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Distracted Driving Measurement for Manual Destination Entry Using Navigation Device

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Abstract – *This paper discusses the measurement of driver distraction for manual destination entry using navigation devices in a simulated traffic environment. 46 participants completed a number of secondary tasks while synchronously conducting the driving activities and performing the detection task. For comparison of the driving scenarios, three scenarios were used which were low speed, high speed, and traffic congestion. Secondary tasks including 0, 1, 2, 3, 4, 5, 7, 9, 14, 20 number of characters were assessed in the study. The results of this study showed that participants were more distracted with more demanding tasks to handle the destination entry as compared to baseline. In addition, we also found that participants attended the worst in terms of higher RT in traffic jam scenarios as compared to other two scenarios. This study shows that doing navigation task specifically destination entry while driving is considered as a distracting activity that possibly elevates the risk of a crash.*

Keywords: Driving distraction, navigation device, driving simulator, road safety

1.0 INTRODUCTION

In the year 2017, 6,740 fatalities were recorded due to road crashes with an average of 18 people were killed every day in Malaysia (Royal Malaysia Police, 2018). Studies had shown that human errors are the major contributing factor, which is about 90% of the road traffic accident (Chan, 2007). One of the severe problems of road safety is driver distraction. Distracted driving can be defined as doing any activities other than main activity which is driving, which can divert the driver's attention (Ranney, 1994). Driver distractions can vitiate the performance of the drivers when they cannot give full attention to the main activity during dangerous situations (Young & Salmon, 2012). Numerous literature mentioned that driver distraction is well known as a causal factor in vehicle accidents (McEvoy et al., 2007; Stutts et al., 2001; Wang et al., 1996). These numbers will have a possibility to increase in the future because of the escalated usage of in-vehicle technologies such as navigation devices.

The navigation devices may be helpful to guide drivers to go to a specific destination but it has potential to distract drivers in several ways, which are physical, visual, auditory and cognitive distractions (Ranney, 2008). Physical distraction happens when the driver has to use hand to control the device to do manual destination entry. Visual distraction occurs due to the amount of time looking at the display while entering a destination or observing the directions. For auditory distraction can happen when the driver is listening to auditory commands. In additional, cognitive distraction involves delays in attention and judgment. Distraction occurs when two mental tasks are performed at the same time when drivers think about the information presented by the navigation device. Destination entry when using navigation devices can be considered as the most distracting activity while driving and it required a time-consuming process (Young et al., 2003). Furthermore, destination entry using manual systems had a higher distraction as compared to the voice-triggered system since it involved longer time for eye glances at the device and higher lane deviation numbers (Tijerina et al., 1998).

One of the empirical methods to study driver behaviour related issues specifically distracted driving is a driving simulator. A driving simulator is an instrument that can simulate a virtual driving environment and resemble real driving condition (Kang & Abdul Jalil, 2004). There are some advantages of using driving simulator as compared to other methods such as on-road driving research, which are controlled and repeatable environment, safety purposes and cost reduction (Nilsson, 1993). Driving simulator enables researchers to isolate experimental variables from other factors that might influence driving performance, therefore improving the accuracy of the recorded measures. Furthermore, the simulator can study the hazardous driving situation that could not be replicated by on-road study without exposing the subject to unacceptable risks. Simulator study could reduce the research operation cost since the simulation environment and other factors can be controlled. Hence, there are no costs for fuel, toll fare, on-road vehicle maintenance (Eskandarian et al., 2008). Driving simulator experiments is also an alternative to traditional methods such as self-reports which was widely argued to have limitations in studying driving behaviours (Boyce & Geller, 2001).

Detection Response Task (DRT) is one of the methods for measuring driver distraction (Young et al., 2003). DRT is employed for measuring the consequence of driving as the main task and doing secondary tasks on driver attention (Engström et al., 2013). The DRT method is a task in which participants respond to repeated stimuli presented within a specific duration. Detection performance measured in terms of response time represents the degree to which selective attention is affected by the tasks under evaluation (ISO, 2016). The study was generally aimed to measure driver distraction in terms of response time for manual destination entry using navigation devices in simulated traffic environments. Besides, this study intended to compare participants' response time with respect to within-subject variables (i.e. character numbers and driving scenarios)

2.0 METHODOLOGY

The study was designed using a convenience stratified sampling method. A total of 46 participants with ages range between 18 and 57 years old (mean age: 31.43) participated in the study voluntarily. All participants are licensed drivers. The MIROS Driving Simulator Cabin (CabinDS) was used in this study. The platform for the simulator is a second generation of Perodua Myvi 1.3 litre. The main components CabinDS system are steering wheel, pedals, transmission, full car cabin, LCD projector and screen, computer, simulation software, video camera, and sound system. Figure 1 illustrates the overview of the CabinDS and the designated driving scenarios. SILAB Version 5.0 was used as the simulation software in the development of the driving scenarios. Three types of driving scenarios were developed in this study, which were low speed (40 km/h), high speed (110 km/h) and traffic jam.

