

# Hazard Detection among Young and Experienced Drivers via Driving Simulator

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**Abstract** – Hazard perception test (HPT) is one of a common task in perceiving hazard among drivers. Many countries have been adopting this method to assess an individual's driving competency in order to acquire driving licenses. Computer-based assessment was a common method widely used to carry out the HPT. Previous hazard perception studies using Malaysian samples reported mixed findings on the effectivity of reaction time-based HPT. Dissimilar with the common method, this study employed a full-size cabin driving simulator to study hazard perception, focussing on hazards detection between two groups of drivers: young and experienced. Results from 28 (15 young, 13 experienced) drivers indicated that young drivers detected hazards faster than their experienced counterparts, even though both groups have the same performance of hazard recognition. Correlational analysis revealed that driving frequency may be a factor contributing to the difference in response time between these two groups. Further analysis also indicates that different road environments contribute to different hazard perception performance.

**Keywords:** Hazard perception test, driving simulator, young drivers, hazard detection, experienced drivers, novice

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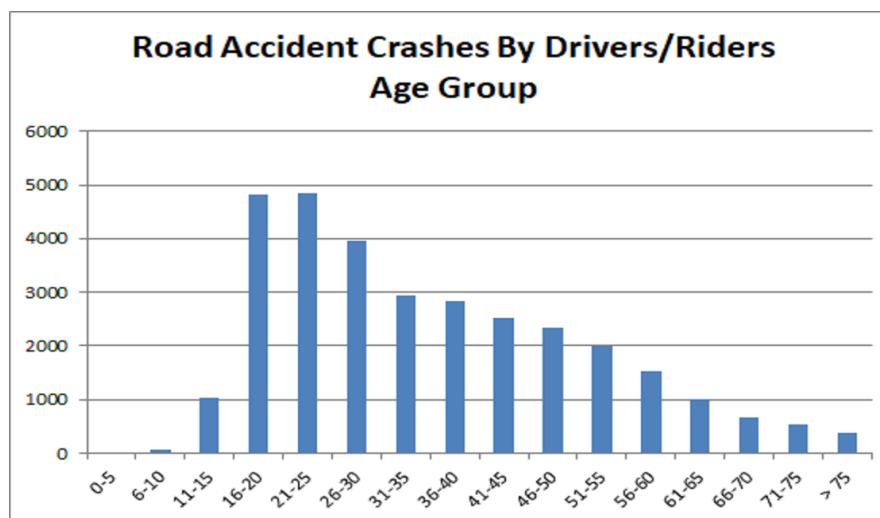
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## 1.0 INTRODUCTION

There are various hazardous conditions that we encounter in everyday life, and one of them is a hazardous road situation. Hazard perception is a skill how people perceive danger and risk in the situation. Depending on education and experiences, one's hazard perception varies. How road users perceive hazards on the road are crucial for them to avoid potential collision. In Malaysia, Hazard Perception Test (HPT) is not included in the national driving licensing system. However, in *Buku Panduan Pembelajaran Kurikulum Pemanduan Pemandu (KPP)* by Road Transport Department (2006), Chapter III in Part 4, hazard is being mentioned with the following sub-topic:

- Accident preventions – DADA (Define, Analyse, Decide, Act)
- Type of hazards
- Hazard action plan
- Vehicle control system

Hazard is taught theoretically, in the class session, but not practically during the driving session. Therefore, new drivers may not have enough exposure to hazardous situations while driving. Statistic by Royal Malaysia Police in 2015 shows an inverted trend between age and number of crashes (see Figure 1). Fewer accidents number with the growing age could be due to better driving skills and mature hazard perception skills. The statistic also reveals that highest number involved in road accidents were drivers/riders within the age group of 21-25, followed by age group 16-20. This shows that young drivers contribute to the highest number of accidents in Malaysia. This crashed pattern of age group is evidently consistent since 2011.



