ORIGINAL ARTICLE

EFFECT OF ROAD DESIGN ON HAZARD ANTICIPATION BEHAVIOR AMONG MOTORCYCLISTS DURING MERGING IN TRAFFIC

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ABSTRACT

Road accident is one of the top contributing factors for human fatalities around the world. Among the road users, motorcyclist is considered one of the most vulnerable road user group that contributed to a large number of road crashes. For this study, the focus is on the effect of merging road design on hazard anticipation behavior of motorcyclist during merging in traffic. The objectives are: (i) to evaluate hazard anticipation behavior among motorcyclist during merging into an urban expressway and; (ii) to evaluate the effect of merging road design on motorcyclists hazard anticipation behavior during merging into an urban expressway. *An observational study was conducted in which three thousand-two hundred of motorcyclists were observed at sixteen scenarios locations – eight scenarios for each straight and curved road. Dependent variable for this study was the percentage of hazard anticipation behavior performed by motorcyclist. If a motorcyclist turns his or her head towards the target zone while in the launch zone, he or she was scored 1, else 0. Overall, only 46.5% of motorcyclists do practise safe riding behavior by anticipating hazard during merging in traffic [x^2 (1) = 15.680, p = < 0.0001]. Comparing the motorcyclists' hazard anticipation between the straight and curve merging road, it was found that motorcyclists tend to anticipate hazard less at the straight road [M=29.94; SD=1.16] than at the curve road [M=63.69; SD=17.50], and the difference is significant [t (8)-3.68, p=0.02]. These findings suggest that the merging road design does affect motorcyclists' hazard anticipation performance, and it can be recommended to the road construction authority in designing future merging road. In addition, because the percentage of hazard anticipation among the motorcyclists can be considered as low (46.5%), thus, a recommendation can be made to the respective authority to improve the current riding education program such as to promote and provide more information about hazard anticipation.*

***Keywords**: Hazard Anticipation, Merging Road, Motorcyclists, Expressway, Observational Study, Road Safety*

INTRODUCTION

World Health Organization (WHO) reported that road traffic injuries are the eight leading cause of death worldwide. It was estimated that, the number of road traffic deaths yearly is approximately 1.35 million (World Health Organization, 2018). On average, the number of road deaths is reported to be around 3,287 daily (Association for Safety International Road Travel, 2014). The rise of road traffic deaths is at an alarming state, where it has become the leading causes of death among children (aged five to fourteen) and young adults (fifteen to twenty-nine). Moreover, more than half of the road deaths in the world involved pedestrians, cyclists and motorcyclists (World Health Organization, 2018).

Based on the Ministry of Transport Malaysia, in 2017, the total number of road accidents reported to be roughly half a million and increase by one percent from the previous year (Ministry of Transport Malaysia, 2017). The statistics by WHO shows that, Malaysia has the third deadliest of road accident deaths in ASEAN and Asia. It recorded a 23.6 out of 100,000 road accident and more than half of it involved motorcyclists (World Health Organization, 2018). Motorcyclist is among the vulnerable road user group with no external protection when facing hazard. A study conducted by Manan and Varleyhi (2012) found that, most of the Malaysian motorcycle fatalities occurred along straight road sections. By looking at the type of road geometry, straight road and curve road contributed to nearly 90% of motorcyclists' fatalities when compared to T-junction, cross-junction and others type of road geometry (Manan & Varleyhi, 2012). The number of road traffic deaths at straight road is three times higher than the curve road (Darma et al., 2017). Thus, more focus should be given on this type of road geometry.

