ORIGINAL ARTICLE

STOPPING AND HAZARD ANTICIPATION BEHAVIORS AMONG MOTORCYCLISTS AT UNSIGNALIZED T-JUNCTION: A FIELD STUDY

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ABSTRACT

Hazard anticipation is an essential skill for the road user, especially the vulnerable road user group. This is because the vulnerable road user group have the highest risk of road injuries due to no external protection. Among the group, the number of road deaths involving motorcyclists is at an alarming state. By comparing the number of road accidents at the intersections, T-junction has a higher rate than cross-junction. Thus, the aim of the study is to evaluate motorcyclists' behavior at the unsignalized T-junctions. The objectives are: (i) to evaluate the stopping behavior of motorcyclists at the stop area when approaching the T-junction; and (ii) to evaluate the head movement behavior of motorcyclists before turning into traffic. A field study was conducted at fifteen scenarios that were combined into one complete circuit. Twenty male participants between the ages of 18-29 years old were recruited for the study. The participants were equipped with a head tracker in order to analyse their stopping behavior and head movements at the T-junctions. Dependent variables for this study were the stopping behavior and the hazard anticipation score of motorcyclists. If a motorcyclist stops at T-junction before entering the primary route, he was scored 1, and 0 if not stopping. Besides, a motorcyclist was also scored 1 if he performed head movement (anticipate potential hazard) before entering the primary route, and 0 if not performed. In general, the performance of the motorcyclists at the unsignalized T-juntion is poor. The average percentage of motorcyclists who did not stop is higher (72.3%) than motorcyclists who stopped at the stop area. For the head movement, a majority of the motorcyclists only performed a single head turn towards the opposite area they are intended to turn into. While for the second and third head movement, a majority of the motorcyclists are neglect making the head turns. The head turn is performed only when there is high traffic volume and when the vision of motorcyclists was blocked. The results from this study provide an additional insight into the hazard anticipation skill among Malaysia motorcyclists. Moreover, driving schools need to emphasize more on hazard anticipation skill in driving curricular in order to improve road safety among motorcyclists.

Keywords: *Road Safety, Hazard Anticipation, Unsignalized T-junction, Head Movement, Stopping Behavior*

INTRODUCTION

Annually, about 1.35 million death occurred because of road crashes. Statistics by World Health Organization (WHO) reported that, in 2016, road traffic injuries are among the ten leading causes of death among all ages. More than half of the total road deaths in the world were contributed by the vulnerable road users (pedestrians, cyclists and motorcyclists) (World Health Organization, 2018). In the South-East Asia region, majority of deaths on the road are among the riders of two- and three-wheelers (World Health Organization, 2018). Moreover, among the South-East-Asia countries, Malaysia is placed second among the countries with a highest number of road traffic death (per 100, 000) and approximately more than half of the fatalities involved motorcyclists (Manan & Varleyhi, 2012). The trend of road accidents in Malaysia has been increasing since the year of 2012, and in 2017, the number of road accidents recorded was 533.88 in 1000 people (Statista, 2018). In 2016, Malaysian Institute of Road Safety Research (MIROS) reported that, out of 27 million registered vehicles in Malaysia, more than half a million involved in road crashes (Malaysian Institute of Road Safety Research, 2017).

The contributing factors that increase these crashes may be due to the motorcyclists' behavior. It was reported by the Road Safety Department Malaysia, the leading causes of road accidents in Malaysia is due to risky driving (Road Safety Department Malaysia, 2014). One of the reasons risky behavior is the main causes of crashes in Malaysia is perhaps because of the lack of hazard perception and anticipation skills among the road users. Hazard anticipation can be define as driving or riding skills of road users in anticipating potential hidden or latent hazard (Hamid, 2013). Many studies have proved that hazard anticipation is imperative in road safety aspects. It has been shown that younger novice drivers are less able to anticipate hazards (Pradhan et al., 2009; Fisher, et al., 2007), motorcyclists are less able to glance at the intersection (Muttart et al., 2011), motorcyclists performed less head check during merging in traffic (Adnan et al., 2018; Abu Hassan et al., 2017; Zabidi et al., 2016) and less than half of the motorcyclists did not anticipate hazards in campus environment (Ahmad Rahman et al., 2017).

