AENSI Journals
Australian Journal of Basic and Applied Sciences
ISSN:1991-8178
Journal home page: www.ajbasweb.com

Visual Masking of Motorcycle Turn Signals by Amber Position Lamps

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ARTICLE INFO
Article history:
Received 25 June 2014
Received in revised form
8 July 2014
Accepted 10 August May 2014
Available online 30 September 2014

Keywords:
APL DRL Visual masking
Turn Signal Motorcycle conspicuity

ABSTRACT
Poor conspicuity of motorcycle and its rider is one of the underlying factors of motorcycle accident. In view of this issue, the APL implementation for motorcycle is proposed to supplement current Headlight-On regulation, which is already a success in reducing crash casualties among motorcyclists. This study was conducted to examine the effect of adjacent motorcycle on visual masking of turn signal detection at noon and dusk settings. Visual Reaction Times (VRT) of 50 participants were obtained in series of video clips, involving a fleet of motorcycle and turn signal activation. APL-On was found to present a significantly negative effect on turn signal detection at both noon and dusk. Additionally, the visual masking of turn signal was significantly noticeable when the number of motorcycle in a fleet with APL-On increases between one and three. Although the APL implementation improves motorcycle conspicuity, concerns should be given on the detrimental effect it might cause to turn signal detection.

To Cite This Article: Mohd Khairudin Rahman, Mohd Syazwan Solah, Azhar Hamzah, Noor Faradila Paiman, Mohd Firdaus Siam, Aqbal Hafeez Ariffin, Norlen Mohamed, Wong Shaw Voon, Visual Masking of Motorcycle Turn Signals by Amber Position Lamps. ***Aust. J. Basic & Appl. Sci.**, 8(14): 1-6, 2014*

INTRODUCTION

Motorcycle casualties are a growing concern in Malaysia. Each year, motorcyclists constitute more than half of the total traffic, with an average of 2% increment for the last ten years (ADSA, 2011). Furthermore, the trend of motorcycle fatalities keeps on increasing and shows no sign of declining in the near future (Abdul Manan and Varhelyi, 2012). One of the main factors associated with the high crash rates among motorcyclists is conspicuity issue i.e. low motorcycle conspicuity, or the inability of the motorcyclist to be seen by other road users (Radin Umar *et al*, 1995). Nevertheless, over the years, the rates of conspicuity-related crashes in many countries have declined; largely contributed by the introduction of mandatory daytime running light, herein referred as DRL legislation for motorcycles. The impact of such legislation is evident in the USA, whereby 13 percent reduction of motorcycles crashes was recorded (Williams and Lancaster, 1996). In local context, DRL regulation implementation in Malaysia since July 1992 has resulted in 22 percent decrease in motorcycle conspicuity related crashes within the following six months (Radin Umar *et al*, 1995).

Nevertheless, efforts are continuously renewed to enhance the conspicuity aspect of motorcycles and riders, by means of regulation amendment in the UN R 53, which specifies the requirements of the installation of motorcycle lighting devices. The regulation has recently included the provision for permitting front turn signals to be reciprocally utilized as amber position lamp, herein referred as APL (United Nations, 2013). Principally, a motorcycle, while running, shall be supplemented with one activated headlamp that functions as DRL and/or two continuously lit amber turn signals as APL. The APL constant actuation, however, must be switched off when the turn signal lamp is flashing.

Thus far, the overall benefit of APL in increasing the conspicuity of motorcycle is still a question mark, given the short period of the regulation. In order to become more practical, the APL shall make use of more powerful source of light, such as light-emitting diode, which is uncommon in small engine displacement (cc) motorcycles. Furthermore, luminous intensity and surface area of APL can strongly influence the perception of motorcycle conspicuity (Morita *et al*, 1995). With respect to small cc motorcycles, the conspicuity effect of APL is debatable, since motorcycles with front APL are equivalent in conspicuity rank with the ones without APL during daytime and dusk assessment (Mohd Khairudin *et al*, 2013).

In addition to low ownership cost factor, small cc motorcycles are popular in Asian cities due to their relatively small size. A typical traffic lane with more than 1.7 m in width is able to accommodate two

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motorcycles (Hussain *et al*, 2005). Accordingly, motorcycle makes up the most significant composition of traffic, particularly at intersections with traffic light, especially during peak hours in Taiwan, Malaysia and Vietnam streets (Hsu *et al*, 2003). The implementation of APL on top of mandatory ‘headlamp-on’ seems to generate more intense ‘visual noise’ and subsequently affects turn signal efficacy. This situation is known as visual masking, in which the presence of second stimulus, called the ‘mask’, has a negative impact on the visibility of primary target (Enns and Lollo, 2000).