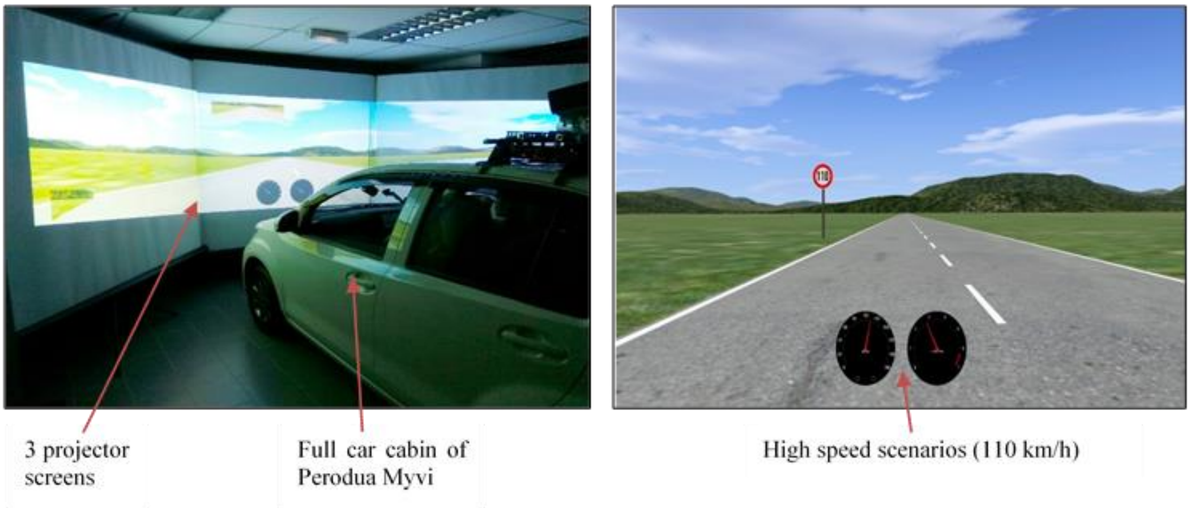

Figure 1: Overview of the CabinDS

Tactile Detection Response Task (TDRT) was used in the study. It requires drivers to respond to the vibration they feel, by pressing a small switch attached to the finger. It involves tactile stimuli that are presented by means of small vibrators attached to the skin. The stimulus was presented at temporal intervals randomly, uniformly distributed between three and five seconds. The stimulus stayed on for a maximum time of one second. Participants performed the driving task and the secondary tasks concurrently according to driving scenarios. The navigation task using manual destination entry with different character numbers was used in the study as a secondary task. A mobile phone was secured in the driving simulator windscreen using a suction holder. Notes Application was installed in the mobile phone so that participants required to key-in the specific address repeatedly as much as possible within two minutes duration according to the specified character numbers. The details of addresses associated with character numbers are shown in Table 1.

Table 1: List of character numbers and addresses

Character	Addresses
0	No address (baseline)
1	1
2	kg
3	lrg
4	sate
5	taman
7	pelangi
9	teknologi
14	jalan semenyih
20	lorong kajang raya 2

Upon arrival, participants were briefed about the study, safety precautions, and their rights while participating in the study by the researcher. The risk associated with simulator studies such as simulator sickness was explained to the participants. The participants then gave their consent by signing the consent form. After the briefing, the participants self-administered a questionnaire regarding demographic information and driving experience. Participants were subjected to simulator sickness screening before and after the experiment using the Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1993). The purpose of the screening was to ensure that the participants were fit to drive the driving simulator and to evaluate the risk of simulator sickness after the driving session. All subjects passed these tests.