**Figure 1:** Number of divers/riders involved in accidents by age group (Royal Malaysia Police, 2015)

Therefore, the ability to detect and identify hazards while driving is crucial to determine safety precautions that drivers need to take when they approach hazardous situations. While Crick and McKenna (1992) adopted this ability to identify potentially dangerous traffic situations as the definition of hazard perception, Horswill and McKenna (2004) view hazard perception as driver's situation awareness for potentially dangerous incidents in the traffic environment. Regardless of either view, both agree that incompetent hazard perception plays an important role in the occurrence of crashes, especially those involving novice drivers. This is because hazard perception skill improves by driving experiences and is an essential part of driving tasks (SWOV, 2010).

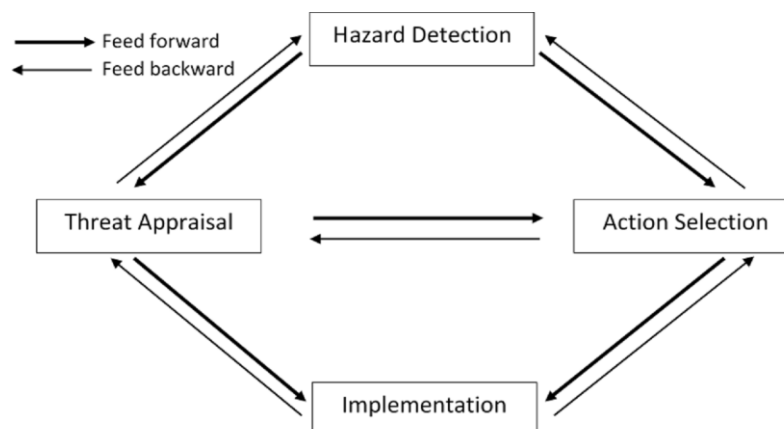
Consequently, many countries, such as Australia, Sweden, United Kingdom, and the Netherlands, have adopted HPT as part of their licensing system. The test's objective is to test the novice drivers' ability to detect potential hazards on road that may occur while their actual driving. Further, in Australia, the HPT is used as diagnostic for whether a driver has enough hazard perception skills to graduate for driving license; as well as to identify drivers with high risk of crash involvement (NSW Roads and Traffic Authority, 2011).

In Australia, young and inexperienced drivers contribute a large percentage of traffic crashes and injuries (Senserrick & Haworth, 2004). Researchers also concluded that young

drivers' involvement in risky driving behaviour is a major contributing factor to a higher rate crashes and injuries (Laapotti et al., 2001). Previous studies have shown that novice drivers are slower in detecting hazards and they often detect fewer hazards than experienced drivers (Underwood et al., 2011). In a series of studies done in Nottingham researchers reported that there was a clearly different pattern of eye movements between new and experienced drivers indicating that the latter drivers are more aware than the former. Even though experienced drivers that have undertaken the hazard perception training are not necessarily safer drivers and have fewer accidents; nevertheless, support for hazard perception training in novice drivers leads to improved performance on HPT exists (Haworth & Mulvihill, 2006).

Just like any skill, drivers improve their ability to detect hazards as their experience grows (Borowsky et al., 2010). Experience plays an important role in the development of driving skills (Harrison, 1999) and hazard perception skills improve with experience (Pradhan et al., 2011; Underwood et al., 2003). Further, it has been shown that experienced drivers detect and predict hazardous situations better than novice drivers (Crundall et al., 2010; Borowsky et al., 2009). As the drivers' age further, however, Horswill et al. (2008) reported that hazard perception ability is likely to decline because of decreases in cognitive and visual function.

Groeger (2000) details four processes involving hazard perception: Hazard detection; Threat appraisal; Selection of actions to avert the hazard; and Implementation of actions chosen. The relations of these processes are in Figure 2.



**Figure 2:** Hazard perception model of Groeger (Grayson et al., 2003)

Similar to the other parts of the globe, young drivers/riders age 16-25 contribute to the highest number in road accident crashes in Malaysia (Royal Malaysia Police, 2011). Unlike the abovementioned countries, HPT is not yet part of a formal licensing system. This is because; implementation of such conditions requires more research on HPT as a diagnostic tool. Apparently, such researches are scarce for Malaysian context.

