ORIGINAL ARTICLE

# EFFECT OF AUDITORY DISTRACTION ON HAND AND FOOT REACTION TIME AMONG AGEING MALAYSIAN AUTOMOBILE DRIVERS

**Nazlin HA[1,2] and Siti Zawiah MD[1]**

*[1]Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia.*
*[2]Department of Engineering, Faculty of Engineering & Life Sciences, Universiti Selangor, Selangor, Malaysia.*

*** Corresponding author: Nazlin HA**
**Email:** nazlinhanie@gmail.com

## ABSTRACT

*The involvement of ageing drivers in traffic accidents were reported but little cited on the severity of auditory driving distractions. Driving distraction contributes to increases in reaction time which can lead to safety traffic risks. Thus, in this study, hand and foot reaction times were measured in response to different distractions within the identical simulated driving route. The task varies in a controlled setting where soundless distractions were present, Comfortable Loudness Level (CLL), Uncomfortable Loudness Level (ULL) auditory distractions, and phone call distraction. Participants were among 40 Malaysian driving license holders consists of 57.5% males and 42.5% females with age mean, (M=51.83, SD=14.058). Results indicated that both hand and foot reaction time were shortest for CLL and longest during phone call. Ageing male scored shortest hand reaction time of 1.15s during CLL distraction. For foot reaction time, ageing male scores shortest of 0.92s for both CLL and no distractions. Pearson's coefficient of correlation shows r>0.5. The results indicated hand reaction time was affected by foot reaction time (r=0.665), was significantly more for foot when compared with hand, could be because of difference in nerve conduction velocity and movement time of the hand when compared with that of foot.*

***Keywords**: auditory distraction, CLL, ULL, phone call, hand reaction time, foot reaction time*

## INTRODUCTION

Distracted driving is defined as any behaviour that distracts the driver from driving, including converse or texting on the phone, eating and drinking, interacting with individuals in the automobile, entertainment or using navigating devices, or anything that distracts the driver from the safely focused driving activity. A driver is distracted when they committed to a second activity while driving. Consequently, in order to be classified as distracting, a secondary task must have some measureable impact on driving performance [1]. Technically, a driver can't always be multitasking securely throughout, particularly when the second activity is complex or time consuming. The second activity places additional requirements on the driver, which can lower the driving performance. It may, for instance, cause the driver to become less observant and less focused, or make bad choices about how to safely control the automobile. This reduced driving standard implies that a driver is more likely to fail to anticipate risks, and the diversion could lead to accident opportunities [2].

Furthermore, driving activity includes the concurrent processing of numerous information such as external information on other drivers, road signs and traffic lights, as well as internal automobile's information related to one's own driving behaviour. One significant criterion in a driving activity is the reaction time of the hand and foot, defined as the lapsed time between a sensory stimulus presentation and the subsequent behavioural response. The reaction time offers a comprehension of how fast an person would respond to an case and is a critical element of safety driving and preventing accidents [3,4]. Reaction time in aging drivers was generally correlated with slower response times and poorer stimulus recognition, suggesting that variability could be a helpful measure of overall neural integrity[4]. Two types of limitations prevailed among ageing drivers. Firstly, the ageing driver faced difficulties with decision making under time pressure, and secondly, the ageing driver has problems with the requirements of simultaneous activities. These problems become apparent in accident statistics where ageing drivers are over involved in traffic accidents when they are overtaking or being overtaken, and in accidents when approaching junction. In most cases the ageing driver was at fault and failed to give right-of-way or failed to stop at a stop sign. The cause for this impaired performance lies both on the level of the sensory systems and on the level of cognitive functioning [5].

Longer reaction time may result in road safety hazards. Reaction time as its practical implications have been extensively studied and may have excessive consequences. Many variables influence response times, including age, gender, physical fitness, level of fatigue, diversion, alcohol, type of personality, biological rhythm, health, auditory or visual stimulus [6]. However, the mental processing time of the driver is extremely subject to alterations in the presence of distractions that contribute to the driver's mental

workload. The greater the mental workload of a subject, the longer it is anticipated to be its mental processing time. Driving performance can therefore be reduced as a consequence of active listening because auditory processing can decrease as a consequence of activation of the parietal lobe, a region of the brain responsible for the motor movements involved with driving tasks[2].

The aim of this study was to determine the impacts of auditory distractions within distinct types of auditory distractions on both hand and foot reaction times of the driver.