The participants underwent the familiarization session until they felt confident enough to drive. Next, the participants underwent the actual driving session. They were reminded that they were allowed to end the session without any obligations and were monitored through CCTV to keep the interaction at a minimal level. The sequence of the tasks used the counterbalancing condition that adapts a balanced Latin square, thus different in each run as shown in Table 2. Upon completion of the driving session and post-simulator sickness screening, participants were debriefed. The participants then shared their driving session experience and comments with the researchers. Each participant required approximately three hours to perform all the procedures.

Table 2: List of character numbers for each participant

Participant No.	Character Numbers									
1	7	9	2	3	14	20	1	5	0	4
2	2	0	1	7	9	4	5	20	14	3
3	1	2	3	4	20	14	9	7	5	0
4	20	4	5	2	1	0	3	14	9	7
5	14	1	4	20	2	5	0	3	7	9
6	9	3	20	0	4	7	14	1	2	5
7	5	20	14	9	7	2	4	0	3	1
8	3	5	9	14	0	1	7	4	20	2
9	4	7	0	5	3	9	20	2	1	14
10	0	14	7	1	5	3	2	9	4	20
11	5	2	9	7	0	14	20	1	3	4
12	14	1	3	5	20	7	4	9	0	2
13	7	4	1	3	14	2	9	20	5	0
14	20	0	7	2	1	4	14	3	9	5
15	9	14	4	20	3	5	2	0	7	1
16	3	9	14	0	4	1	5	2	20	7
17	1	5	2	14	9	3	0	7	4	20
18	0	20	5	1	7	9	3	4	2	14
19	2	3	20	4	5	0	7	14	1	9
20	4	7	0	9	2	20	1	5	14	3
21	0	2	9	20	3	7	4	5	14	1
22	3	14	0	2	1	9	7	4	5	20
23	9	20	1	4	2	14	3	7	0	5
24	1	7	20	9	4	2	5	0	3	14
25	5	1	3	0	9	4	14	20	7	2
26	20	5	2	1	7	3	0	14	9	4
27	2	3	14	7	5	20	9	1	4	0
28	4	9	7	5	14	0	20	2	1	3

29	14	4	5	3	0	1	2	9	20	7
30	7	0	4	14	20	5	1	3	2	9
31	14	0	5	20	2	7	4	9	1	3
32	7	9	20	4	5	0	3	1	2	14
33	9	3	0	14	7	1	5	4	20	2
34	4	14	7	2	0	20	9	3	5	1
35	20	5	14	3	4	9	1	2	7	0
36	3	7	2	9	1	5	14	0	4	20
37	1	2	4	0	20	3	7	5	14	9
38	5	4	3	1	9	2	20	14	0	7
39	0	1	9	7	14	4	2	20	3	5
40	2	20	1	5	3	14	0	7	9	4
41	5	7	0	4	14	2	1	20	3	9
42	14	5	3	20	7	4	9	2	0	1
43	1	2	14	3	0	20	5	9	4	7
44	0	14	2	7	20	5	3	1	9	4
45	20	3	7	1	2	9	0	4	5	14
46	9	4	5	3	7	14	1	0	2	20

3.0 RESULTS AND DISCUSSION

Table 3 lists a general statistic of the participants, which could influence the results of the study. 24 males and 22 females participated in the study with average 11.09 years of driving experience. All participants were licensed drivers with an average driving distance of 19,673 km a year and an average driving experience of 11 years. In addition, 13% (N = 6) of the participants have a history of involving in a road crash for the past 3 years. Furthermore, 34.8% (N= 16) of them were involved in near-miss crash.

Table 3: Descriptive summary of the participants

Categories	**Min**	**Max**	**Mean**
Age (year)	18	57	31.43
Diving experience (year)	1	35	11.09
Annual driving mileage (km)	20	100000	19672.61
Crash involvement (times in 3 years)	0	1	.13
Near miss crash involvement (times in 3 years)	0	6	.74
Talking using mobile phone (times in a week)	0	14	1.80
Texting (times in a week)	0	14	2.11
Navigation using smartphone (times in a week)	0	7	1.24
Other navigation device (times in a week)	0	5	.43

Figure 2 summarizes the percentage of doing distraction activities while driving in a week among participants. It shows that most of the participants were talking using mobile phones, texting and navigate using a smartphone while driving with percentage of 60.9%, 54.3% and 52.2% respectively. Talking using mobile phone and texting were the most frequent activities did by the participant (i.e. 14 times). However, only 21.7% participants were using other navigation device while driving with maximum 5 times usage in a week as shown in Table 3. This finding is aligned with the study conducted by Aini and Sharifah (2016) who found that more than 50% of drivers in Klang Valley were using mobile phones for receiving and making calls, typing and reading a message (texting) and to get a direction.