In Malaysia, riding education curricular does not emphasize on the hazard perception skill (Jabatan Pengangkutan Jalan Malaysia, 2015). Moreover, the current riding test is mainly testing the leaners riders on how to balance and maneuver motorcycle rather than develop motorcyclists' hazard perception skills, especially in the risky environment (Jabatan Pengangkutan Jalan Malaysia, 2015). Hence, this may be the reason why motorcyclists who were not equipped with this skill – hazard anticipation – are unaware of its importance and not practicing it on the road.

The road segment in Malaysia includes the straight road, bend road, roundabouts, interchanges, staggered junction, and T/Y junction. Analyzing the road segment, the straight road has the highest number of road traffic deaths, followed by bend/curved road, and T/Y junction. By comparing road accidents at the intersection, the rate of road accidents at T/Y junction is two times higher than the cross junction (Darma, Karim & Abdullah, 2017). The possible factors that contribute for accident at T-junction may include, fail to check for the presence of other vehicles, disobey the rules of the road, fail to merge safely, and the presence of obstacles that block the view at the intersection. Thus, more studies need to be conducted to determine essential criteria to focus on, in order to improve motorcyclists' hazard anticipation skills and knowledge when approaching T-junction.

The aim of the study is to evaluate motorcyclists' hazard anticipation behavior at unsignalized T-junction. In order to obtain the aim, several objectives need to be achieved, and they are: (i) to evaluate the stopping behavior of motorcyclists' at the stop area when approaching T-junction; and (ii) to evaluate head movement behavior of motorcyclists' before turning into traffic.

METHODS

Area of the Study

The area of study was in the International Islamic University Malaysia (IIUM) Gombak Campus. The field study was conducted inside the IIUM main campus for safety purposes (i.e. minimizing the exposure to the hazards). Generally, like any other riding or driving research, the area covered in this study is considered sufficient to generalize the behavior of motorcyclists on the stopping behavior and the hazard anticipation performance at the T-junctions, rather than generalizing the idea towards the Malaysian population (Zabidi et al., 2016).

Participants

Twenty male participants between 18-29 years of age have completed the experiment (male was chosen for convenience sample, and only future research may explore female participants). They were IIUM students with valid B2 licence (i.e. motorcycle not exceeding 250 cc, because majority of Malaysian use this type of motorcycles) or at least has a Probationary Driving License (i.e. leaner's permit). The participants also require to have their own motorcycle with valid registration and insurance (to optimize familiarity between the participant and the motorcycle). Besides that, they also need to have a good eye vision (with or without corrected) and in good health (not ill during the experimental session) – to make sure the collected data were accurate. Gender, ethnic background, and minority status were not considered in the study.

Scenarios

Fifteen scenarios were included in the experiment. The scenarios were selected based on the criteria of the unsignalized T-junction. A riding loop or circuit was designed such that it included all the scenarios, where a participant was started and finished the experimental session at the same location. The speed of the riding circuit is 30 km/h – i.e. campus area. The length of the route is about ten kilometer and it takes about twelve minutes to be completed. At each scenario, the surrounding roads were classified into two categories: (i) leaving road – the road the motorcyclists are coming from; and (ii) entering road – the road the motorcyclists will be merged into. Moreover, two zones were classified, and they are the launch zone (labelled as A) and the target zone (labelled as B) in Figure 1 (example of the motorcyclist's view of the scenario) and Figure 2 (example of the plan view of the scenario) below. The launch zone is the area in which it is crucial for a motorcyclist to anticipate hazard while the target zone is the area where potential hazard might emerge (Hamid, 2013). The potential hazards include other vehicles – on the leaving and entering road, and surrounding pedestrians.