This study was conducted to evaluate and establish visual masking of front turn signals among small cc motorcycles at noon and dusk period. Additionally, the effect of number of motorcycles ridden side by side was also measured.

Methodology:

The main objective of this study was to investigate the effect of APL on turn signal conspicuity, in the cases of time of day and number of motorcycle. 52 respondents were recruited from Kajang district of Selangor to participate in the video experiment. This study was conducted to analyze Visual Reaction Times (VRT) of turn signal detection for APL and control motorcycle.

Of the 52 paid respondents participated in this study, 54% are male and 46% are female. 60% of the respondents were drawn by systematic random sampling among MIROS staff, and another 30% were volunteer participants coming from various backgrounds. The mean age was 29.5 years, with the youngest at 18 and the eldest at 42 years old, thus having a standard deviation of 5.54. All respondents must have a valid driving licence. 53.8% of them were frequent motorcycle riders.

The data collection was divided into two sessions, which were during noon and dusk. The implementation of the procedure required approximately 20 minutes to be completed by a participant. In general, participants were required to view series of video clips of motorcycles, ridden side by side, that were projected on a 42-inch Samsung branded LCD screen (Fig. 1). There were some guidelines and instructions that needed to be given to participants before training and executing the actual task. Prior to the detailed briefing, participants were given an overview of the experiment, its expected duration, experiment and safety procedures.

Each participant was asked to perform 2 trials for the familiarization purposes. They were allowed to do more trials if necessary. During trial and actual sessions, video clips that showed either 2, 3 or 4 units of motorcycles, ridden side by side, were randomly presented. Each video was presented for 8 seconds. Participant would have to press spacebar on keyboard when the turn signal activation by a motorcycle was detected. Next, participant was asked about to guess the direction of the motorcycle turn signals via multiple choice answers. In between sessions, participants were asked about their opinion on the effect of APL on turn signal detection, the difference in response time between noon and dusk, and the effect of turn signal design.

For input to the respondents for their review, 30 video clips were carefully prepared by the research team with the assistance from a group of licensed motorcyclists. A few scenarios were planned involving two predetermined daytime periods, which were noon and dusk. These periods were selected due to the suspicion of the followings; at noon, the bright sun glare during daytime may overshadow the headlight DRL and turn signal lights, thus creates low visibility to the opposing motorists, while during dusk it is anticipated that the turn signal light visibility increases due to relatively dimmer surrounding. For each video clip, motorcyclists were instructed to ride in pairs, three and four motorcycles simultaneously, side by side, to and from a predetermined start and end point. Each clip has a recorded duration of 8 seconds with the planned turn signal of a specified motorcycle activated 2 second after each ride achieved speed of 40 km/h. For each day condition, 15 clips were prepared which comprised of 5 APL, 5 Control and 5 dummy clips.

Fig. 1: A participant is viewing a clip during the experiment.

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The recording of video clips was carried out by trained research officers and research assistants in controlled environment located in Putrajaya area. The selected road was a closed road, approximately 250 meters in length with 4-lane dual carriageway with median. For study purpose, only one carriageway was used. The research was conducted using four units of underbone type motorcycles, branded Honda Wave 100 model. As the objective of the research was to evaluate the visual masking of turn signal caused by amber position lamps on motorcycle, the motorcycles were fitted with additional device, APL adaptor. The device was obtained from a local motorcycle shop and it was assembled by officers at MIROS lab. Besides that, all the motorcycles were fitted with new batteries to ensure stability of electrical current during data collection.

RESULTS AND DISCUSSION

Fifty two participants took part in the experiment. Subsequently, two participants' data were discarded because these participants had difficulty to identify the direction of the aforementioned lamps, although the turn signals in the video were able to be detected. Furthermore, several null data resulted from participants' failure to detect the turn signal during the whole duration of a clip were also excluded.

Table 1: VRT for noon. Figures are in seconds.

Condition	VRT			
	Mean	SD	Min Value	Max Value
2 MC / APL-On	1.779	0.560	0.923	3.223
2 MC / Control	1.384	0.829	0.162	3.073
3 MC / APL-On	2.103	0.622	1.199	4.385
3 MC / Control	2.117	0.676	0.788	3.578
4 MC / APL-On	2.393	0.858	0.940	4.162
4 MC / Control	1.998	0.596	1.145	4.219

Table 2: VRT for dusk. Figures are in seconds.

