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Assessment of Young Drivers' Driving Behaviour and Driving Speed Along Horizontal and Vertical Alignments

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Abstract: Young drivers are more likely to experience car crashes as they tend to have risky driving behaviours. This study aims to assess young drivers' driving behaviour and driving speed along the horizontal and vertical alignments of roads. The 20 young drivers who participated in this study were asked to complete a self-reported assessment (Driver Behaviour Questionnaire) and then invited for an on-road driving assessment during daytime and night-time, along horizontal and vertical road alignments at a selected route in Skudai, Johor. The results from the Driver Behaviour Questionnaire revealed that distractions during driving was the most frequently reported behaviour that caused car crashes amongst young drivers, followed by error and violation. Speed profile was found to be higher during daytime when compared to night-time. A significant difference in speed between male and female drivers was noted at horizontal curves during daytime and vertical curves during night-time. The study concluded that such aberrant driving behaviours would have an impact on the driving performance, particularly on horizontal and vertical curves.

Keywords: Driving behaviour, driving speed, young drivers, horizontal alignment, vertical alignment

1. Introduction

In a highway system, vehicular speed depends on several factors, such as vehicle performance, driver capabilities, geometric features, weather conditions, prevailing traffic conditions, speed limit, and traffic control devices. It can also be affected by situational factors such as urgency of the trip, familiarity of the driver with the road, etc. Road designers have to take all of these factors into consideration while designing roads, to achieve a high level of mobility, accessibility, and safety for road users.

All drivers aim to drive safely on the roads. However, young drivers face a higher risk of being involved in motor vehicle crashes than older drivers. In particular, such crashes are more likely to happen during night-time [1]. Speeding is the major contributing factor that causes vehicular crashes and resultant injuries of young drivers [2]. Young drivers' speed choice is influenced by factors such as driving skills and adrenaline motivation. Evidence from past studies shows that, although young male drivers take efforts to improve their driving traits, they get profoundly influenced by motivational factors such as thrills in exceeding speed limits [3]. Young male drivers adhere less to traffic laws as

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compared to female drivers and older drivers [4]. Young drivers tend to carry a disrespaective attitude towards speed limits [5]. Inexperienced young drivers often neglect posted speed limits, which leads them to indulge in speeding behaviour. Besides, young drivers perceive risky driving to be inoffensive, and hence drive recklessly. This proclivity of young drivers towards risk-taking indicates that such people tend to overestimate their driving capabilities. Moreover, young drivers tend to get distracted easily while using a hand phone or involving in other such multi-tasking during driving.

In recent times, distracted driving has been reported to be one of the main reasons for traffic crashes [6], especially among young drivers. Significant sources of distraction during driving are the use of hand phone, communication with fellow passengers, eating, operating the car's multimedia, and so on. Amongst these, the use of hand phones is reported to be the most dominant source of distraction that causes car crashes [7]. A study carried out by Huisingh et al. [8] on 11 intersections in Alabama (US) revealed that conversing on the phone while driving caused 31.4% of distracted driving. Likewise, it was found that 3.4% of the drivers in the United Kingdom and 14.1% of the drivers in Spain are using hand phones while driving [9], [10]. Increased use of hand phones during driving has been a major reason for the increase in the number of traffic crashes in the recent years. The NHTSA reports that the use of hand phones while driving caused 12% of fatal crashes and 6% of injury collisions in the USA, in 2014.

Young drivers below the age of 25 do not pay much heed to varying roadway geometrics and show lesser control during distracted driving. In contrast, professional drivers in the age group of 25-50 depict better control during distracted driving and were able to better adjust their driving behaviour to suit roadway alignment alterations [11]. Thus, the driver's experience was observed to be one of the most relevant parameters in controlling road accidents. Drivers with more experience exhibit a 50% lesser probability of being involved in crashes [12]. Drivers with daily exposure to traffic, such as taxi drivers, have better control of their vehicles and hence experience lesser crashes when compared to unprofessional drivers [13]. Drivers in the age-group of 16-20 years were found to be more prone to road accidents than those in the age-group of 25-45 years [14]. Drivers between 17-20 years were reportedly involved in fewer crashes with increased driving experience and licensing age [15]. Young male drivers showed a higher crash incidence when compared to young female drivers, owing to lesser risk perception [16].

Curves on roadways are categorized as the highest crash-prone locations. As per the Fatality Analysis Reporting System (FARS), in the United States, 5000 fatalities were recorded each year since 2005, on horizontal curves connecting two rural lanes, due to runoff road crashes [17]. Such fatalities are caused because of the road alignment features which require additional speed reduction or careful manoeuvring to handle risk factors such as sharp curves or inadequate sight distance [18]. Many researches have reported that drivers' error rates increase in horizontal road alignments, as the complexity of alignment increases. Such instances could be significantly relevant for young drivers with lower risk perception and lesser driving experience, which makes them more susceptible to crashes.