Among others, to the best of authors' knowledge, Lim et al. (2013) compared hazard perception skill between novice and experienced Malaysian drivers and reported the inability of reaction time-based HPT to distinguish between these two groups. Because Lim et al. (2013) considered 4-years drivers as experienced, this may be a possible explanation of such results. Consequently, Ab Rashid and Ibrahim (2017) further picked up the work and replicated reaction time-based HPT using more experienced drivers (e.g. 30 years of driving experience). Their study partially supported Lim et al. (2013) results: even though both groups of novice

and experienced drivers responded equally quick/slow when identifying hazards, the latter group recognised more hazards relative to the former.

Both of these studies, however, adopted a computer-based approach when conducting HPT. Unlike driving a simulator, computer-based approach lacks the feeling of driving. Would the results differ if HPT is conducted using a simulator? Can a simulator-based HPT be a better diagnostic tool when distinguishing between young and experienced drivers? These are the gaps this study tried to address.

In general, this study aimed to compare hazard perception while driving between young drivers with experience drivers in a simulated driving environment. Specifically, to determine the mean difference of hazard perception score (HPS) and hazard response time (HRT) between young and experienced drivers across driving scenarios as well as to determine mean difference of hazard detection score (HDS) between highway, urban and rural scenarios.

## 2.0 METHODOLOGY

### 2.1 Research Design and Sampling

This study is a quantitative study using a driving simulator. Three driving scenarios were created of which in each scenario, several hazards were created on the road (see Table 1). Some of the hazards would appear when a driver reached a certain point in the simulation (i.e. dynamic hazards) while some others were static by the roadside. In total, this study involved 13 hazards. Based on the PDRM report in 2015, drivers making dangerous turning and speeding were the main faults for road accidents and both of them contribute high number in fatality. Accordingly, the highest number of accidents happened on straight roads, followed by curvy roads, Y or T junctions and cross junctions (Royal Malaysia Police, 2015).

**Table 1:** Hazardous Driving Scenarios

Item	Description of Hazardous Driving Scenarios	Analysis Code
<i>Highway</i>		
1	A parked lorry on the left road side of the participant	Hwy1
2	A speeding bus overtakes the participant	Hwy2
3	A speeding lorry overtakes the participant	Hwy3
4	A slow motorcycle in front of the participant	Hwy4
<i>Rural roads</i>		
5	A motorcyclist comes from behind and rides in front of participant slowly	Rur1
6	An animal crossing from the left roadside of the participant	Rur2
7	A bicyclist riding slowly on the left road side of the participant	Rur3
8	A busy unsignalised T-Junction	Rur4
9	Lorries parked on both side of the road	Rur5
<i>Urban roads</i>		
10	A pedestrian walking on the left roadside of the participant	Urb1
11	Pedestrians crossing a road using a zebra crossing	Urb2
12	A wooden box in the middle of the participants' driving lane	Urb3
13	A bus stopping at a bus stop on the opposite traffic direction	Urb4