Condition	VRT			
	Mean	SD	Min Value	Max Value
2 MC / APL-On	1.970	0.979	0.018	4.640
2 MC / Control	1.812	0.615	0.704	3.363
3 MC / APL-On	2.604	0.629	0.192	4.283
3 MC / Control	2.212	0.692	0.939	4.008
4 MC / APL-On	2.660	0.606	1.712	4.425
4 MC / Control	2.220	1.066	0.183	4.885

MC refers to the number of motorcycles side by side.

This study explicitly concerned about the effect of adjacent motorcycles in masking turn signal indication, conducted at two times of day, noon and dusk. Average VRTs for both cases of APL equipped (APL-On) and control (APL-Off) motorcycles were statistically analyzed. Calculations were performed using Statistical Package for Social Science (SPSS) software Version 16.0. The obtained results for noon and dusk experiment are presented in Table 1 and Table 2, respectively.

T-test on VRT, with APL as the factor, was separately performed for both times of day. The result for noon showed that VRT for APL-On was statistically different than that for control lamp, $t(293) = 2.814$, $P < 0.01$. Similarly, the VRT for dusk in accordance to APL was also statistically different from each other, $t(294) = 3.545$, $P < 0.001$. The mean VRT for noon were 2.087 seconds for APL-on and 1.842 seconds for control lamp. For dusk, the mean VRT for APL-On and control lamp were 2.417 seconds and 2.079 seconds, respectively.

The finding of the experiment suggests that the introduction of APL-On for motorcycle, in addition to current Headlight-On regulation, presented an effect on VRT for turn signal. Specifically, the result suggests that APL-On on motorcycle had caused the respondents to detect turn signal more slowly i.e difference of 245 and 338 milliseconds at noon and dusk, respectively. The result agreed with the indication from a previous study that the visibility of a car's front turn signal decreased in the presence of an adjacent lamp (Sivak *et al*, 2001). However, it should be noted that the cases of 2 and 4 motorcycles had a significant effect of slower turn signal detection for APL-On for noon, while at dusk, the cases of 3 and 4 motorcycles were pertinent, as depicted in Figure 2 and 3.

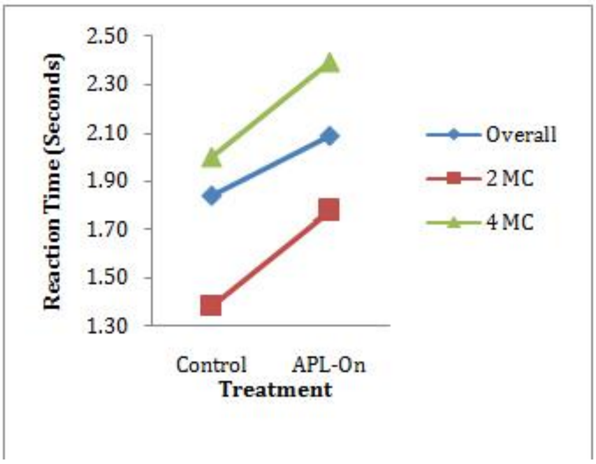

Fig. 2: The effect of APL on reaction time of turn signal detection for at noon.

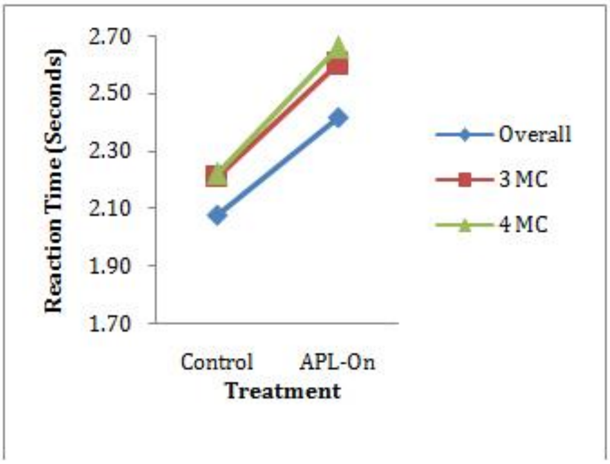

Fig. 3: The effect of APL on reaction time of turn signal detection at dusk.

The mean VRT obtained in this experiment were deemed acceptable considering the design value for driver reaction time is 2.5 seconds. The design value however depends on the type of situation, the degree of urgency and the speed of the vehicles (Triggs and Harris, 1982). In view of front turn signal, the situation is complex because aside from the critical stimulus, there are other light sources nearby i.e headlight that could potentially aggravate the lamp detection. Moreover, the VRT would have been greater if field experiment was deployed, in which the respondent was sitting in a moving car and other driver distraction factors such as vibration of the vehicle and glare from sunlight were factored in.