As mentioned earlier, young drivers are the most vulnerable population of drivers, as they are more exposed to risks while driving in steep horizontal or vertical road alignments, which increases their chances of being involved in crashes. In this regard, this study aims to assess young drivers' driving behaviour and driving speed along horizontal and vertical road alignments, based on a sample group of drivers′ self-reported behaviour and empirical investigation of their driving speed.

2. Materials and Methods

2.1 Participants

20 final year students (10 male and 10 female) of the School of Civil Engineering at Universiti Teknologi Malaysia, in the age range of 24-26 years, participated in this study. In order to be qualified for the study, participants had to have a valid driving license and be familiar with the study area. The number of participants in our focus group study (where participants respond to questions) is similar to those in the study conducted by Diels et al. [19]. However, that study used 30 drivers for observational study (where participants drive on the road) whereas our study used only 20. Therefore, in order to improve the validity of our findings, we instructed each participant in our study to take up more car trips along the study area. No monetary compensation or inducement was provided to the participants for taking part in this study.

2.2 Drivers' Self-Reported Survey

All participants were asked to complete the Driver Behaviour Questionnaire (DBQ), to identify their aberrant driving behaviours. The DBQ is widely used around the world for this purpose. The original version of the questionnaire comprises 50 items referring to drivers' aberrations [20]. However, this study adapted and used only 26 driving behaviour-related items, which included 15 items on distraction, 7 items on violations, 7 items related to error and 7 items related to lapses, for use in the Malaysian setting. Participants were asked to give their responses on a five-point scale (1 = never, 2 = hardly ever, 3 = occasionally, 4 = frequently, and 5 = nearly all the time) on how often in the previous year they indulged in specific types of aberrant driving behaviours. Demographic data, driving experience and crash involvement information were also gathered along with the DBQ. Those participants who had been involved in

crashes were asked to indicate the cause of such crashes. Participants were informed that submission of completed questionnaires implied participants' consent to their responses being used in the study. However, confidentiality and privacy of information was ensured and anonymity was maintained, as no direct personal information was requested from the participants. Data preparation and analysis was carried out using IBM SPSS (Statistical Package for the Social Sciences) Statistics Version 22.

2.3 On-Road Drivers' Speed Behaviour Survey

Driving speed investigation was carried out on a single carriageway road that had the provision of a street light, as shown in Fig. 1. Jalan Pontian Lama and Jalan Sejahtera 1, which represent horizontal and vertical alignments respectively, are located at Skudai, Johor. The total distance of the study area is approximately 3.1 km, with Jalan Pontian Lama measuring around 1.3 km in length and Jalan Sejahtera 1 measuring about 1.8 km in length. The posted speed limit on this road stretch is 60 km/h.

Fig. 1 - Selected study route

In this survey, all participants were asked to drive an auto-shift gear car along the study route, starting from Point A and ending at Point C, accompanied by one in-car observer, during off-peak daytime and night-time. Each participant was required to make 8 trips, distributed as 4 trips during daytime and 4 trips during night-time. During this on-road driving speed survey, the in-car observer used a Track Logger app installed in a mobile phone to capture the coordinates, distance, and speed of the vehicle in one-second intervals. The collected data was then transferred to Excel worksheets for data preparation and analysis.

3. Results and Discussion

3.1 Drivers' Behaviour

The analysis of questionnaire responses indicated that a majority of the respondents have more than 4 years of experience in driving (65%), followed by people with at least 1 to 4 years of driving experience (25%) and finally, those with less than one year of driving experience (10%). In terms of driving frequency, the results revealed that 45% of the respondents drive car every day. 20% of the respondents drive almost every day, while another 20% drive a few days a week. Thus, the study assumed that respondents drive their own car. Only 15% of the respondents drive as less as a few days a month. With respect to accident involvement, it was revealed that almost half of the respondents had been involved or nearly involved in accidents. The remaining half of the respondents reported that they had not experienced any accidents so far. A majority of the respondents confessed that distraction is one of the main factors that led them to meet with accidents. This is because, any other activity which competes for the driver's attention during driving can distract them and thereby seriously impact road safety.