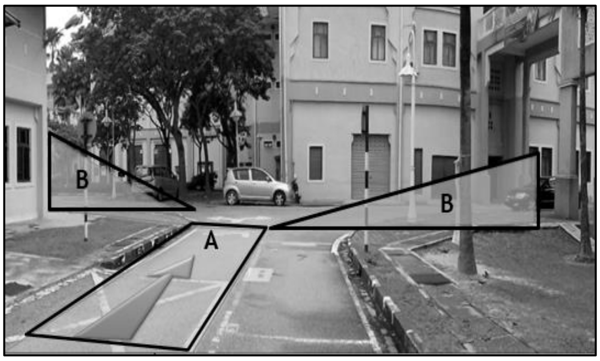

Fig. 1 Motorcyclists' view of one of the scenario

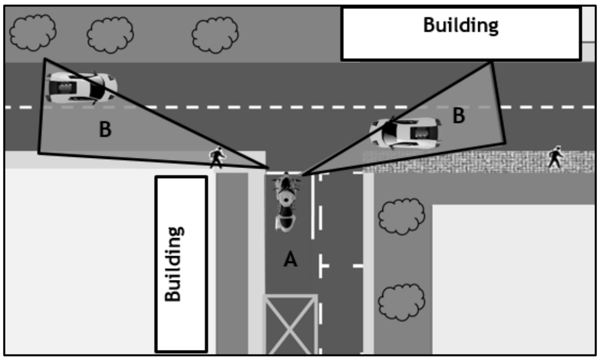

Fig. 2 Plan view of E0 scenario

Apparatus and Stimuli
For this study, head tracker (head movement detector) and safety gears for motorcyclists' protection were used. In addition, administrative forms and questionnaire were also used to collect and record the experimental data.

Head tracker: SJ1000 action camera was used. The features include: (i) 1.5 inch HD display; (ii) Dual Mode with Full HD resolution (1920x1080 pixels); (iii) 12.0 Megapixel camera; and (iv) 140° wide angle lens. The head tracker was attached on the experimental helmet that was used in the experiment (Figure 3). The head movement performed by the motorcyclists can be detected through the recorded video.

Fig. 3 The SJ1000 camera was equipped on the experimental helmet

Safety gears: The safety gears for the motorcyclists are include the riding jacket, glove, helmet, safety vest, and knee guard. All this gears were provided by the researcher to ensure the safety of the participants. However, participants were allowed to use their personal safety gears as long as it have a similar safety standard.

External hard drive: Seagate with a capacity of one Terabyte (Tb) was used to store the collected data from the head tracker. The videos collected were not exposed to the public and the identity of the participants were not disclosed.

Administrative forms: (i) Informed Consent form – an agreement between a participant and the researcher. In the form, all procedures, guidelines and route of the experiment will be explained; (ii) Demographic & Questionnaire - to obtain data related to riding performance; (iii) Participant Data form – to record data of participants' performance (stopping behaviour and head movements); and (iv) Payment voucher form - to record details regarding the compensation made to the participants.

Video of the experimental circuit: A participant was given a map of the experiment route, however, to ensure participant knows exactly the direction, a video was shown. The video shows all the T-junctions that needs to be ridden through and details of the route.

Field vehicle: The vehicles used in the field study are motorcycles belong to the participant so that they are familiar with the operational of the motorcycle.

Design of the Study
The study was conducted on Monday, Tuesday, Wednesday, and Thursday. Friday and weekends were excluded to avoid any factoring effects on the motorcyclists' behaviour (i.e. mood and alertness level among the motorcyclists may be differ). Moreover, the experiment was run between 9:00 a.m. to 12:00 p.m. and 2:00 p.m.to 5:00 p.m. (i.e. in order to avoid the rush hours – lunch hour).

Procedure
The procedure of the experiment includes: (i) Pre-experiment; (ii) During experiment; and (iii) Post-experiment

Pre-experiment: Firstly, before the riding test was conducted, participants were given an informed consent form to fill in. It allowed the participants to make a decision whether they agree to the terms of the form and willing to participate in the test. Next, the questionnaire related to personal and riding experiences was given. Then, participants need to select the time of the test, fixed by the researcher; (i) 9.00 a.m. to 12.00 p.m.; or (ii) 2.00 p.m. to 5.00 p.m. After the selection was made (date and time), participants were informed to come to the experiment location with a complete safety gears (or wear the safety gears provided by the researcher).