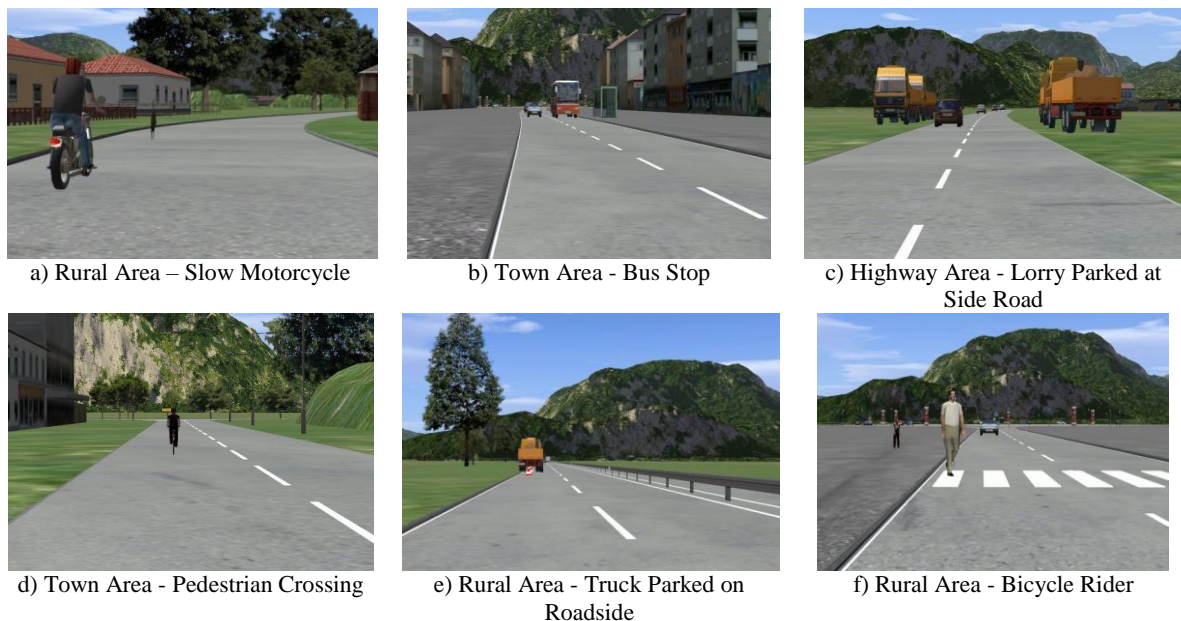
Therefore, the simulation scenarios include the elements of junction turning, speeding vehicles, pedestrian crossing, and motorcycle riders. Other hazards were also included in the scenario such as static obstacles (e.g. boxes) on the road and animal passing.

## 2.2 Simulation Development

Driving simulation consists of several scenarios for the simulator was developed with the following phase:

- Hazard identification
- Terrain design
- Scenario development
- Traffic design

Identified hazards were translated into the scenario by using Ergoneers Silab, a computer software for developing driving simulation. Several road types like straight road, junctions and roundabout were created before adding traffic scenarios into the simulation. Figure 3 contains screenshots of the simulation scenarios.



**Figure 3:** Screenshots of the simulation scenarios

## 2.3 Sample

There were two categories of subjects – young drivers and experienced drivers. Young drivers were considered at the beginning age of gaining driver licenses (i.e. 18 years old) until 30 years. Young drivers should have valid driving license and have driving experience of less than five years. In contrast, experienced drivers are those with more than 5 years driving on roads, and with the beginning age of 24 years old and more. 28 subjects participated: 15 of them were young drivers, age between 19 to 24; and 13 experienced drivers, age 25 between to 51. Participants were recruited using random and voluntary basis. Participants must have valid driving license and in good health condition during the experiment.



## 2.4 Instrument

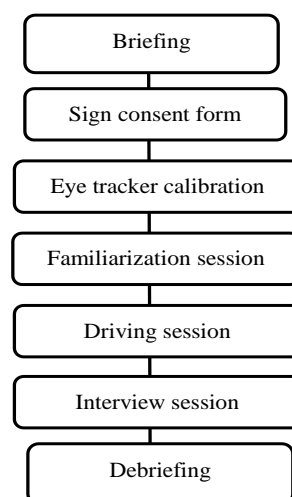
Data collection took place at the Malaysia Institute of Road Safety Research (MIROS) driving simulator lab using a full-size cabin driving simulator with fixed base (see Figure 4). The simulation was projected on a 3 panels large screen display. The panel was set to create almost 180° driving view from inside of the car cabin. Data acquired from the simulator was synced using Silab software. SPSS and Microsoft Excel were used as additional data analysis tools.