Out of the 26 items regarding driving behaviours, the responses to the top five items had a mean value of above 3.50. The items were categorized as: (a) Distractions, (b) Violations, (c) Errors and (d) Lapses. The findings, as shown in Table 1, indicate that distractions, violations and errors were the most repeated aberrant behaviours prevalent among

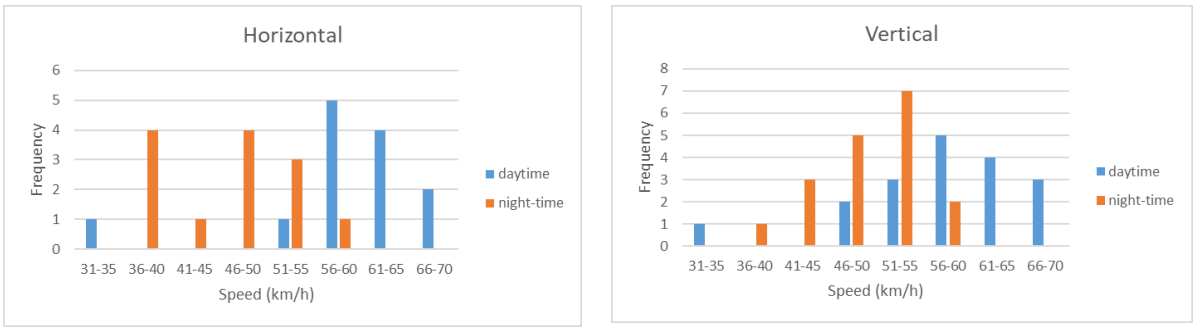
the participants. The most frequently reported aberrant behaviour was driving errors, wherein the drivers claimed that they often forgot to check the rear view before reversing their vehicles, when changing lanes or when making U turns. Such careless actions will lead to distortion in traffic and thereby increase the probability of crashes. The results also showed that the respondents occasionally operate the radio, CD, or cassette, always interact with passengers, and nearly all the time operate their phones using their hands, while driving. The effects of such distractions on drivers can vary from person to person; however, they are considered to be responsible for 25–80% of vehicular accidents [21], as they compete for the drivers' mental attention. Thus, instead of focusing on driving, the brain focuses on other tasks, thereby creating the risk of crashes. The use of a mobile phone or navigation system during driving increases the average following distance, decreases the average car speed, and increases the variability of car speed [22], [23]. A number of studies suggest that conversing with a passenger have similar or lesser detrimental effects than conversing on a cell phone [24]. Horberry, et al. [7] found that drivers' mean speed decreased when they were interacting with an in-car entertainment system, such as radio or CD-player. However, in terms of violation, they mostly obeyed the speed limits in residential areas.

Table 1 - Means and standard deviations of top five most frequently reported aberrant driving behaviours among participants

Item No.	Item	Mean	Std. Deviation
c1	Forget to check rear view mirror before pulling out, changing lanes and U turn.	4.55	0.60
a5	Switch on the radio, CD, or cassette while driving.	4.35	0.81
a3	Interaction with fellow passengers and children while driving.	3.8	0.83
a8	Holding Hand phone while driving.	3.65	1.26
b1	Obey the speed limit in a residential area road.	3.55	0.68

3.2 Effect of Lighting on Speed

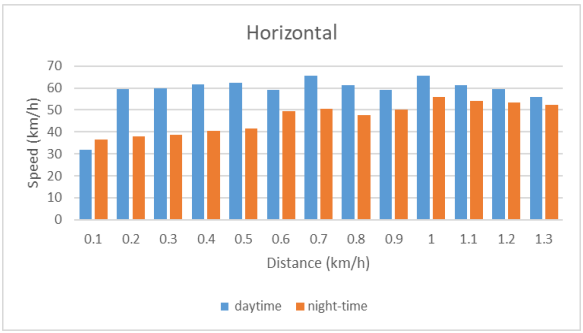
The impact of daylight on driving in horizontal and vertical curves was also assessed in this study. As shown in Fig. 2(a), speed distribution on the horizontal curve showed that drivers are most likely to drive at 56-60km/h during daytime and around 36-44km/h and 46-50km/h during night-time. On the contrary, the most frequent speed choices on the vertical curve during daytime was between 56-60 km/h, as shown in Fig. 2(b). During night-time, the highest frequency of speed in the vertical curve was between 51-55 km/h.



