

ORIGINAL ARTICLE

EVALUATION OF MOTORCYCLISTS' HAZARD ANTICIPATION BEHAVIOR AT UNSIGNALIZED ROUNDABOUTS: ON-CAMPUS VS. OFF-CAMPUS

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ABSTRACT

Annually, more than 1 million teenagers and young adults died in road traffic crashes, and road traffic accident is one of the alarming causes of mortality rate in Malaysia. Motorcyclists are among the most vulnerable road users and this is mostly due to improper riding behavior. This study focuses on improper behavior - performance of the hazard anticipation - of motorcyclists when entering the roundabout. The objectives of this study were; (i) to evaluate the percentage of overall hazard anticipation behavior among motorcyclists during entering roundabouts; (ii) to compare the hazard anticipation behavior among motorcyclists during entering roundabouts with different road environment - on-campus vs. off-campus roundabouts. A naturalistic observation was done at eight scenarios - four at on-campus roundabouts and four at off-campus roundabouts. Dependent variable for this study was the percentage of hazard anticipation among motorcyclists before entering the roundabouts. If a motorcyclist anticipated hazards towards the target zone (the area which the potential hazard may merge) while in the launch zone (the area of two second before merge onto the roundabout). On average, only 54.5% of the motorcyclists anticipated the hazards, while the other 45.5% did not anticipated the hazards. The data was then analyzed by using the chi-square goodness of fit test. The null hypothesis - the equal performance - was rejected, $\chi^2(1) = 6.480$, $p = 0.011$. Comparing the effect of the road environment where the roundabouts are located, the result shows that there was a significant difference in the percentage of hazard anticipated for on-campus scenarios ($M=30.75\%$, $SD=13.28$) and off-campus scenarios ($M=78.25\%$, $SD=11.18$) conditions: $t(6) = -5.474$, $p=0.002$. Thus, the null hypothesis for this comparison - the equal performance - was rejected. This result suggests that location of the roundabout (either on-campus or off-campus) do effect the hazard anticipation behavior among motorcyclists. In general, these findings suggest that an improvement in the current riding education program is needed, as well as to facilitate more awareness program to promote concern on hazard anticipation among motorcyclists.

Keywords: *Motorcyclists Behavior, Head Check, In-Campus and Off-Campus, Observational Study*

INTRODUCTION

Every year, 1.24 million people of 15-29 years of age die under the road traffic crashes and become one the most causes of death among people (World Health Organization, 2004). The middle-income countries, i.e. African and Eastern Mediterranean, have claimed almost 90% of deaths, resulted from road traffic injuries (World Health Organization, 2004). Apart of the number of death, there are approximately tens of millions of people that are injured and disabled every year, mainly caused by road traffic (World Health Organization, 2004).

In Malaysia, there are accumulative registered motorcycles with a rate of 70% among the 6.2 million active vehicles registered, and 113,962 out of them involved in road accidents causing fatalities to 3,640 riders in 2011 (Malaysian Institute of Road Safety Research, 2011). Every year, the number of registered motorcycles is rapidly increase, and every year, road accidents is claim at least 1% of the registered motorcycles (Malaysian Institute of Road Safety Research,

2011). Thus, it is important to conduct an in-depth study of motorcycle crashes with the increasing number of motorcycle fatalities each year in order to develop more appropriate countermeasures (NHTSA, 2010).

Hazard anticipation is an action of road users to anticipation potential hazard that may emerge and result a collision among the road users. Several studies have shown that, hazard anticipation is a crucial issue in road safety. It has been shown that younger novice drivers are less able to anticipate hazards ((Fisher, Pradhan, & Knodler, 2007); (Pradhan, Pollatsek, Knodler, & Fisher, 2009)), motorcyclists are less able to glance toward hazards at the intersection (Muttart, et al., 2014), and motorcyclists performed less head check during merging in traffic (Zabidi, et al., 2016). Thus, is it crucial to study more on the performance among motorcyclists in anticipating hazards during riding to improve the road safety situation.

For this project, the hazard anticipation behavior among motorcyclists before entering the

unsignalized roundabouts would be the focus. Roundabout is a circular intersection with an island at its center (The British Columbia Ministry of Transportation and Infrastructure, 2008). A roundabout is designed to ensure the smooth traffic flow and help control the mass number of vehicles at one time (Department of Transport and Main Roads Queensland, 2012). Safe riders would slow down - stop if necessary - and prepare to give way to the vehicles inside the roundabout if he or she see a roundabout sign as soon as they approaching the roundabout (Department of Transport and Main Roads Queensland, 2012). The riders need to indicate their intention when approaching the roundabout so that other vehicles can enter the roundabout and they can exit the roundabout safely (Department of Transport and Main Roads Queensland, 2012).