The involvement of motorcyclists in the large part of road crashes, and the causes of it is still far from understanding. Generally, several studies have been conducted to observe the behavior of motorcyclists, to be specific during merging in different types of traffic, for instance at; an urban expressway (Adnan et al., 2018), campus environment (Ahmad et al., 2017) and, highway and town environment (Zabidi et al.,

2016). These studies, highlight the head check behavior of motorcyclists during merging in traffic and shows how well motorcyclists anticipate hazard on the road. Hazard anticipation is crucial in making sure the safety of road user, especially among the young and novice rider. Driving or riding curriculum in Malaysia is still lack in the aspect of safe riding. Hence, to improve hazard anticipation behavior among motorcyclist, the curriculum need to be revamped and more emphasized on hazard anticipation skills should be given to the rider. Besides that, they need to learn how to handle motorcycle in risky driving situation instead of just focusing on testing how to balance and manoeuvre motorcycle in normal situation (Jabatan Pengangkutan Jalan Malaysia, 2015).

The aim of this study is to observe the effect of merging road design on hazard anticipation behavior among motorcyclists during merging in traffic. To obtain the aim, two objectives were set to be achieved: (i) to evaluate hazard anticipation behavior among motorcyclist during merging into an urban expressway and (ii) to evaluate the effect of merging road design on motorcyclists hazard anticipation behavior during merging into an urban expressway.

METHODS

Area of the Study

The area of study was along the Kuala Lumpur Middle Ring Road 2 (MRR2). Like any other riding or driving research, the area covered in this study is ample enough to generalize hazard anticipation behavior of motorcyclists' while merging in traffic (Zabidi et al., 2016).

Participants

For this study, 3200 motorcyclists were observed. There is no restriction on the motorcycles observed, for instance, type of license owned by motorcyclist, type of motorcycle used, color of motorcycle or CC (cubic centimeters) of the motorcycle engine. Gender, age and ethnic background were also not considered in the study.

Scenarios

In other similar observational study, the number of scenario varies from three (Garay-Vega, 2008), four (Samuel et al., 2013), eight (Manan & Varleyhi, 2013) and sixteen (Adnan et al., 2018) scenarios. Hence, for this study sixteen scenarios were chosen and considered sufficient to be conducted. Mainly, the scenarios involve leaving road – the road that motorcyclist are coming from – and the road that the motorcyclist will merge into.

All the scenarios were named according to the signature of the place or nearby building area. Two types of road segment were observed in the study, namely straight road and curved road. Each type of road design consist of eight chosen scenarios. In the straight road segment, the scenarios were as follow; (i) Golek – Golek, (ii) Kepong, (iii) Ford Service, (iv) Giant Permata, (v) Batu Caves, (vi) Dunlop Permata, (vii) Genting Klang and (viii) PETRONAS Karak.

In the curve road segment, the scenarios were as follow; (i) Melawati, (ii) PPR Ampang, (iii) Cempaka, (iv) Pandan Indah, (v) Dataran Pandan Indah, (vi) PPR Intan Baiduri, (vii) Desa Tun Razak and (viii) Auto City.

There were two zones known as launch zone (labelled as A) and target zone (labelled as B) in Figure 1, 2, 3, and 4 below. The launch zone is the area in which it is crucial for a motorcyclist to anticipate hazard while target zone is the area where potential hidden hazard might emerge (Hamid et al., 2013). The Genting Klang scenario and PPR Ampang, will be used as an example to show the details of the environment scenarios in straight road and curve road respectively.