**Figure 4:** MIROS Cabin Driving Simulator (CabinDS)

## 2.5 Procedure

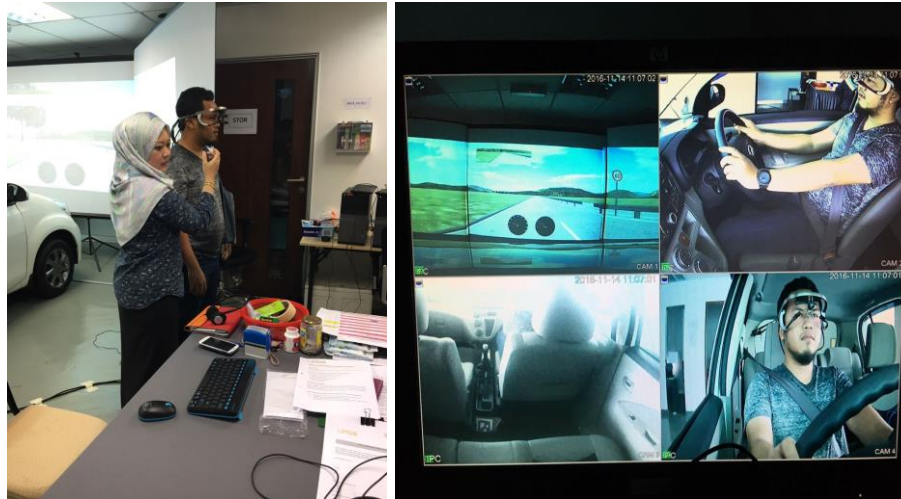
Data collection involved only one participant per session which took approximately 1.5 hours to complete all of the procedures. The drivers were exposed to several hazards while driving and were asked to verbally identify the hazard. A research assistant recorded the responses in D-Lab software which was pre-designed with the list of hazards in the driving scenarios. The full procedure of the study is in Figure 5.



**Figure 5:** Study process flow

Participants were given consent form before the experiment begin to comply with the ethics requirement. After that, researchers fix an eye tracker to the participants' head to track eye gazing activity (the corresponding data is not for analysis of this publication). Then participants were given an opportunity to get themselves familiar and comfortable with the

instruments. Only then, the actual data collection began. Upon completion, participants step outside and sit for an informal interview session to obtain their feedback on the procedure. In addition, they also provided demographic information such as age, driving experiences and past accident experiences (not analysed in this publication). Before they exited the lab, participants were debriefed and given an appreciation token. Figure 6 contains a capture of the situation during data collection.



**Figure 6:** A subject was going through the experiment session in driving simulator

### 3.0 RESULTS AND DISCUSSION

Total subjects for this study with valid data were 28 people – 15 young drivers and 13 experienced drivers. The age range was from 19 years to 51 years old. Age for young drivers' ranges from 19 years to 25 years ( $M=21.87$ ,  $SD=1.85$ ) with driving experiences range from 1 year to 4 years ( $M=2.92$ ,  $SD=1.03$ ). Age for experienced drivers ranges from 24 years to 51 years ( $M=31.31$ ,  $SD=4.61$ ) with driving experiences range from 7 years to 20 years ( $M=12.08$ ,  $SD=4.5$ ).

#### 3.1 Hazard Perception Score (HPS) between Young and Experienced Drivers

Mean difference of Hazard Perception Score (HPS) between two categories of drivers were analysed using the  $t$ -Test procedure. HPS is defined as the percentage of hazards each participant identified relative to all hazards regardless of all driving scenarios in the study. For example, a participant's HPS is 38.5% indicates that he or she recognized five out of total 13 hazards in this study.

The results of an independent-samples  $t$ -Test on the effect of experience on HPS show no significant results. There was no statistically significant difference in the perception scores for young drivers ( $M = 33.8\%$ ,  $SD = 15.9\%$ ) and experienced drivers across all types of driving scenarios ( $M = 42.0\%$ ,  $SD = 21.2\%$ );  $t(26) = -1.16$ ,  $p = 0.22$ . Table 2 lists HPS mean and standard deviation for both young and experienced drivers.

**Table 2:** Mean and standard deviation for hazard perception score for driving experiences

Independent variable	Hazard Perception Score (%)	
<i>Subject's Categories</i>	Mean	Std. Deviation
Young drivers	33.8	15.9
Experienced drivers	42.0	21.2

HPS for experienced drivers are higher than their young counterpart. This indicates that experienced drivers recognized more hazards on the road relative to young drivers. This difference, nonetheless, is not significant. Even though this finding is consistent with the results of Lim et al. (2013) study, it does not support the more recent study by Ab Rashid & Ibrahim (2017).

