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Study of Methods for Improving the Conspicuity of Two-wheeled Vehicles in Daytime and at Dawn/Dusk

(Comparison of Headlamp, Daytime Running Lights and Position Lamps)

1. Introduction

As methods for improving the conspicuity of two-wheeled vehicles in daytime and at dawn/dusk, the use of automatic headlamp on (AHO), daytime running lights (DRL) and position lamps (PL) has been considered.

Starting from 1991, Japan progressively introduced AHO for two-wheeled vehicles. AHO regulation, whereby the the headlamp automatically turned on while the engine is running, was legislated in 1996, and made mandatory in 1997 for all new two-wheeled vehicles.
The ratio of AHO-equipped vehicles to the total number of two-wheeled vehicles in service rose from zero in 1990 to over 70% in 2001.

According to a report analyzing the "specific accidents" involving two-wheeled vehicles in accident configurations closely associated with the conspicuity of two-wheeled vehicles (head-on collision, right-angle collision, collision while turning right, crossing collision) and resulting in fatality or injury to riders in Japan [(1)], AHO was found effective in reducing the number of such specific accidents in daytime and at dawn/dusk. The report concluded that as a result of the increased AHO equipping ratio to the total two-wheeled vehicle fleet from zero in 1990 to 71% in 2001, the number of specific accidents was reduced by 12,124 cases (16.0%) during the same period.

Meanwhile, DRL became mandatory for four-wheeled vehicles in several European (mainly Scandinavian) countries and in Canada [(2)]. As discussions on DRL have been underway by the United Nations Working Party on Lighting and Light-Signaling (GRE) and by the European Union [(3)(4)], it seems possible that mandatory DRL for four-wheeled vehicles may be introduced in international regulations.

Considering the large number of two-wheeled vehicles in Japan (13.2 million in 2005), there are rising concerns that if DRL is introduced in four-wheeled vehicles, DRL for four-wheeled vehicles will impair the conspicuity of two-wheeled vehicles.

According to a study on the conspicuity of two-wheeled vehicles with AHO and PL turned on while trailed by a passenger car with its headlamps on [(1)], the combination of AHO and PL on was found desirable for further improving the conspicuity of two-wheeled vehicles against the conspicuousness of headlamps lighted four-wheeled vehicles in daytime and at dawn/dusk. However, the study has not examined the effect of DRL equipped on both two-wheeled vehicles and four-wheeled vehicles.

Consequently this study was conducted to compare the effect of AHO, DRL and PL on improving the conspicuity of the two-wheeled vehicle trailed by a four-wheeled vehicle with its DRL turned on in daytime and at dawn/dusk.

2. Purpose

The purpose of this study was to verify the effect of AHO, DRL (as defined in ECE R87) and PL on improving the conspicuity of the two-wheeled vehicle trailed by a four-wheeled vehicle with its DRL turned on.

3. Method

In an experimental situation where a two-wheeled vehicle was approaching while trailed by a passenger car with its DRL on, the subjects were instructed to observe the oncoming two-wheeled vehicle and evaluate its conspicuity and the annoyance of its lamp.

3.1. Test Vehicles

Two units each of 400 cc-class motorcycles and passenger cars were employed.

3.2. Lighting Conditions for the Test Motorcycle

As shown in Figure 1, the following ten lighting conditions were applied to the test motorcycles, where luminous intensity means the luminous intensity in candela (cd) as measured in the direction of the subject's eyepoint.

(1) No Lamps on
(2) AHO (passing beam on; 460 cd)
(3) DRL Single on (580 cd)
(4) DRL Pair on (each 580 cd)
(5) AHO + DRL1 on (580 cd)
(6) AHO + DRL2 on (each 580 cd)
(7) AHO + White PL on (each 30 cd)
(8) AHO + Amber PL on (each 30 cd)
(9) AHO + White PL on (each 58 cd)
(10) AHO + Amber PL on (each 58 cd)

The test motorcycles were equipped with the following types of lights, and their shapes and installation position were:

* Headlamp: circular (170 mm diameter); height (850 mm from lamp's center point to ground)
* DRL: oval (V40 mm x H120 mm); separation from headlamp (150 mm); height (630 mm for DRL1, 650 mm for DRL2)
* PL: circular (60 mm diameter); separation from headlamp (150 mm); height (850 mm)

3.3. Lighting Conditions for the Test Passenger Car

The two test passenger cars were equipped with a pair of DRL each 580 cd in luminous intensity, 650 mm high from the lamp's center point to ground, and 1,400 mm separation between the two DRL units measured from their center point to center point (Figure 2).