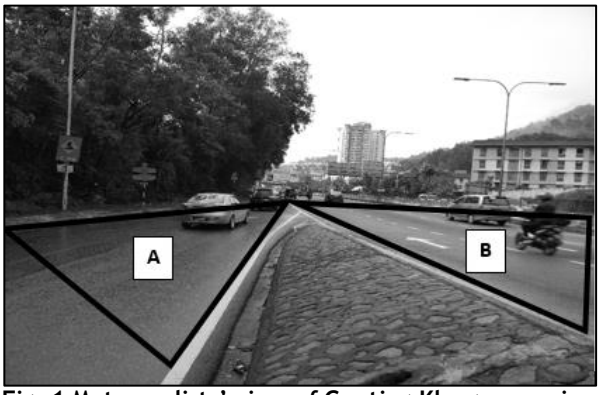

Fig. 1 Motorcyclists' view of Genting Klang scenario

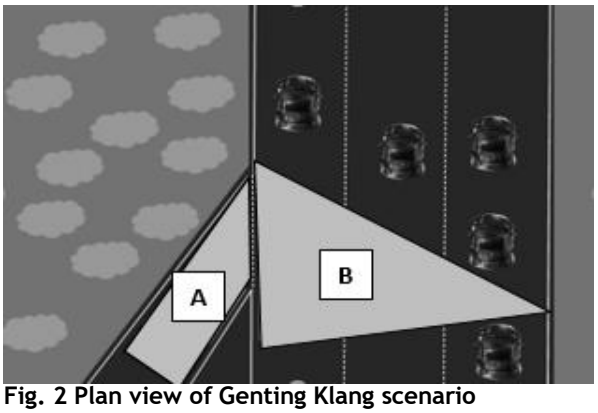

Fig. 2 Plan view of Genting Klang scenario

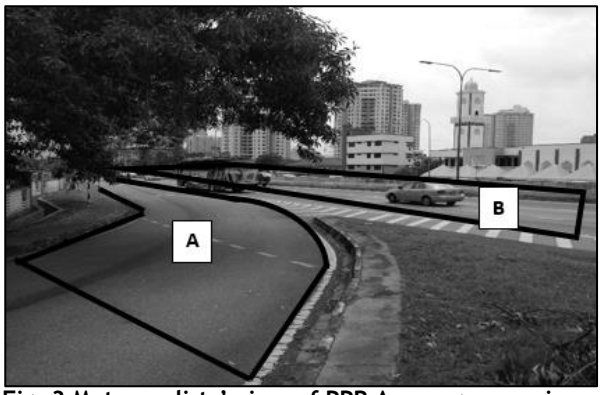

Fig. 3 Motorcyclists' view of PPR Ampang scenario

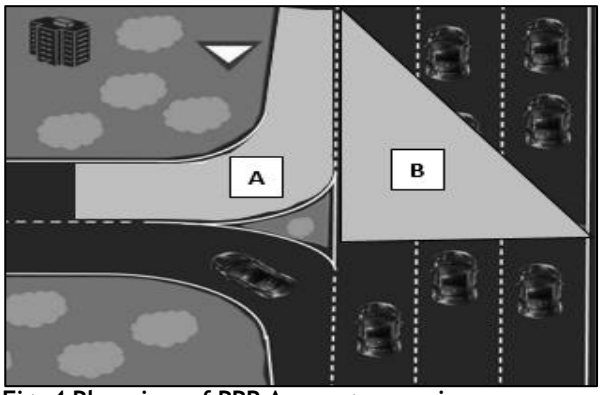

Fig. 4 Plan view of PPR Ampang scenario

Apparatus and Stimuli

Safety cone: To ensure the safety of observer during the experiment, a safety cone was placed nearby the observer.

Smartphone: Xiaomi Mi5 smartphone was used. The smartphone was used to take picture of the scene through the motorcyclists point of view.

Video recording system: Panasonic HC-V210 video recorder was used to record videos and capture images of the motorcyclists during the observation. A DigiEye TR-37 tripod was used to ensure the stability of video recorder. Besides that, SanDisk memory card was used in the video recorder which can store up to 32 gigabytes data.

Portable hard disk: A 1TB Seagate portable hard disk was used to store all the videos from the recording to be analyzed.

Score sheet: The score sheet was used to keep track of the data in each scenario during obsevation. On the sheet, the observer will have: (i) name oft he scenario; (ii) day, date and time of the observation; (iii) remark of the observation if any and; (iv) score of the observation.

Design of the Study

The study was conducted on Monday, Tuesday, Wednesday and Thursday only. Friday and weekends were excluded to eliminate any possible effect on the motorcyclist behavior (i.e. motorcyclists alertness) (Adnan et al., 2018). The obesrvation was conducted only on good weather condition (i.e not raining). The recording of the experiment was divided into two slots which were morning slot and evening slot. The morning slot were from 9:00 A.M. to 12:00 P.M. while the evening slot were from to 2:00 P.M. to 5:00 P.M.