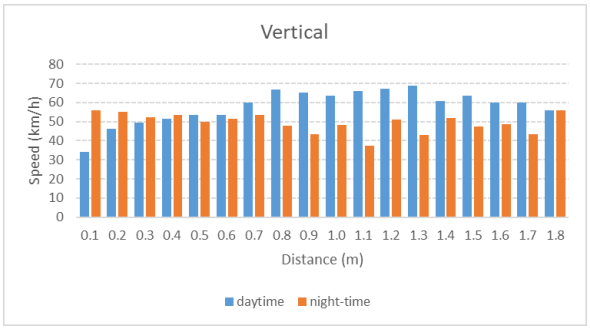
(a) (b)

Fig. 2 - Speed distribution during daytime and night-time; (a) Jalan Pontian Lama; (b) Jalan Sejahtera 1

Fig. 3 shows the speed profile of drivers during daytime and night-time. As presented in Fig. 3(a), the speed pattern along the horizontal curve was found to be higher during daytime when compared to night-time. This might be due to limited sight distance. A similar pattern was observed in the vertical curve, as shown in Fig. 3(b), wherein the speed during daytime was observed to be higher than during night-time. Also, it can be seen that speed increases gradually during both daytime and night-time with increase in distance, except for night-time driving in the vertical curve.



(a)



(b)

Fig. 3 - Speed profile during daytime and night-time, (a) Jalan Pontian Lama; (b) Jalan Sejahtera 1

While driving at night, drivers may experience problems such as vision deterioration, which can reduce their driving performance [25]. Both Fig. 2 and Fig. 3 given above indicate that drivers tend to drive slower in the night-time when compared to daytime. One possible explanation for this result is that the lighting in the study route may be insufficient on certain points of the curves, thus reducing night-time visibility. Insufficient light can impact drivers' confidence in controlling speed, thus causing them to drive at reduced speed. It is also important to note that drivers usually do not maintain constant speed on horizontal and vertical curves because they tend to improve driving stability along the curvature of the road [26].

Based on the null hypothesis that there is no difference in driving speed between daytime and night-time at 95% confidence level, T-test was conducted on speed data for both lighting conditions. The results of this test, as shown in Table 2, indicate that the p-value is less than 0.05 either at horizontal curve or vertical curve. Thus, null hypothesis was rejected and the difference in speed between daytime and night-time is significance.

Table 2 - T-test result on speed data during daytime and night-time

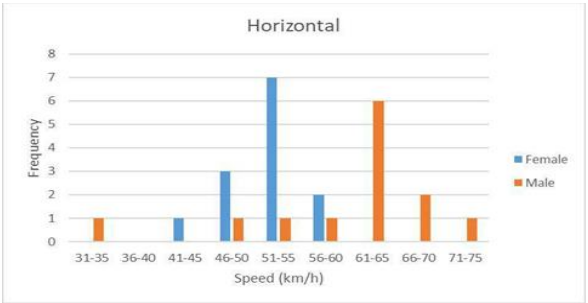
Case	1	2
Curve	Horizontal	Vertical
p-value	0.001*	0.001*

*p-value < 0.05, reject null hypothesis

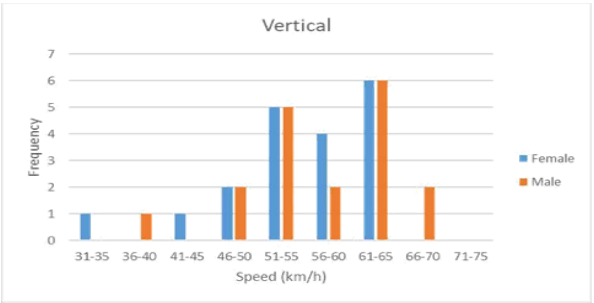
3.3 Effect of Gender on Speed

The speed data of male and female drivers was also compared to determine any differences in speed choices between genders along vertical and horizontal curves. Fig. 4(a) and Fig. 4(b) show the speed distribution for male and female drivers on horizontal and vertical curves, respectively. The speed patterns of male and female drivers on the horizontal curve indicate that females mostly drive at 51-55km/h while males drive at 61-65km/h, which is 10km/h faster than their female counterparts. On the other hand, the distribution of speed on the vertical curve indicates that both males and females drive at 61-65km/h in vertical curves.

Fig. 5 and Fig. 6 show the speed profile for male and female drivers during daytime and night-time, respectively. As can be seen in Fig. 5, female drivers drive slower than male drivers on horizontal curves during daytime. On the vertical curve, the speed profiles of male and female drivers were almost similar during daytime. However, during night-time, the speed pattern of male and female drivers on the vertical curve seemed to be different. Female drivers chose to drive at a higher speed, as shown in Fig. 6.