However, in Malaysia riding program, hazard anticipation is still a new approach, and so much is needed to improve it. In explanation, anticipate the hazard is a one thing, and what to anticipate is another. Currently, there is no proper procedure in addressing this issue. Currently, there is no prevalence study on the hazard anticipation behavior among motorcyclists before entering the roundabouts, and this study will address this issue. This data is important to be obtained so that a recommendation could be made to the authority to include the concern in the riding education program so that it could potentially promote the hazard anticipation among motorcyclists so that it could improve the road safety.

The objectives of this naturalistic observation are; (i) to evaluate motorcyclists' hazard anticipation behavior during entering the roundabouts; (ii) to compare the difference of motorcyclists' hazard anticipation behavior during entering roundabout in different environments - on-campus and off-campus roundabouts.

METHODS

Area of the Study

The area of study was the Klang Valley metropolitan area. Like any other riding or driving research, this scope is sufficient enough to generalize motorcyclists' hazard anticipation behavior during entering roundabouts rather than to generalize it to any particular population (e.g. Hamid, Divekar, Borowsky, & Fisher, 2013).

Type of the Study

Naturalistic study was done in which natural observation of 800 motorcyclists during entering roundabouts - 400 motorcyclists at four on-campus roundabouts and 400 motorcyclists at four off-campus roundabouts - were observed. Natural observation consists of observing a

behavior in its own natural living with no interruption on the part of the investigator (Cherry, 2014). Therefore, naturalistic observation method was chosen in order to obtain prevalence of the motorcyclists' hazard anticipation behavior during entering roundabouts. This study was only focuses on unsignalized roundabout.

Scenarios

There were eight scenarios were selected in this study. In general, each scenario involves the *launch zone* - an entering road that motorcyclists are coming from, and the zone is about two seconds before entering a roundabout - and *target zone* - the area in which motorcyclists should anticipate hazards before entering a roundabout (i.e. to the left side of the roundabouts as Malaysia is a left hand side driving). The eight scenarios were classified into two categories - on-campus and off-campus. The first are those roundabouts that located inside college areas, and the latter are roundabouts that located outside campus areas (Note: Most of Malaysia Campuses are gated community). Scenarios of each category will be listed below, and an example of each will be described.

On-campus Scenario: There are four scenarios were observed namely: (i) IIUM; (ii) UKM; (iii) UPM; and (iv) UNITEN. These scenarios were named after the name of the college they are located. Example of the IIUM scenario will be described below. Figure 1 and 2 illustrates the motorcyclists' view and plan view of the IIUM scenario. The launch zone and target zone are labelled as A and B respectively.



Figure 1: Motorcyclists' View of IIUM Roundabout

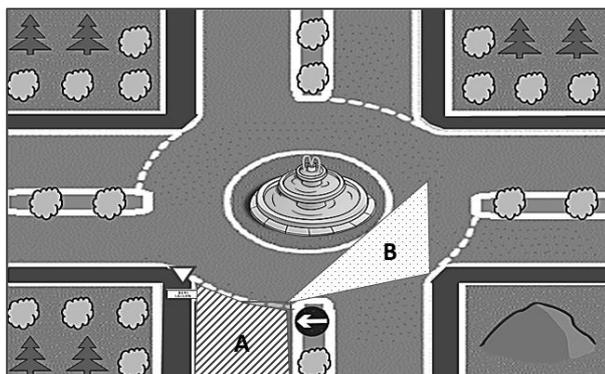


Figure 2: Plan View of IIUM Roundabout

The entering road consist of two lanes and it is separated from the opposing lanes with an island of garden. The roundabout consists of four exits with an island in the center. The surrounding environments include the pedestrian walkway, bushes, trees, and IIUM great fountain at the center of the roundabout.

Off-campus Scenario: There are four scenarios were observed namely: (i) Loke View; (ii) Salak South; (iii) Jalan Duta; and (iv) Jalan Ipoh. These scenarios were named after the name of the road they are located. Example of the Loke View scenario will be described below. Figure 3 and 4 illustrates the motorcyclists' view and plan view of the Loke View scenario. The launch zone and target zone are labelled as A and B respectively. The entering road consist of two lanes and it is separated from the opposing lanes with a median strip. The roundabout consists of four exits with an island in the center. The surrounding environment includes several businesses building and a flyover that crossing the middle of the roundabout.