3.4. Test Course

A test course with a 3.5 m wide lane on each side was set on the general-purpose test road of the Japan Automobile Research Institute.

(1) No lamps on

(2) AHO

(3) DRL1

(4) DRL2

(5) AHO + DRL1

(6) AHO + DRL2

(7) AHO + White PL (30 cd)

(8) AHO + Amber PL (30 cd)

(9) AHO + White PL (58 cd)

(10) AHO + Amber PL (58 cd)

Fig. 1 Motorcycle Lighting Conditions

Fig. 2 Passenger Car Lighting Condition

3.5. Subject Location and Oncoming Vehicle Operation

Figure 3 shows the location of the subjects and the operation setup of the test motorcycle and the passenger car. The subjects were seated on three rows of benches. The seating heights of the benches were so varied that the eyepoints of the subjects were located approximately 1.0 m, 1.2 m and 1.4 m high from the ground for the front, middle and back rows, respectively. The eyepoint location of the subject second from the innermost person in the middle row was equivalent to the eyepoint location of the theoretical driver of a passenger car running along the center of the same lane (hereafter "Eyepoint"). The oncoming motorcycle and the passenger car which trailed the motorcycle at a distance of approximately 30 m were both driven at a steady speed of 60 km/h as the vehicles approached and passed by the Eyepoint.

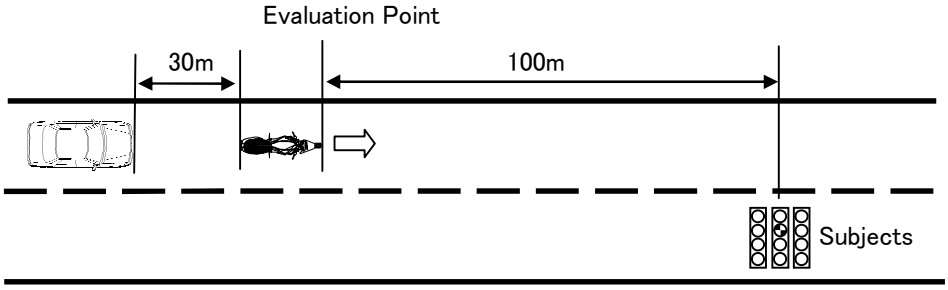

Fig. 3 Subject Location and Oncoming Vehicle Operation

3.6. Evaluation of Motorcycle Conspicuity and Motorcycle Lamp Annoyance

Instructions were given for the subjects to observe the approaching motorcycle on the opposite lane and to evaluate motorcycle conspicuity and motorcycle lamp annoyance (Figure 4).

Prior to the observation, the subjects were asked to imagine being a driver trying to make a right turn at an intersection. During the observation of the oncoming motorcycle, a signal was sounded for one second when the motorcycle reached the point 100 m ahead of the Eyepoint, whereupon the subjects recorded the motorcycle conspicuity and the motorcycle lamp annoyance.

Fig. 4 Experimental Situation (Test Motorcycle Tailed by Car)

3.7. Evaluation Scales

The motorcycle conspicuity and the motorcycle lamp annoyance were evaluated on the following scale:

Evaluation Scale of Motorcycle Conspicuity
5. Adequate
4: Somewhat adequate
3: Just acceptable
2: Somewhat inadequate
1: Inadequate

Evaluation Scale of Motorcycle Lamp Annoyance
5: Not annoying at all
4: Not annoying
3: Just acceptable
2: Somewhat annoying
1: Annoying

Since a value of 3.0 is the just acceptable level in both scales, the conspicuity and the annoyance were judged acceptable if the average evaluation value was 3.0 or higher.

3.8. Test Conditions

As aforementioned, ten lighting conditions were applied to the test motorcycles and one applied to the test passenger cars. The tests were conducted on several occasions under varied sky illuminance conditions below 70,000 lx, selecting appropriate daytime and dawn/dusk hours on fine or moderately cloudy day. Each test was repeated about 15 times.

3.9. Subjects

A total of nine subjects ranging in age from 23 to 59 (average 42) were employed in the tests. All the subjects were lamp experts.