During Experiment: When a participant came to the experimental location, his motorcycle was checked so that it is in a good condition. After that, a participant was shown a video of the route and this session took about ten minutes. Then, a participant was equipped with the safety gears and the experimental helmet. The switch of the head tracker was turned on once a participant is ready to start the ride. During the riding session, a Marshall was assigned to follow the participant (in distance) to monitor the safety of the participants as well as to ensure that a participant was on the right path of the experimental route. If a participant faced any health problem or mechanical problem of the motorcycle, the experiment will be stopped immediately to prevent unwanted situation happens during the test. However, none of the participants faced this issues.

Post-experiment: After a participant completed the riding session, he was asked to complete the payment voucher and was compensated with MYR15 and was thanked for his participation. Lastly, the recorded video of the head tracker was transferred into the external hard drive for future analysis phase.

Dependent Variables

Dependent Variable 1: Percentage of the score on stopping behavior during approaching the T-junctions. A participant was scored 1 if he stopped in the stop zone, and 0 if he did not stop. There are fifteen scenarios in total, thus, the maximum score is fifteen.

Dependent variable 2: Percentage of the score on performing the 1st head movement (anticipate potential hazards at the target zone - on the right, Malaysia is a left-driving country) while in the launch zone. A participant was scored 1 if he anticipates the hazard while in the launch zone (the camera angle shows that he turning his head toward the target zone), and 0 if he did not anticipate the hazards on the target zone while in the launch zone. There are fifteen scenarios in total, thus, the maximum score is fifteen.

Dependent variable 3: Percentage of the score on performing the 2nd head movement (anticipate potential hazards at the target zone - on the left, Malaysia is a left-driving country) while in the launch zone. A participant was scored 1 if he anticipates the hazard while in the launch zone (the camera angle shows that he turning his head toward the target zone), and 0 if he did not anticipate the hazards on the target zone while in the launch zone. There are fifteen scenarios in total, thus, the maximum score is fifteen.

Dependent variable 4: Percentage of the score on performing the 3rd head movement (anticipate potential hazards at the target zone - on the right, Malaysia is a left-driving country) while in the launch zone. A participant was scored 1 if he anticipates the hazard while in the launch zone (the camera angle shows that he turning his head toward the target zone), and 0 if he did not anticipate the hazards on the target zone while in the launch zone. There are fifteen scenarios in total, thus, the maximum score is fifteen.

Each dependent variable carried a maximum of fifteen marks. Thus, the total overall score for each participant is sixty.

Hypotheses

Most of the participants will fail to stop at the T-junction because, previous studies have shown that one of the main contributing factors among motorcyclists is the failure to stop when merge onto the primary road (Preusser et al., 1995; Pai et al., 2009). Moreover, majority of the motorcyclists were also reported to have no intention to stop at the stop line, regardless if there is a traffic or no traffic (Manan & Varleyhi, 2015; Manan, 2014).

In term of the hazard anticipation, it was hypothesized that majority of the motorcyclists will fail to merge onto the primary road (i.e. entering road) safely because it was reported by previous studies that motorcyclists involved in serious traffic conflicts that results by poor manner of entering at the intersection (Manan & Varleyhi, 2015).

RESULTS

Overall score of the motorcyclists' performance at the T-junctions

Figure 4 shows the overall score of the motorcyclists' performance at the T-junctions. Based on the graph, the average score obtained by all participants was 30 points, which is half of the total score for the riding test. The highest score obtained was 39, while the lowest was 23. From the average score obtained, it shows that motorcyclists are indeed lack in road safety awareness when they are approaching the T-junctions.