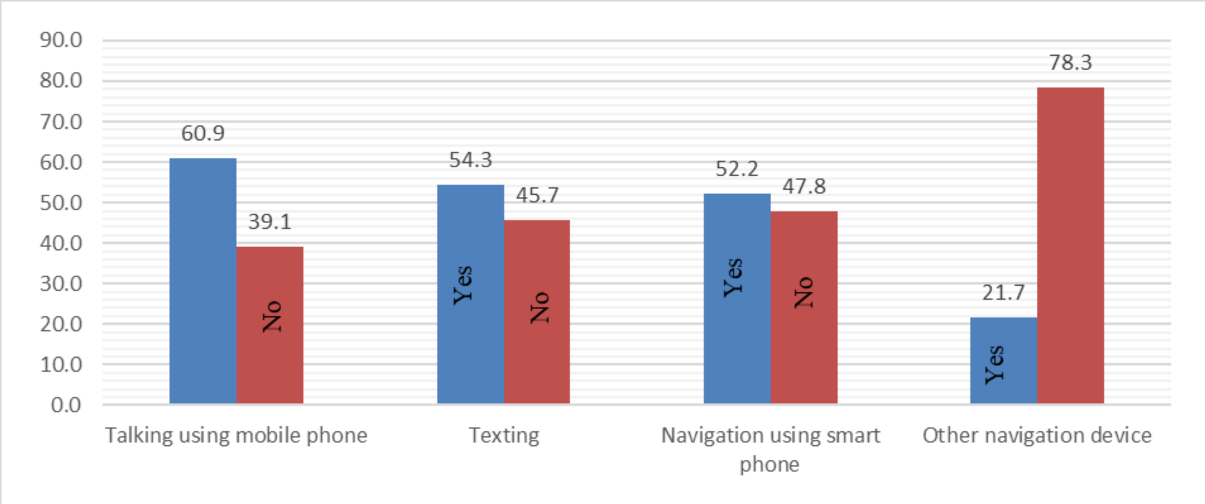

Figure 2: Percentage of doing distraction activities while driving in a week

The analysis of Response Time (RT) were subjected to mixed factorial repeated-measures ANOVA procedure to study mean differences of RT with respect to within-subject variables which were character numbers and driving scenarios. Mixed factorial repeated-measures ANOVA revealed a significant main effect of character numbers on RT, $F(6.10, 256.12) = 25.29$, $p < .001$. In addition, simple contrasts revealed that RT for all other characters are significantly higher than the baseline, $F_{baseline\ vs.\ 1char}(1, 42) = 96.12$; $F_{baseline\ vs.\ 2char}(1, 42) = 76.53$; $F_{baseline\ vs.\ 3char}(1, 42) = 51.71$; $F_{baseline\ vs.\ 4char}(1, 42) = 85.39$; $F_{baseline\ vs.\ 5char}(1, 42) = 77.42$; $F_{baseline\ vs.\ 7char}(1, 42) = 78.76$; $F_{baseline\ vs.\ 9char}(1, 42) = 126.24$; $F_{baseline\ vs.\ 14char}(1, 42) = 95.63$; $F_{baseline\ vs.\ 20char}(1, 42) = 94.89$; all pairs had $p < .001$. Main effect of driving scenarios on RT was also significant, $F(2, 84) = 31.54$, $p < .001$; with significant difference between traffic jam and 40 km/h scenario, $F(1, 42) = 44.37$, $p < .001$; as well as between also traffic jam and 110 km/h scenario, $F(1, 42) = 41.90$, $p < .001$. There was also a significant interaction effect between character numbers and driving scenarios, $F(9.51, 399.31) = 2.48$, $p = .001$ (Greehouse-Geisser corrected). Figure 3 shows the RT for each character number based on driving scenarios. Overall, RT for traffic jam scenario were higher than both 40 km/h and 110 km/h driving scenarios in all character number conditions.