4. Results

According to the Road Traffic Law of Japan [5], the hours beginning from sunset and ending at sunrise is defined as the nighttime. Also, it has been reported that on a fine day the sky illuminance is roughly 500 lx at sunset and 1,000 lx five minutes before sunset as measured by an illuminance meter placed horizontally [6]. Consequently the test results when the sky illuminance were more than 500 lx would be examined in this report.

4.1. Evaluation of Motorcycle Conspicuity

Figure 5 shows the average evaluation values on motorcycle conspicuity recorded by the nine subjects, in relation to sky illuminance.

When sky illuminance was 30,000 lx (corresponding to a relatively bright cloudy day), the motorcycle conspicuity value was less than 4.0 for the no lamps on condition, however, the values exceeded 4.0 for the AHO and the DRL on (single, pair) conditions.

When sky illuminance was less than 20,000 lx, the motorcycle conspicuity evaluation value declined with a drop in sky illuminance.

When sky illuminance was 5,000 lx (corresponding to 30 minutes before sunset on a fine day), the motorcycle conspicuity evaluation value declined below the acceptable borderline of 3.0 for the no lamps on condition, but remained in the acceptable range for the AHO and the DRL on conditions. For these reasons, it would be desirable to have the AHO or DRL of the motorcycle turned on when sky illuminance was not higher than 5,000 lx.
At a sky illuminance of 5,000 lx, the motorcycle conspicuity value for the DRL1 on condition was higher than for the no lamps on condition but lower than for the AHO condition.

When sky illuminance was between 1,000 lx (corresponding to five minutes before sunset on a fine day) and 500 lx (corresponding to sunset on a fine day), the motorcycle conspicuity values were below the acceptable borderline of 3.0 for the no lamps on, DRL1 on, DRL2 on and AHO conditions. However, acceptable values were gained when DRL1, DRL2 or PL were lighted together with AHO. Accordingly, it would be desirable for a sufficient conspicuity of the motorcycle to have DRL or PL turned on together with AHO at dawn/dusk.