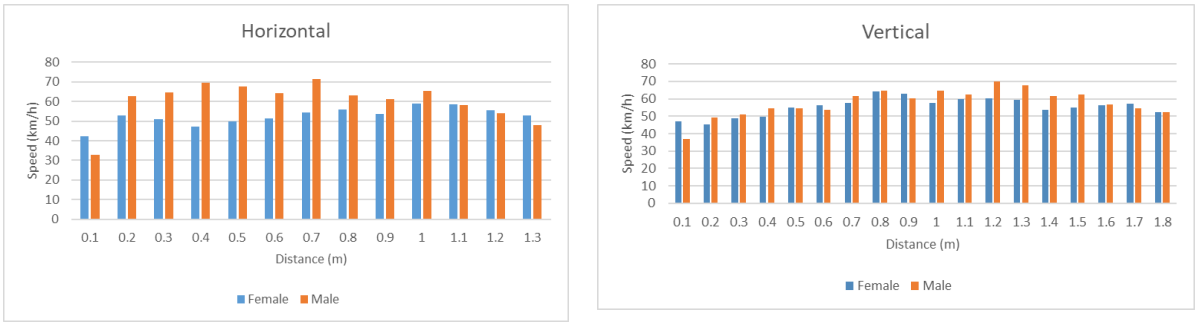


(a)



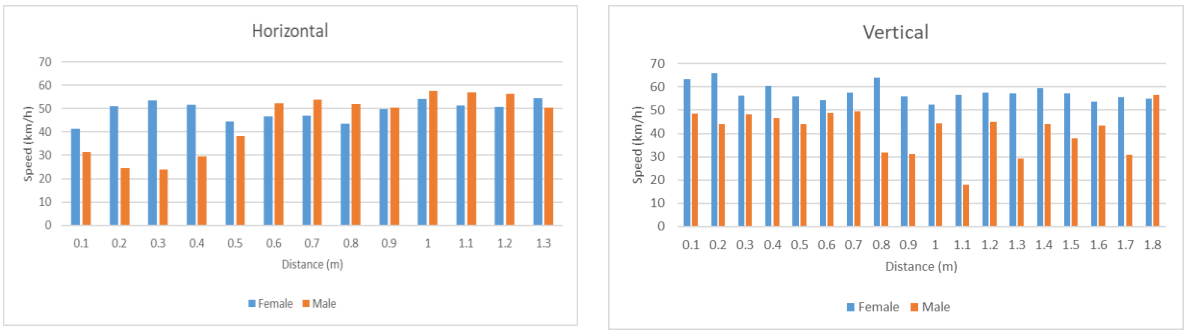
(b)

Fig. 4 - Speed distribution for male and female drivers; (a) Jalan Pontian Lama; (b) Jalan Sejahtera 1



(a) (b)

Fig. 5 - Speed profile for male and female drivers during daytime; (a) Jalan Pontian Lama; (b) Jalan Sejahtera 1



(a) (b)

Fig. 6 - Speed profile for male and female drivers during night-time; (a) Jalan Pontian Lama; (b) Jalan Sejahtera 1

T-test was then performed with the null hypothesis that there is no difference in driving speed between male and female drivers at 95% confidence level. The results of daytime driving as presented in Table 3 below showed that only one p-value is below 0.05, so the null hypothesis was rejected. Thus, it can be summarized that there is a significant difference in speed between male and female drivers on horizontal curves during daytime. The t-test results for night-time driving, as given in Table 4 below, shows that speed difference is significant between male and female drivers on vertical curves only. This indicates that, both male and female drivers were not influenced by curvature of roads and lighting conditions.

Table 3 - T-test result on speed data for male and female during daytime

Case	1	2
Curve	Horizontal	Vertical
p-value	0.014*	0.162

*p-value < 0.05, reject null hypothesis

Table 4 - T-test result on speed data for male and female during night-time

Case	1	2
Curve	Horizontal	Vertical
p-value	0.109	0.000*

*p-value < 0.05, reject null hypothesis

4.0 Conclusion

Based on the synthesis of evidences obtained from the study, the following summary points can be inferred:

- Most of participants have a driving experience of more than 4 years. The most frequently reported aberrant driving behaviour among all of the participants is distraction, followed by errors and violations.
- Speed patterns during daytime and night-time does not show a very good distribution of data. Driving speed pattern in vertical and horizontal curves, however, is higher during daytime when compared to night-time. In terms

of statistical analysis, there is significant difference in mean speed between daytime and night-time for both type of curves.

- Speed distribution between male and female drivers is slightly different on vertical and horizontal curves during daytime and night-time. However, significant difference in speed between male and female drivers was found only for the horizontal curve during daytime and vertical curve during night-time.

Distraction is the most frequent problem faced by young drivers while driving. Since this aberrant driving behaviour will have a profound effect on driving performance and safety especially on horizontal and vertical curves, the concerned authorities should educate drivers and enforce laws to discourage such behaviour, as inconsiderate drivers not only put themselves at risk but also other innocent road users.

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