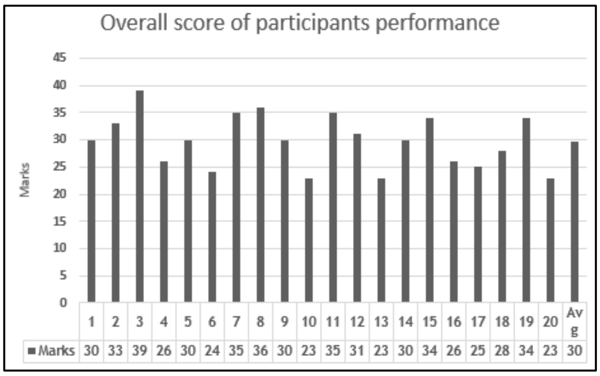

Fig. 4 Overall score of the motorcyclists' performance at the T-junctions

Percentage of the score on stopping behavior during approaching the T-junctions

Figure 5 below shows the percentage score of participants stopping behaviour during approaching the T-junctions. On average, the percentage of motorcyclists who did not stop at the stop zone (72.3%) is higher than motorcyclists who stopped at the stop zone (27.7%). The percentage difference is 44.6% which is way above the needed percentage for it to be classified as significant difference at 95% confident interval (i.e. 11.32%), thus, the motorcyclists' stopping behaviour is said to be significantly poor. In scenario 1 and 14, there was no motorcyclist stopped at the stop zone. On the other hand, only in scenario 3, 7, and 12 is where half of the motorcyclists comply with the stop rule at the T-junction.

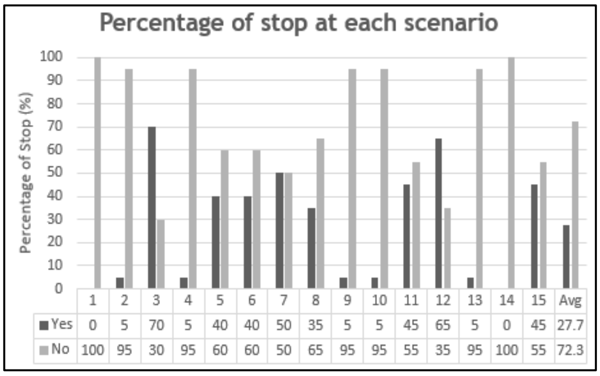

Fig. 5 Percentage score of stopping behaviour at each scenario

Percentage of the score on performing the 1st head movement while in the launch zone.

Figure 6 shows the percentage of the first head movement performed by the motorcyclists at the T-junctions. On average, the majority of the motorcyclists performed the first head movement at the T-junctions (93%). The percentage difference is 86% which is way above the needed percentage for it to be classified as significant difference at 95% confident interval (i.e. 11.32%), thus, motorcyclists is said to performed significantly good in term of the 1st head movement to the target zone while in the launch zone. It was observed that, in scenario 3, 5, 6, 10, 11, and 15, all motorcyclists performed the 1st head movement at those T-junctions.

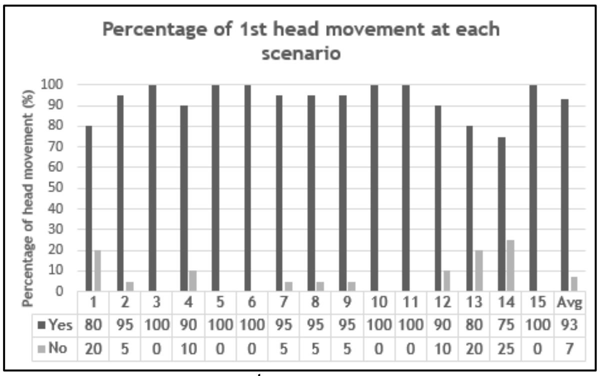

Fig. 6 Percentage of 1st head movement at each scenario

Percentage of the score on performing the 2nd head movement while in the launch zone.

Figure 7 shows the percentage of the second head movement performed by the motorcyclists at the T-junctions. Based on the results, two-thirds (66%) of motorcyclists did not perform the second head movement while in the launch zone. Only one-third (34%) performed the second head movement, in which it was observed that only in scenario 5, all motorcyclists performed the second head movement. The percentage difference is 32% which is way above the needed percentage for it to be classified as significant difference at 95% confident interval (i.e. 11.32%), thus, motorcyclists is said to performed significantly poor in term of the 2nd head movement to the target zone while in the launch zone.