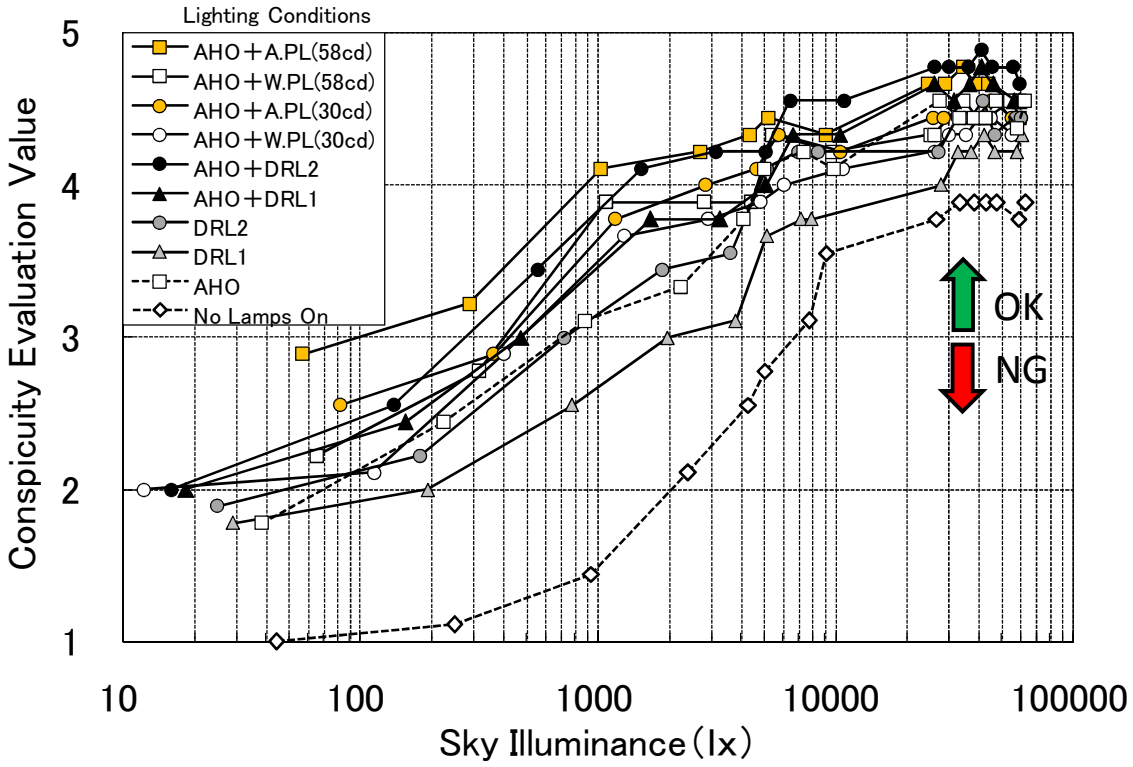

Fig. 5 Motorcycle Conspicuity Evaluation in Relation to Sky Illuminance

Figure 6 shows the average motorcycle conspicuity evaluation values at sky illuminance of 1,000 lx. The values are rounded off at the second digit below the decimal point.

DRL1 on condition was evaluated as giving a higher conspicuity than the no lamps on condition but resulting in a lower conspicuity than AHO condition. On the other hand, the AHO and DRL2 on conditions were rated equivalent in the level of evaluated motorcycle conspicuity.

The motorcycle lighting condition that gained the highest conspicuity value was AHO + amber PL (58 cd) condition. If the luminous intensity of PL were identical, the combination of AHO and amber PL gave a higher conspicuity than that of AHO and white PL by a difference of 0.2 to 0.3 points. Comparing the PL luminous intensity between 30 cd and 58 cd, the higher intensity PL in combination with AHO produced a higher conspicuity evaluation value by a difference of 0.4 to 0.5 points.

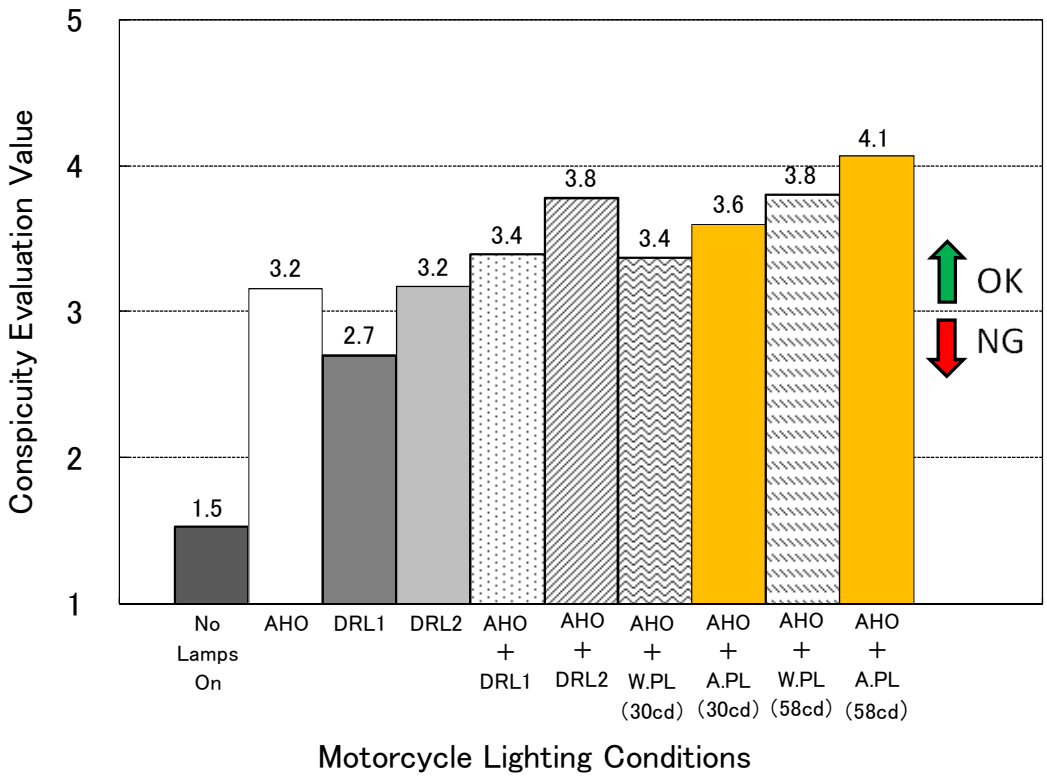

Fig. 6 Motorcycle Conspicuity Evaluation at 1,000 lx in Sky Illuminance

4.2. Evaluation of Motorcycle Lamp Annoyance

Figure 7 shows the nine subjects' average evaluation values on motorcycle lamp annoyance in relation to sky illuminance.