Figure 3: Motorcyclists' View of Loke View Roundabout

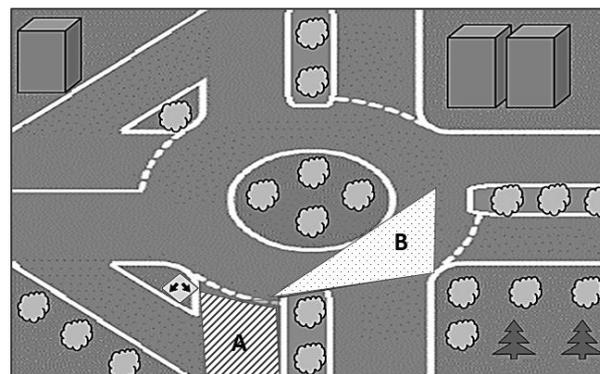


Figure 4: Plan View of Loke View Roundabout

Other Apparatus

In the study, a video recording system - Panasonic HC-V210 - was used. During the playback, data analyst would be able to see all the video output (i.e. just like any other regular video recording system) of a certain location or time during the observation. Time stamp and date will be on the video output. In addition, a tripod - DigiEye TR-37 - was used as a stand for the video recorder (i.e. to minimize the vibration occurrence during the recording). The battery lifetime of the system is about 2 hours. Therefore, a spare battery was prepared as a backup. The system also includes a memory card Sandisk for the recording. The size of the memory card is 32 gigabytes. A spare memory card of the same model and size was prepared as a backup. Video data storage - Seagate - was used to store the recorded video data. The capacity of the storage is 1 terabyte and estimated to be able to store about 63 hours of video recording of the system used. Duct tape was used in this study to mark the launch zone of each scenario. This was to make sure that the scoring phase become easier and standardize. The chosen color of the duct tape is red because it will be contrast to the major background of surrounding environments - e.g. green for grass, gray for road, white for road's lines. A scoring sheet was designed to administrate the scoring during the observation. On the scoring sheet there were column for scenario name, date, time taken, and a column for scoring.

Study Design

The study was conducted on Monday, Tuesday, Wednesday, and Thursday. Friday and the weekends will be excluded. This was to avoid any potential factoring effects on the motorcyclist behavior (e.g. the mood among motorcyclists would be different during the weekend comparing to the weekdays, and Friday in Malaysian involves a longer lunch hour due to the Friday prayer). The time of a day to conduct the observation was classified into two three-hours-slots - namely morning and evening. The morning and evening slots were from 9.00 a.m. to 12.00 p.m. and 2.00 p.m. to 5.00 p.m. respectively. Time period from 12:00 p.m. to 2:00 p.m. was

excluded to avoid the rush hours due to the lunch hours (i.e. different traffic congestion).

Scenario Counterbalancing: The scenarios were arranged such that sequencing of the scenarios to be observed was counterbalanced in term of the day and time they are being observed. A Latin Square was used to counterbalance the scenarios. The scenarios were labelled as R1, R2, R3, R4, R5, R6, R7 and R8. The letter R represents the roundabout. The numbers - 1, 2, 3, 4, 5, 6, 7 and 8 - are simply assigned to the scenarios to differentiate them. The arrangement of the scenarios observed is shown in Table 1 below. As can be seen from Table 1, for each scenario, let take an example of R1, the observations were run on the different day (one on Monday, and one on Tuesday) and different time slot of the day (one during morning slot, and one during evening slot).

Table 1: Scenarios counterbalancing

	Monday	Tuesday	Wednesday	Thursday
AM	R1, R8	R2, R5	R3, R6	R4, R7
PM	R5, R4	R6, R1	R7, R2	R8, R3

Procedure

The procedure for this study were categorized into three phases - pre-observation, during observation, and post-observation.

Pre-observation: On a particular day of the study, a scenario was chosen to be observed based on the Latin Square designed. At the chosen scenario's location, duct tape was pasted to mark the launch zone of the scenario. This was to make sure that the experimenter will be able to score the observation. After that, the video recorder system was set up. The tripod was stood on the flat surface for a quality video recording and the angle of the video was checked to ensure that the launch zone and the target zone can be seen clearly in the LCD monitor of the video recorder.

During Observation: The details of the observation - scenario name, day, time - was filled on the scoring sheet. After that, the observation was done and scored.

After Observation: The data was transferred into the video data storage, and was kept safely in the locked laboratory's cabinet for future use.