### 3.2 Hazard Response Time (HRT) between Young and Experienced Drivers

For each hazard that participants identified, the time gap between the beginning of hazard occurrence and participants' making response defines the Hazard Response Time (HRT) index. The smaller value of HRT indicates quicker response to the hazards, showing a good hazard perception skill. *t*-Test procedure was used to analyse the mean difference of HRT between young and experienced drivers.

**Table 3:** Mean and standard deviation for hazard response time for each driving experiences

Independent variable	Hazard Response Time(s)	
<i>Subject's Categories</i>	Mean	Std. Deviation
Young drivers	12.8	10.3
Experienced drivers	20.2	10.5

An independent-samples *t*-Test to compare the effect of experience on HRT for all categories of hazard revealed a significant difference in the response time between young drivers ( $M = 12.8$  s,  $SD = 10.3$  s) and experienced drivers ( $M = 20.2$  s,  $SD = 10.5$  s);  $t(136) = -4.15$ ,  $p \leq 0.01$ . Table 3 lists HRT mean and standard deviation for both young and experienced drivers.

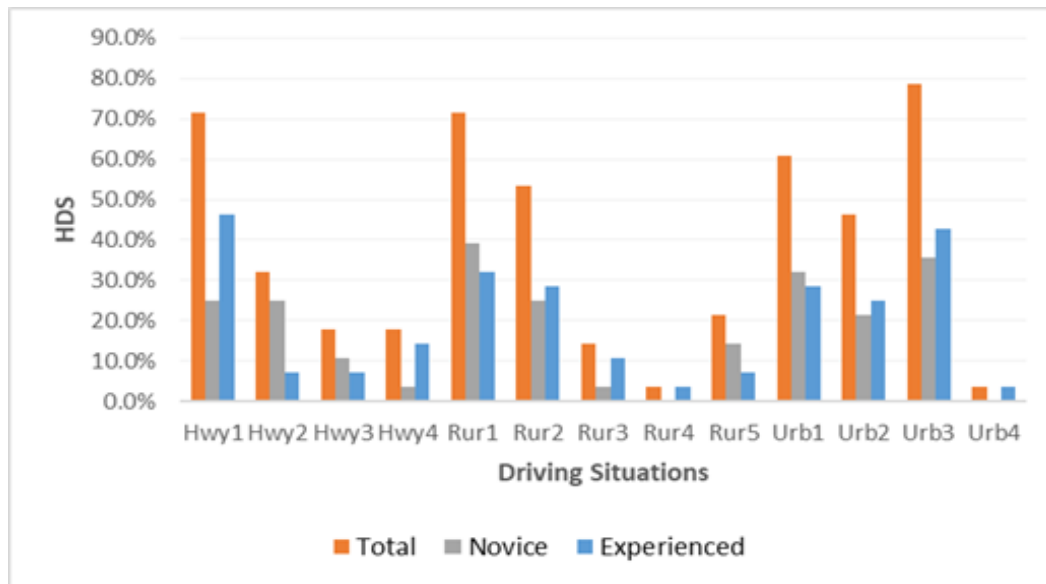
In contrast to both previously mentioned studies (Lim et al., 2013; Ab Rashid & Ibrahim, 2017), this study showed a significant effect of driving experience to hazard perception response time. The means of response time between these two groups are, however, counterintuitive; whereby young drivers responded faster to hazard, when detected, relative to experienced drivers.

A possible explanation for this perplexity may be due to methodology artefact: Young drivers who participated in this study are very young relative to experienced drivers who are a lot older. Because the study utilized fixed based driving simulator, it could be that older drivers feel less comfortable with the instruments, hence creating unnecessary stress during data collection, which then created interference with then hazard perception skill. Even though steps to reduce this uncomfortable feeling were taken during the data collection (i.e. familiarization with the instruments, SSQ), it may be insufficient.



### 3.3 Hazard Detection Score (HDS) between Driving Scenarios

Figure 7 contains descriptive results of the hazard detection score (HDS). Percentages of HDS for each scenario were calculated for a total of 28 participants who participated in the experiment. Overall, the HDS was very low with most driving situations have HDS of less than 50%. Further, only one participant was able to detect “a busy unsignalized T-Junction” and “a bus stopping at a bus stop on the opposite traffic direction” as hazardous (see Rur4 and Urb4 respectively). The most detected hazard by participants was “a wooden box in the middle of the participants’ driving lane” in rural road (Urb3).