Scenario counterbalancing was applied to eliminate confounding variables in the experiment. This is by making a slight different treatment to different participant groups (Andale, 2017). The scenarios were catagorized into two road segment namely straight road and curve road. Latin Square is a set of numbers arranged in which there will be only one number in a row or column (Weisstein, 2010). The scenarios were labelled as S1, S2, S3, S4, S5, S6, S7, S8, C1, C2, C3, C4, C5, C6, C7 and C8. The letter S and C represents the road design of the scenario – S for straight and C for curve. The number – 1,2,3,4,5,6,7 and 8 – were simply assigned to each of the scenario to differentiate the eight scenarios in both road design. The observation at each of the scenario was run twice, both were on different time and day. Table 1 below shows the arrangement of scenarios that were observed.

Table 1 Arrangement of scenarios that were observed

		Monday	Tuesday	Wednesday	Thursday
Week 1	Morning	C1	S7	S2	S6
	Evening	C7	S5	C4	S2
Week 2	Morning	S4	C3	S1	C2
	Evening	S3	S6	S8	S7
Week 3	Morning	C5	C8	C6	S5
	Evening	C2	C5	S4	C1
Week 4	Morning	S8	C7	S3	C4
	Evening	S1	C6	C8	C3

Procedure

On a particular day, Table 1 above was referred to select the scenario to be observed. Once selected, the observer went to the scenario location and a monitoring system was setup. The monitoring system consist of the video recorder and it was setup to cover both the launch zone and target zone area. Once the setup was completed, the scoring sheet was used to fill in the details of the scenario location – name, day and time. Then, the observation was started, in which a hundred motorcyclists were observed at a particular observation period and their behavior (either motorcyclist turn his or her towards the target zone) were recorded. Once the observation is finished, the video data was transferred into a video data storage and was further analysed.

Variables and Hypotheses
Dependent Variable 1: Hazard anticipation behavior (overall) - percentage of hazard anticipation behavior of motorcyclists; if a motorcyclist turn his or her head towards the target zone while in the launch zone he or she will be scored 1, and if not, he or she will be scored 0.

Hypothesis 1: Hazard anticipation behavior (overall) – hazard anticipation behavior among motorcyclist is low, thus motorcyclist will turn his or her head less frequently due to lack of knowledge or experience (Haworth, Symmons & Kowadlo, 2000).

Dependent Variable 2: Hazard anticipation behavior (different types of road design)

Hypothesis 2: In straight road – motorcyclist will turn his or her head less frequently to anticipate hazard. This is parallel with study by Adnan et al., (2018) where the number of motorcyclists who performed head check is less than the number of motorcyclists who did not performed head check. In curve road – motorcyclists turn their head more frequently, because they cannot see the incoming hazard (Olsson, 2011).

RESULTS

In this study, 3200 motorcyclists were observed at sixteen selected scenarios – eight scenarios for each straight road and curve road - around the Kuala Lumpur MRR2 area.

Overall percentage of hazard anticipation behavior among motorcyclists
Figure 5 below shows the overall percentage of hazard anticipation behavior performed by motorcyclists during merging in traffic at each scenario location (straight and curve road scenarios).