Variables and Hypotheses

Dependent Variable: Percentage of hazard anticipation performed by motorcyclists. If a motorcyclist turning their head toward the target zone while in the launch zone, he or she was scored 1, else 0.

Hypothesis 1: Overall Behavior

H_0 = The percentage of motorcyclists who anticipated hazard before entering the

roundabouts is equal to the percentage of motorcyclists who did not anticipated hazard before entering the roundabouts.

H_1 = The percentage of motorcyclists who anticipated hazard before entering the roundabouts is not equal to the percentage of motorcyclists who did not anticipated hazard before entering the roundabouts.

Hypothesis 2: Comparison between on-campus and off-campus scenarios

H_0 = The percentage of hazard anticipation performed by motorcyclists at the on-campus scenarios is equal to the percentage hazard anticipation performed by motorcyclists at the off-campus scenarios.

H_1 = The percentage of hazard anticipation performed by motorcyclists at the on-campus scenarios is not equal to the percentage hazard anticipation performed by motorcyclists at the off-campus scenarios.

RESULTS

Overall Behavior

In total, 800 motorcyclists were observed at eight scenario locations (n=100 for each scenario). Figure 5 illustrates the percentages of motorcyclists who anticipated and did not anticipated hazard at each scenario locations and the average of all the scenarios. On average, only 54.5% (yes: n=436) motorcyclists anticipated the hazard (turning his or her head towards the target zone while in the launch zone). The data was then analyzed by using the chi-square goodness of fit test. The null hypothesis was rejected, $\chi^2(1) = 6.480$, $p = 0.011$.

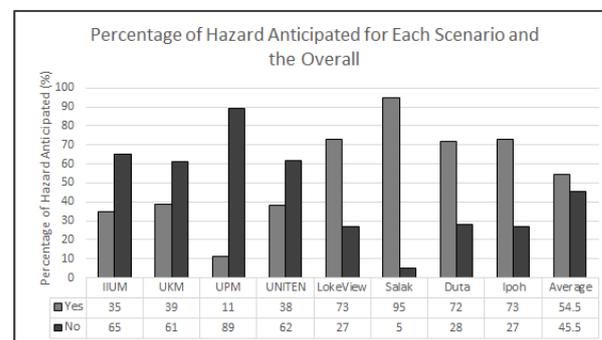


Figure 5: Percentage of motorcyclists who anticipated the hazard before entering the roundabouts

Comparison between on-campus and off-campus scenarios

In total, 400 motorcyclists were observed at four on-campus roundabouts, and 400 motorcyclists were observed at four off-campus roundabouts. Figure 6 illustrates the percentage of hazard anticipated at on-campus scenarios. At on-campus roundabouts, only 30.75% of motorcyclists observed did anticipated the hazards. The pattern at each scenario are similar in which the percentage of motorcyclists who did

anticipated the hazard are always less than who did not anticipated the hazard.

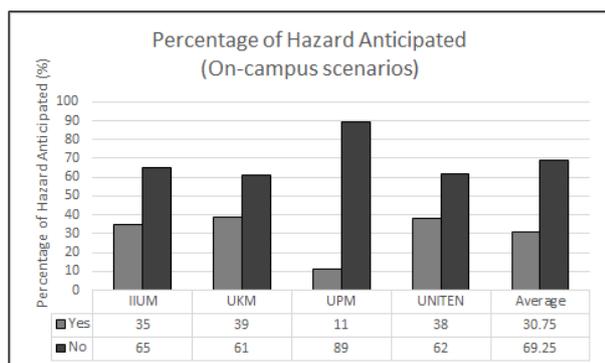


Figure 6: Percentage of Hazard Anticipated (On-campus scenarios)

Figure 7 illustrates the percentage of hazard anticipated at off-campus scenarios. At off-campus roundabouts, 78.25% of motorcyclists observed did anticipated the hazards. The pattern at each scenario are similar in which the percentage of motorcyclists who did anticipated the hazard are always greater than who did not anticipated the hazard.

In order to analyse the difference of hazard anticipation behaviour among the motorcyclists between the on-campus and off-campus scenarios, independent sample t-test was utilized. The SPSS output showed that there was a significant difference in the percentage of hazard anticipated for on-campus scenarios ($M=30.75\%$, $SD=13.28$) and off-campus scenarios ($M=78.25\%$, $SD=11.18$) conditions: $t(6) = -5.474$, $p=0.002$. Thus, the null hypothesis for this comparison is rejected. This result suggests that location of the roundabout (either on-campus or off-campus) do effect the hazard anticipation behavior among motorcyclists.