**Figure 7:** HDS based on driving situations

The comparison of HDS for different driving scenarios, regardless of participants’ experiences, employed a one-way Analysis of Variance (ANOVA) procedure. The driving scenarios were categorized into highway, urban and rural roads driving. Mean and standard deviation of HDS for each scenario are in Table 4.

**Table 4:** Mean and standard deviation for hazard detection score for each driving scenarios

Driving scenarios	HDS (%)	
	Mean	Std. Deviation
Highway	34.8	19.65
Rural	30.64	19.20
Urban	46.42	27.82

The results of ANOVA on HDS revealed significant variation among driving scenarios [ $F(2,81) = 3.676$ ,  $p = 0.03$ ]. Tukey post-hoc test was conducted on all possible pairwise contrasts showing that HDS for urban roads ( $M = 46.42\%$ ,  $SD = 27.82\%$ ) and rural roads ( $M = 30.64\%$ ,  $SD = 19.20\%$ ) differed significantly,  $p = 0.028$ . In contrast, no significant differences appeared of HDS between highway and urban roads ( $p = 0.138$ ), or between highway and rural roads ( $p = 0.768$ ).

Overall, HDS was very low. Certain types of hazards were almost unrecognized and went undetected. Statistical analyses revealed significant differences in the HDS for certain types of roads. Participants irrespective of driving experience were able to detect more hazards on urban roads compared to hazards on rural roads. This effect may be due to rural roads' traffic situation that is usually less havoc, and hence easier for participants to predict any entity they encounter. Because of the higher degree of predictability, consequently, participants may think that these objects as manageable, less hazardous, and hence not declaring them as hazards during the data collection.

#### **4.0 CONCLUSION**

The study has successfully compared hazard perception skills across two different categories of drivers: experienced versus young. Given the non-straightforward findings (i.e. some are partially supporting previous work, whereas some are contradicting), it clearly indicates the needs of more research. Crundall et al. (2010) points a feasible direction of future hazard perception research by employing a *What happens next?* instead of reaction time based, procedure. While this is a promising direction, given the strength of current study is the use of driving simulator, we believe an interesting direction for simulation related hazard perception study is to explore the processing model Groeger (2000) proposed, in particular the response after perceiving hazard. Of course, hazard perception is important, but equally crucial is how drivers respond or react upon perceiving the hazards.

On the application/implementation note, the hazard perception test is yet to be part of national licensing system. Even though other countries have adopted it years ago, with current study findings as well as others in the literature about hazard perception tests, we would think that it is still too early to use it as a *diagnostic* tool for national licensing system. Nevertheless, opportunity for using HPT as a *training* tool is certainly wide open for trainers and authorities to implement. Specifically, it can be utilised in driving institutes to gauge candidate drivers' competencies in detecting hazards, and consequently profile the type of hazards that need more attention during training. Further than driving institutes, similar concepts can also be applied in other sectors as well; especially in industries that involve high use of road networks (e.g. courier drivers/riders, logistic drivers, high-stress drivers such as ambulance drivers, etc.).

Besides human-based interventions, such as for training purposes, HPT can also be applicable for road environment improvement. A specific HPT targeting for detection of roadside hazards can provide insights for road designers and engineers to improve their design to either making it less hazardous, or if not possible, to easing its detection. In other words, a good road environment is the one that improves hazard perception across road users.

As for the current study, possible future improvements may include stronger methodology. Specifically, researchers can consider controlling for possible influence of comfort with unfamiliar technology – in this case the eye tracker of the simulator itself. We attributed some of the findings for this because this is a limitation that this study missed to address. The control can be done either during participants' recruitment or during data analysis statistically using ANCOVA or partial correlation procedures, for example.

To conclude, the team believes that hazard perception skill needs more attention from researchers, especially in Malaysia. This is to not only address the scarcity of our understanding in this topic but more importantly to speed up the process of saving lives on the road. After all, road safety is our responsibility, together.

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