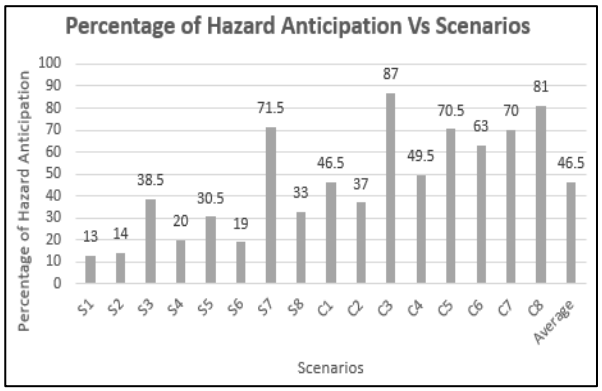

Fig. 5 Overall percentage of hazard anticipation behavior in each scenario

It can be seen in Figure 5 the average percentage of motorcyclists who did not practised safe riding behavior is higher (53.3%) than the percentage of motorcyclists who practised safe riding behavior (46.5%). Majority of the motorcyclists in straight road area have lower percentage of hazard anticipation skills. Only in S7 scenario the percentage of hazard anticipation performed by motorcyclists is more than two-third (71.5%) compare to the number of motorcyclists who did not performed. From the results, scenario in S7, C3, C5, C6, C7, and C8 shows more than half of the motorcyclists have higher percentage of hazard anticipation behavior. The percentage of hazard anticipation behavior in curve road shows that most of the motorcyclists do practice safe riding behavior except in C1, C2 and C4 scenario. The results was further analyzed by using the chi-square goodness fit test. The null hypothesis was rejected, x^2 (1) = 15.680, p < 0.0001.

Comparison of straight road and curve road on the percentage of hazard anticipation behavior
Figure 6 below illustrates the comparison between hazard anticipation behavior of motorcyclists during merging in traffic at straight road and curve road situation.

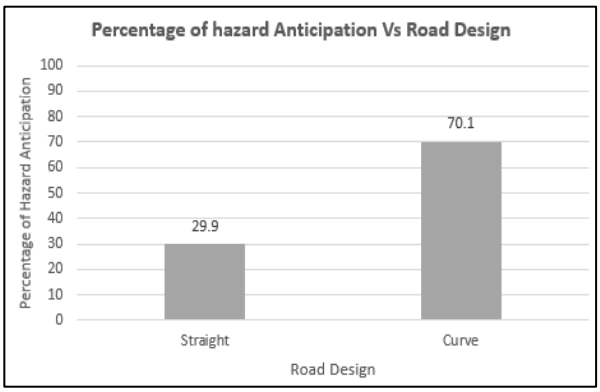

Fig. 6 Comparison of average percentage of hazard anticipation behavior by road design

Based on Figure 6, the average percentage of hazard anticipation by motorcyclists during merging in curve road is two times higher than in straight road. The percentage different beween straight road and curve road is 40.2%. Thus, accept the hypothesis made earlier in which the percentage of hazard anticipation by motorcyclists during merging at curve road will be higher than straight road. In straight road category, most of the scenarios are not far off from the average value except for S1 and S2 – which are among the least, and S7 – which is doubled the average value. Based on the straight road scenario, S7 scenario is considered to promote a better hazard anticipation behavior among motorcyclsists. Next for curve road segment, most of the scenarios are not far off from the average value except for C2 – in which it is far off from the average percentage. The graphs illustrate that, curve road design increase the hazard anticipation behavior among motorcyclists during merging in traffic. On the other hand, straight road design causes

mototrcyclists to less anticipate hazard during merging in traffic.

DISCUSSION

Overall percentage of hazard anticipation behavior among motorcyclists

Based on the findings in Figure 5, overall percentage of hazard anticipation behavior performed by motorcyclists is lower than the number of motorcyclists who performed it. In general, the results indicate that most of the Malaysian rider do not practice safe riding behavior, as less than half of the motorcyclists (46.5%) performed hazard anticipation behavior during merging in traffic. Comparing to other studies, this finding is congruent with the findings by Zabidi et al., (2016) where they found that 60.1% of motorcyclists did not performed head check during merging in traffic. Besides that, Adnan et al., (2018) also found that, two-third of motorcyclists did not performed head check during merging into an urban expressway.