When sky illuminance was less than 10,000 lx, the motorcycle lamp annoyance evaluation value declined with a drop in sky illuminance, thus indicating an increasing annoyance as the sunset approached.

When sky illuminance was between 5,000 lx and 500 lx, the motorcycle lamp annoyance evaluation value was below the acceptable borderline of 3.0 for the AHO + DRL2 condition. For other lighting conditions, annoyance was evaluated acceptable. For these reasons, it would be inappropriate to have the motorcycle simultaneously turn on its AHO and DRL2 in a low sky illuminance range up to 5,000 lx.

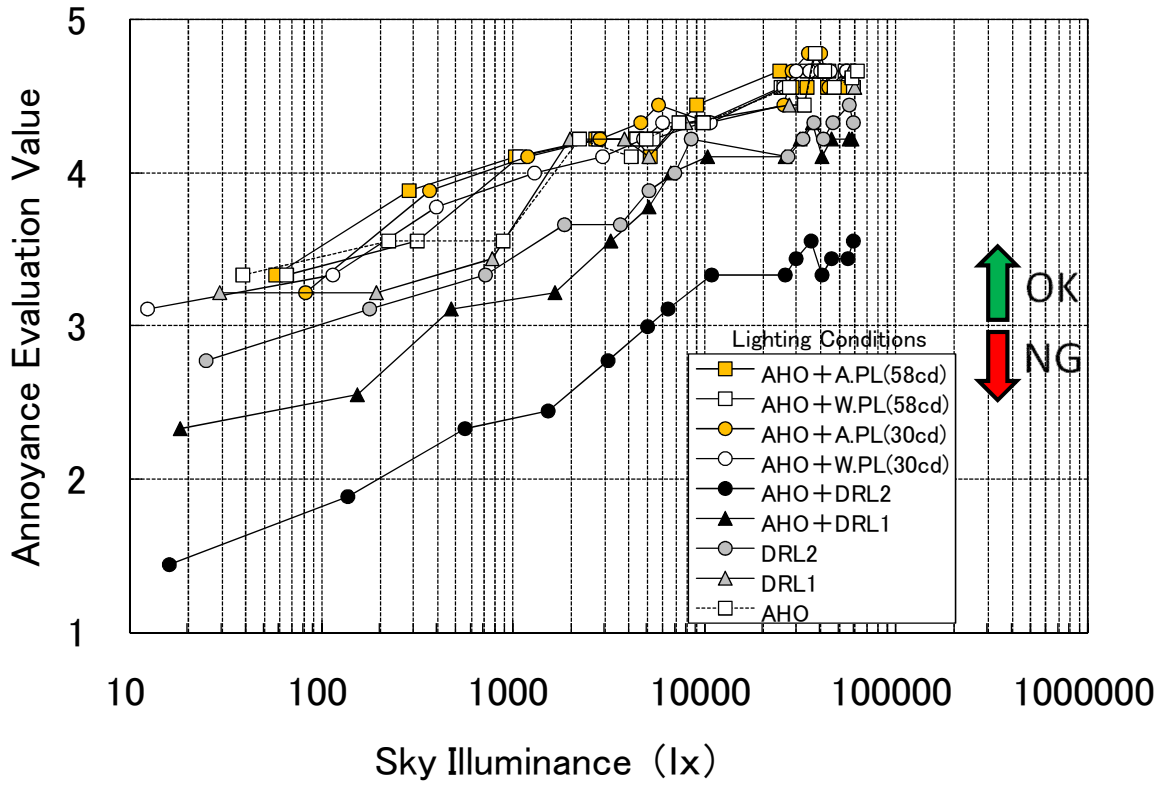

Fig. 7 Evaluation of Motorcycle Lamp Annoyance in Relation to Sky Illuminance

5. Conclusion

It is desirable for two-wheeled vehicles to turn on DRL or position lamps in addition to AHO in order to deal with the introduction of DRL in four-wheeled vehicles.

Position lamps combined with AHO are in acceptable annoyance range but that DRL combined with AHO may result in unacceptable annoyance range. Accordingly, if DRL is to be introduced in two-wheeled vehicles, it is necessary to carefully examine the appropriate number of DRL units and their luminous intensity.

To deal with the introduction of DRL in four-wheeled vehicles, the present study found that the most effective method for two-wheeled vehicles will be to introduce amber position lamps with AHO.

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