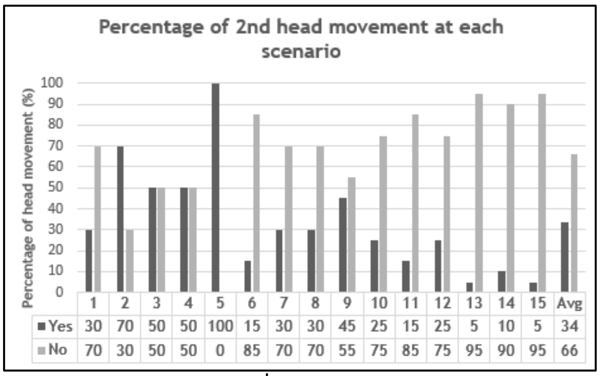

Fig. 7 Percentage of 2nd head movement at each scenario

Percentage of the score on performing the 3rd head movement while in the launch zone.

Figure 8 shows the percentage of the third head movement performed by the motorcyclists at the T-junctions. Based on the findings, more than half (56%) of the motorcyclists did not turn their head at T-junction. Only less than half (44%) of the motorcyclists performed the third head movement, in which it was observed that in scenario 14, all motorcyclists did not turn their head to anticipate the potential hazard. The percentage difference is 12% which is just above the needed percentage for it to be classified as significant difference at 95% confident interval (i.e. 11.32%), thus, motorcyclists is said to performed significantly poor in term of the 2nd head movement to the target zone while in the launch zone.

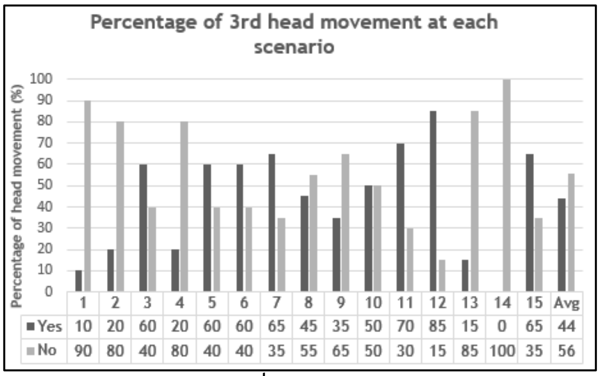

Fig. 8 Percentage of 3rd head movement at each scenario

Figure 8 shows the percentage of third head movement performed by motorcyclists. The percentage difference of making 3rd head movement was 12% and the difference in percent required at 95% confidence level was 11.32%. Therefore, the difference is considered significant. The third head movement is performed to the initial direction of motorcyclists turning movement.

DISCUSSION

Overall score of participants' hazard anticipation performance

Based on the findings in Figure 3, the overall score of the hazard anticipation performance is half of the total point. From the results, it shows that participants lack the hazard anticipation knowledge and skills. This can be related to the riding education curricular in Malaysia, where the curricular does not focus on hazard anticipation skills. Hence, cause it to be less practise and perform in the real environment. The curricular in Malaysia is more focus on how to maneuver motorcycle: (i) make'8' shape turn; (ii) ride on small bridge, not less than seven seconds; (iii) ride between cones; (iv) perform emergency brake; (v) checking five basic things – fitting helmet, checking headlamp, checking rear lamp, checking side mirror, checking signal, and make head check before continuing the journey and; (vi) stop the motorcycle at specified place, then park the motorcycle by using stand (Jabatan Pengangkutan Jalan Malaysia, 2015). Hazard anticipation skill is crucial for motorcyclist during riding in a risky environment for instance at unsignalized T-junction. When approaching a T-junction, motorcyclist need to comply with the rules of the road and assess the road environment to ensure no incoming hazard is approaching (Jabatan Pengangkutan Jalan Malaysia, 2015).