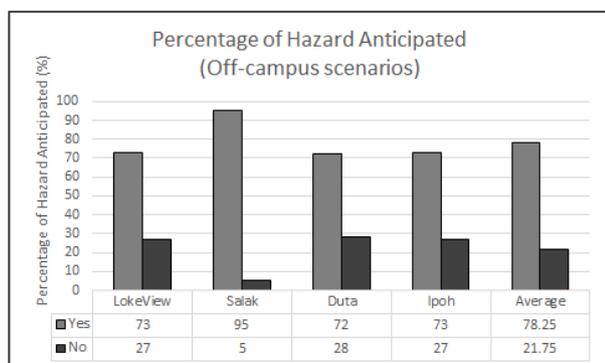


Figure 7: Percentage of Hazard Anticipated (Off-campus scenarios)

DISCUSSION

The first result showed that, in overall, almost half of the motorcyclists (45.4%) did not anticipated the hazard. This suggest that motorcyclists are not concern with the importance of hazard anticipation during riding.

This finding agreed with finding in Zabidi (2016), where he found that 60.1% of motorcyclists did not performed a head check during merging in traffic. With this finding, it suggests that the current riding education program in Malaysia need to be tailored so that it would encourage more awareness about hazard anticipation among the motorcyclists.

The second result is comparing the behavior of hazard anticipation among the motorcyclist at two difference environment - on-campus and off-campus. The result showed that, only 30.75% of the motorcyclists did anticipated the hazard before entering the on-campus roundabouts. In contrast, the opposite finding was observed at the off-campus roundabouts, in which 78.25% of the motorcyclists did anticipated the hazard before entering the roundabouts.

One particular reason for this finding is that, the size of the roundabouts (smaller for on-campus roundabouts, and larger for off-campus roundabouts) do reflect the speed choice of the riders. The larger roundabout will enhance the probability of higher circulatory speed of the vehicle - can lead the vehicle to exceed 30mph (The Department of Regional Development Northern Ireland, 2007). Thus, with the higher speed of vehicles inside the roundabouts, by experience, will encourage other riders (who are about to enter the roundabout) to anticipate the hazards before entering the roundabout. Average speed of the vehicles should be 30km/h when rotating the roundabout without traffic light (Chimdessa, Kassa, & Lemecha, 2013). Thus, as the larger roundabouts would lead the vehicle to exceed 30mph, no wonder it was reported that high proportion of shunt accidents mostly occurs on large roundabout rather than small roundabout (The Department of Regional Development Northern Ireland, 2007). Therefore, it should be promoted that regardless of the size of the roundabout, motorcyclists should have maintained their vehicle speed do not exceed 30mph, and be more careful by anticipating the potential hazards before entering the roundabout.

Another reason for this finding is the traffic congestion. It was noticed that the traffic congestion is heavier at the off-campus roundabouts rather than on-campus roundabouts. The traffic congestion does reflect the rider performance, in which, riders would be more caution with the heavier traffic and anticipate hazard more than rather than that lighter traffic environment. It is also a possibility that, the familiarity of the road environment among the on-campus riders would result a less caution on the importance of hazard anticipation.

There is one crucial limitation in this study. In this study, motorcyclists were observed and

scored based on their performance of 'turning head toward the target zone while in the launch zone'. There is potential that motorcyclists are prefer to just glance (moving their eyes) toward the target zone instead of turning their head. The method used in this study is unable to address this issue. Thus, it is recommended that, future study should consider to monitor the eyes' glance as well. It is interesting to discuss that; it is almost not possible to do this by naturalistic observation method. In addition, to run a field study would jeopardize the safety of the participant (unless the experiment is being done in the control track). Thus, it is highly recommended that such study should be conducted through the simulation study, in which, the environment is safer, and the application of eye tracker per se could recorded the performance of the riders' eyes.

CONCLUSION

In overall, almost half of the motorcyclists (45.4%) did not anticipated hazards before entering the roundabouts. Comparing the on-campus and off-campus roundabouts, on average, it was found that the hazard anticipation performance among the motorcyclists are better at the off-campus roundabouts (78.25%) rather than at the on-campus roundabouts (30.75%). These findings suggest that an improvement in term of safety procedure during entering roundabouts (i.e. hazard anticipation) of the current riding education program is needed.

ACKNOWLEDGMENTS

The research was supported by the Malaysian Ministry of Higher Education through the RAGS 2015-1 grant to International Islamic University Malaysia (Malek Hamid, PI). This study was also supported by the Department of Manufacturing and Materials Engineering, International Islamic University Malaysia, Malaysia.

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