In the clips, the motorcycles were moving at 40km/h and decelerating upon turn signal actuation. Taking into account the difference of 245 milliseconds in the mean VRT at noon, front turn signal for control motorcycle would be detected 2.72 meters before the APL-On one. This distance however doubles up to 5.44 meters considering that both vehicles are moving, as compared to the respondent being stationary in the experiment. Albeit small, the time and distance saved are significant for driver awareness of the situation, before subsequently making decision and responding to the traffic. It should also be noted that the VRT difference would increase when the speed of the motorcycle increases, which resulting in more notable advantage by means of extra reaction time for an opposing driver.

In further analysis, the factors of APL and number of motorcycle in a fleet were grouped together. A one-way between subjects ANOVA was conducted to compare the effect of APL and number of adjacent motorcycles on reaction time for turn signal detection. There was a significant effect of APL when the factor was combined with number of motorcycle in a fleet (either 2, 3 or 4) on turn signal detection at the $P < 0.05$ level [$F(5, 289) = 11.764$, $P = 0.000$] for noon and [$F(5,290) = 9.174$, $P = 0.000$] for dusk. Post hoc comparisons using the LSD test indicated that the mean VRT for the Control/ 2 motorcycles (M = 1.384, SD = 0.829) was significantly different than the APL-On/ 2 motorcycles (M = 1.779, SD = 0.560) for noon. Moreover, the mean VRT for the Control/ 4 motorcycles (M = 2.117 SD = 0.676) was also significantly different than the APL-On/ 4 motorcycles (M = 2.393, SD = 0.858). Furthermore, control lamp was detected significantly faster than APL-On for the cases of 3 and 4 motorcycles in a fleet during sunset.

The introduction of APL adds the source of frontal light for a motorcycle on the road. Besides headlamp, a motorcycle possesses two additional amber lamps that are constantly running when turning indication is not activated. In the context of this study, masking of front turn signals resulted from closer separation distance between those light sources (Sivak *et al*, 2001). This situation was greatly exacerbated by having many adjacent motorcycles ridden in parallel/in tandem; which is common in Asian cities with small cc motorcycles as dominant mode of transportation (Hsu *et al*, 2003).

Further analysis on the influence of adjacent motorcycles suggests that in general, turn signal was more slowly detected for APL-On when the number of adjacent motorcycle increased at both noon and dusk. As explained before, this was already expected, considering more intense 'visual noise' resulting from additional light sources when the number of adjacent motorcycle increased, which subsequently lead to visual masking of front turn signals. In addition, post hoc analysis (LSD) implies that the VRT for APL-On condition were significantly different for all increments in number of motorcycles at noon. For dusk, the significant effect was found for all increments except from 3 to 4 motorcycles. This implies that at dusk for APL-On condition, the maximum number of motorcycle in a fleet is 2 before visual masking of front turn signal occurs, as illustrated in Figure 4.

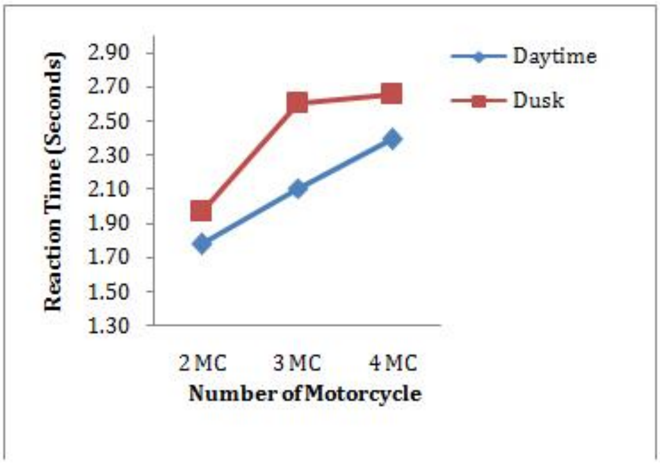

Fig. 4: The effect of number of motorcycle on VRT of turn signal detection for APL-On.

Conclusion:

The findings in this study suggest that APL generates visual masking of turn signal, in situation whereby a motorcycle is ridden in the presence of adjacent motorcycles. As shown in this study, the VRT of turn signal detection increased for APL-On as compared to control motorcycle at noon and dusk. Furthermore, the VRT for APL-On condition showed upward trend when the number of adjacent motorcycles was increased between one and three. Overall, the APL appeared to have negative effect on turn signal detection, in spite of improvement in motorcycle conspicuity. Therefore, the regulation allowing turn signals to be reciprocally utilized as APL should weigh the effects of both contradicting consequences, for overall benefit in road safety.

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