Percentage of stopping behaviour at each scenario

The findings in Figure 4 shows that the majority of the motorcyclists did not comply with the stop rules at the intersection. Motorcyclists did not stop at the stop area when approaching the T-junction. The results is align with findings by Ahmed, Sadulah and Yahya (2015) where more than half of the motorcyclists (58%) tend to violate the stopping rule at the intersection (Ahmed, Sadulah & Yahya, 2015). Moreover, in a condition where there is traffic or no traffic, the majority of the motorcyclists has no intention to stop at the stop line (Manan & Varleyhi, 2015; Manan, 2014). The reason why motorcyclists did not stop at the designated area may be due to; they did not see any approaching vehicles when approaching the intersection. Besides that, motorcyclists may already familiar with the environment and road condition at the intersection. Furthermore, it is to reduce the time taken at the intersection. By not stopping, motorcyclists are able to accelerate and turning faster due to the small size and less inertia. Motorcycles can accelerate faster than other vehicles. Accordingly, making it possible for the motorcyclist to attain the speed of mainstream vehicles. This capability urges them to take the risk and shape their behaviour (Ahmed, Sadulah & Yahya, 2015). According to Muttart et al., (2011), motorcyclists sometimes try to avoid putting their foot to the ground when approaching the stop sign. Some riders performed a weaving technique to allow them to remain upright while moving at low speed (Muttart et al., 2011).

In scenario 3, 7 and 12, the number of motorcyclists making a stop is half or more than the number of motorcyclists who did not make a stop. The reason motorcyclists stop at the stop line is because of the traffic congestion that occurred at each of the scenarios. From the recorded video, traffic was congested in the stated area. Furthermore, at the shoulder of the road many parked cars can be seen, thus limit the vision of motorcyclists.

Percentage of head movement behaviour at each scenario

Based on the findings in Figure 5, the majority of the motorcyclists performed the first head movement at the junction before entering the primary route. Motorcyclists turned their head towards the area that they intended to enter before making the turn. This shows that motorcyclists do anticipate hazard before entering the primary route. As the vulnerable road user, it is crucial to scan the road for any potential hazard before entering the primary route. However, for the second head movement (opposite direction of motorcyclists' turning movement), in most of the scenarios, motorcyclists did not turn their head before entering the primary route. This behaviour may be because omotorcyclists are already familiar with the surrounding environment, so making a single head movement is considered enough for them to anticipate the oncoming hazard. Besides that, due to the familiarize environment, they may predict it well and know when to enter the primary route. In scenario 2 and 5, the number of motorcyclists making a head turn is higher than the number who did not. The reason is that the road view was blocked by the IIUM building, making the potential hazard cannot be seen. Hence, the sense of anticipating potential hazard is high. For the third head movement (initial direction), the number of participants performed head turn was higher at scenario 3, 5, 6, 7, 11, 12, and 15. Most of the scenarios listed are connected with the main road, so there are many vehicles passing by, making the traffic volume in this area is high. As the traffic is high, it is kind of difficult for motorcyclists to enter the primary route without making a head turn. Motorcyclists were poor at turning their head to look for vehicles when entering the road with low traffic volume compared to those entering a road with high traffic volume (Manan & Varleyhi, 2015; Manan, 2014).

CONCLUSION

To conclude, the overall hazard anticipation performance of the motorcyclists is poor. Motorcyclists only manage to score half of the total point in the riding test. The average percentage of motorcyclists who did not stop at the launch zone is higher (72.3%) than motorcyclists who stop at the stop area. For the head movement, the majority of the motorcyclists only performed a single head turn towards the area they intended to turn into. While for the second and third head movement, the majority of the motorcyclists' neglect to make another head turn. The head turn is performed only when there is high traffic volume and when the vision of motorcyclists was blocked.

Contribution: The result from this research provide some information on the behavior of Malaysian motorcyclists at T-junction. Besides that, driving school can make an improvement on the learning system for motorcyclists since the driving curricular provided not focus much on the hazard anticipation.

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