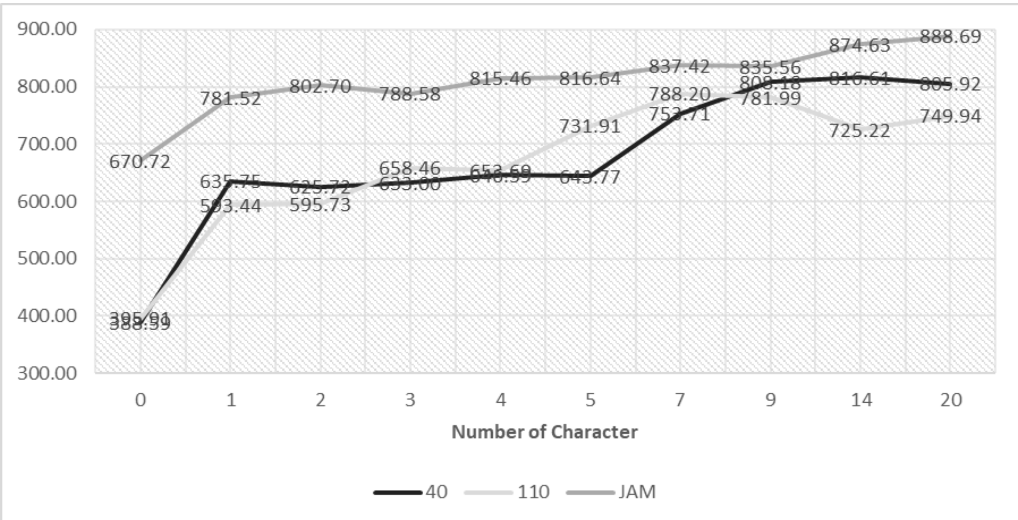

Figure 3: RT for each character number based on driving scenarios

Table 4 shows the RT change percentage as compared to baseline for different character numbers and driving scenarios. The baseline RT was higher in traffic jam scenario, compared to 40 km/h and 110 km/h scenarios. In general, the RT increased with an additional number of characters for each traffic scenario, compared to the baseline. However, the percentage of changes were different across the three traffic scenarios. The highest percentage of change was 32.5% when driving in a traffic jam as compared to 99.09% and 110.15% for 110 km/h and 40 km/h driving scenarios respectively.

Table 4: RT change percentage as compared to baseline for different number of characters and driving scenarios

Number of characters	**Traffic jam**		**110 km/h driving**		**40 km/h driving**	
	RT (s)	**Change from baseline (%)**	**RT (s)**	**Change from baseline (%)**	**RT (s)**	**Change from baseline (%)**
0 (Baseline)	670.72	Reference	395.91	Reference	388.59	Reference
1	781.52	16.5	593.44	49.89	635.75	63.60
2	802.70	19.7	595.73	50.47	625.72	61.02
3	788.58	17.6	658.46	66.32	633.00	62.90
4	815.46	21.6	653.69	65.11	646.59	66.39
5	816.64	21.8	731.91	84.87	643.77	65.67
7	837.42	24.9	788.20	99.09	753.71	93.96
9	835.56	24.6	781.99	97.52	808.18	107.98
14	874.63	30.4	725.22	83.18	816.61	110.15
20	888.69	32.5	749.94	89.42	805.92	107.40

The results of this study show that the character numbers required to manually enter the destination address affect the level of distraction measured in terms of RT among the participants. They are more distracted with the increase of workload to control the navigation device as compared to baseline. This finding is aligned with the association between task demand and the level of distraction (Knapper et al., 2015). Another significant finding was that drivers' engagement in a secondary task while driving in challenging driving scenarios increased RT, which show higher level of distraction. Drivers were found to be more distracted when driving in a traffic jam as compared to free-flowing traffic scenarios (i.e. 40 km/h and 110 km/h scenarios). This finding is contrary to a study that revealed no relationship between the frequency of distracted driver behaviours and the amount of traffic (Foss & Goodwin, 2014). However, our result could denote a potentially higher risk of driving distraction in certain traffic scenarios that can lead to road crash.

4.0 CONCLUSION

Summing up briefly, the objectives of the study were fulfilled whereby to measure the distraction in terms of participants' RT for different character numbers of manual destination entry using navigation device and driving scenarios using a driving simulator. Besides, this study aimed to compare participants' RT with respect to within-subject variables. The findings of this research indicate that drivers are more distracted when dealing with more demanding activity, in this case is to manually key in the address with different character numbers to the navigation device as compared to baseline. In addition, participants attended the worst in term of higher RT in traffic jam scenario. It is recommended that advance-driving simulator with motion platform could be utilised for future study to reduce the existence of simulator sickness among participants and be able to simulate varieties of realistic driving scenarios. Besides, a large-scale study that involves higher number of participants is recommended for future research.

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