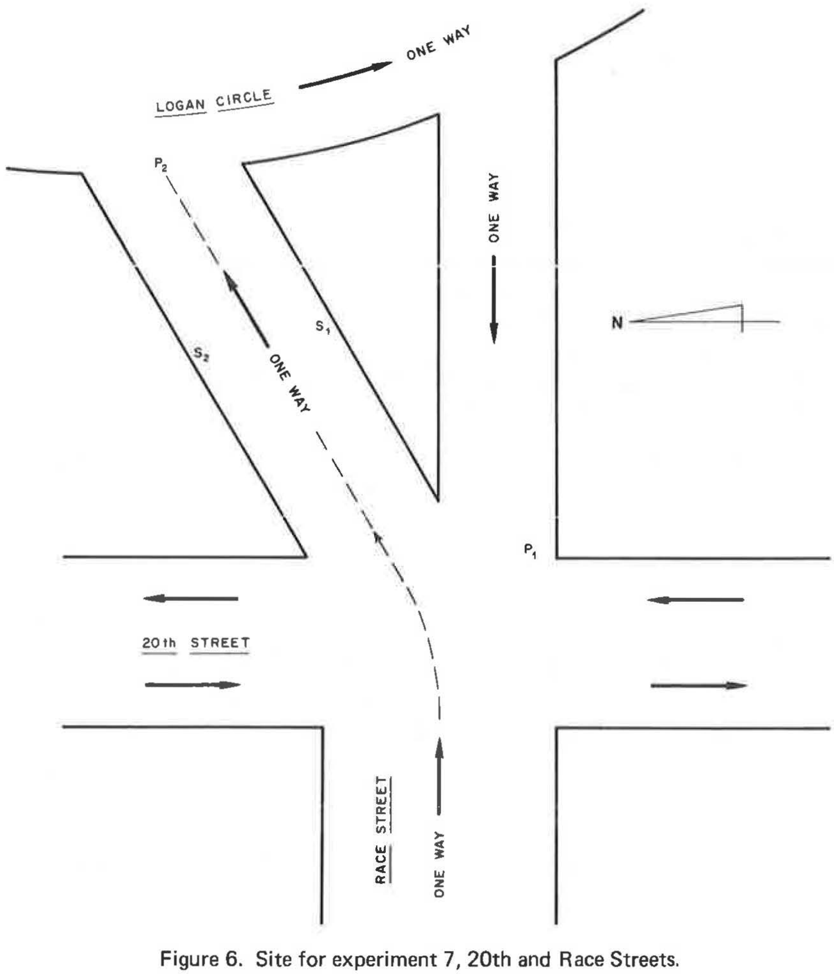

Figure 6. Site for experiment 7, 20th and Race Streets.

raised (12 to 15 in.) red taillights (21 cp each), and (c) dual raised amber taillights (21 cp each). The motorcycle was positioned on Race Street at the intersection with 20th Street (Fig. 6). Motorists traveling on Race Street across 20th Street past the motorcycle were stopped and questioned at the intersection of Race Street with Logan Circle, the next intersection. A total of 332 drivers was questioned.

The results of this experiment showed no increase in noticeability from the use of dual red taillights but did show approximately a 40 percent increase in noticeability from the use of dual amber taillights.

Summary of Rear-Light Experiments

Noticeability is unchanged when motorcycles operate during the daylight with a standard taillight of either 3 cp or 21 cp or with dual red, raised (12 to 15 in.), 21-cp taillights. In addition, higher intensities (up to 100 cp) in conjunction with elevation (12 to 15 in. above the standard taillight position) and contrasting background consisting of a 4-in. black border do not statistically increase noticeability over the no-taillight condition.

The only taillight modification that appeared to increase noticeability was a taillight consisting of two elevated (12 to 15 in.) amber lights (21 cp each). The relative increase over the no-light condition was approximately 40 percent, whereas the absolute difference was 13 percent.

The conclusion of this set of taillight experiments is that present motorcycle taillight systems, even modified by intensity, mounting height, number of lights, and contrasting background, are inadequate as cues for alerting other motorists to the presence of motorcycles during the daytime.

Amber taillights may be of some value as an aid to motorcycle noticeability; however, they do not increase noticeability as much as do headlights. By using them in conjunction with amber front running lights, they may be an alternative to using headlights at all times (for example, under low ambient light conditions such as on cloudy days).

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