The poor behavior of hazard anticipation among motorcyclists can be relate to the driving or riding curriculum which did not emphasize more on hazard anticipation skill. Motorcyclists is not exposed more on the practical side of riding in the real environment, especially in risky traffic situation and how to detect and respond to incoming hazard on the road (Jabatan Pengangkutan Jalan Malaysia, 2015). A large part of the motorcyclists training only focus on training the rider in a small circuit track and theory aspect (Jabatan Pengangkutan Jalan Malaysia, 2015).

Furthermore, in S1 and S2 scenario, the percentage of hazard anticipation behavior are the lowest and both have a longer merging lane compared to others. It can be assume that, the longer merging lane causes motorcyclist not to aware much on the incoming hazard because they have enough time to merge safely into traffic. On top of that, motorcyclists prefer to use the side mirror rather than turning their head to scan for any incoming hazard. On the other hand, S7 scenario has the highest percentage of hazard anticipation in straight road. This scenario has a shorter length of merging lane compared to others. The shorter length of merging lane causes the motorcyclists to frequently monitor the traffic condition before merging. This assumption can be supported by the findings of Adnan et al., (2018) in which shorter merging lane does not provide motorcyclists with ample time and space to merge into traffic safely. Shorter merging lane cause the motorcyclists to have a short period of time to manoeuvre their motorcycles during merging in traffic.

In curve road scenario, C2 scenario has the lowest percentage of hazard anticipation behavior. In this scenario, the length of merging lane is longer compared to other curve road scenario. The same explanation can be made, in which longer merging lane decrease hazard anticipation behavior of motorcyclists. Motorcyclists assume that, longer merging lane will provide sufficient time to manoeuvre motorcycle and merge safely into traffic.

Comparison of straight road and curve road on the percentage of hazard anticipation behavior

By comparing the road design – straight road and curve road – the average percentage of motorcyclists who performed safe riding behavior in curve road is higher compared to straight road. The percentage of hazard anticipation in curve road (70.1%) is double the percentage in straight road (29.9%) scenario. The curve road design promote higher hazard anticipation behavior among the motorcyclist, in contrast, the straight road lead to lower hazard anticipation by motorcyclists. The findings is align with the data by Darma et al., (2017) in which, the number of road traffic deaths is the highest in straight road segment is because of the low performance of hazard anticipation in this type of road segment. Less awareness in anticipating incoming hazard may cause the road crashes to be higher in this type of road segment. In addition, straight road design may cause the road user to become less focus and decrease attention due to the monotony of the road.

Conversely, the design of curve road helps in reducing monotony on the road causes motorcyclists to be more aware of the surrounding environment (Rohani et al,. 2015; Diew, 1989). In curve road scenario, motorcyclists need to perform several action before they can complete a safe merge. In this scenario, motorcyclists need to slow down along the curve and align with the main traffic. Besides that, the mean speed of road user at curve road is lower than the straight road (Rohani et al., 2015; Abele & Moller, 2011).

The findings from this study shows that, curve road design helps in promoting better hazard anticipation behavior among motorcyclists during merging into an urban expressway. However, further research can be done to see whether similar results can be obtain in other types of road environment such as in rural, town and residential area. Besides that, study on the curve road scenarios can be focused on several more things for example vegetation, road environment and angle of the curve.

CONCLUSION

In conclusion, hazard anticipation behavior among motorcyclists is poor. From the study, 46.5% of Malaysian motorcyclists perform hazard anticipation while merging in traffic. Lack of training and exposure in the driving or riding curriculum may be the cause that lead to this behavior. Next, when comparing different road design on motorcyclists hazard anticipation behavior, it was found that curve road increase hazard anticipation behavior of motorcyclists compare to straight road.

Contibution: The outcome from this study provide additional information on hazard anticipation behavior among motorcyclists during merging in traffic. The overall low percentage of hazard anticipation by motorcyclists during merging in traffic – which is 46.5% - shows that more than half of them are not aware of the importance of hazard anticipation. This indicates that Malaysian motorcyclists do not practice safe riding behavior and are at more risk to get into accident. This study can be used as a point to revise the curriculum in driving school and promote awareness among motorcyclists in Malaysia.

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