## METHODS

### Participants

The selection of the participants were among the active drivers living in Selangor and Kuala Lumpur. The recruited automobile licensed drivers with good health condition were grouped into three group namely adult group, ageing and elderly drivers group. The adult group consist of drivers aged ranging from 21 to 39 years old. Meanwhile ageing group were among the drivers aged 50 to 59 years old and elderly drivers were among the drivers aged 60 years and above. A total of 40 subjects were recruited comprising 10 adult, 15 ageing and 15 elderly drivers as shown in Table 1.

The participants' socio demographic information were obtained in this stage. The age and gender were the demographics variables of the participants in each group. The age mean and standard deviation (SD) of Group 1 are 30.6 and 8.072 respectively. There are five male and five female participants who took part in this study. Meanwhile, the age mean and SD of Group 2 are 53.27 and 2.492 with nine male and six females took part in this study. On the other hand, the age mean and SD of Group 3 are 64.6 and 2.261 accordingly. These group consist of nine male and six female participant

***Table 1**. The frequency and age mean of the experimental participants*

| | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| **Category** | young | ageing | elderly |
| **Frequency of participants** | 10 | 15 | 15 |
| **Age mean and SD** | 30.6 ± 8.072 | 53.27 ± 2.492 | 64.6 ± 2.261 |

### Procedure

The purpose of this task is to observe the hand and foot reaction time throughout the designated driving activity[7,8]. Participants underwent four sets of experiments, driving with no distraction, followed by audio distraction with Comfortable Loudness Level (CLL) and Uncomfortable Loudness Level (ULL)[9].

Participants also were tested with phone call distraction during the fourth experiment. The variables for the driving task is described in Table 2.

### Duration

The total duration of the driving task in this study was approximately 30 minute including setup of the participant.

***Table 2**. Variables for Simulated Driving Experiment*

| | Variables | Parameter |
|---|---|---|
| **Independent Variables** | Age | Age group:<br>Group 1 :Young (below 50 years)<br>Group 2: Ageing (50 – 59 years)<br>Group 3: Elderly (60- above) |
| | Soundless Distraction<br>Auditory Distraction | |
| | | Comfortable Loudness Level (CLL) : Kenny G song |
| | Distraction by Phone call | Uncomfortable Loudness Level (ULL) : loud child's tantrum |
| **Dependant Variables** | Foot reaction time | Reaction time at foot reaction event (sec) |
| | Hand reaction time | Reaction time at hand reaction event (sec) |
| **Controlled Variables** | Driving Posture<br>Environment | |

### Experimental route

The participant performed a simulated driving task in University of Malaya, started and ended at Faculty of Engineering as illustrated in Figure 1.

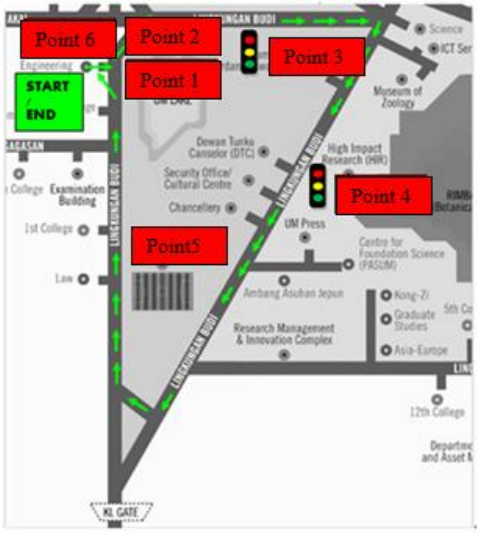



**Figure 1.** Experimental route for driving task

The location and time for each hand reaction and foot reaction event are as stated in Table 3 below:

***Table 3**. Experimental route*

| Event | Event ( sec) | Task |
|---|---|---|
| Point 1 | 0.07 | Hand |
| Point 2 | 0.33 | Foot |
| Point 3 | 0.56 | Foot |
| Point 4 | 1.35 | Hand |
| Point 5 | 4.13 | Hand |
| Point 6 | 4.30 | Foot |

### Measures

In the driving task, performance measures evaluated are as following:

a) Hand reaction time, measured through the driving task that required participants to press a button on the right side of the steering wheel in response to the appearance of an audial cue at hand reaction time event.

b) Foot reaction time, measured through the driving task that required participants to stroke the brake pedal in response to the appearance of an audial cue at foot reaction time event.

### Statistical Analysis

The IBM Statistical Package for Social Science (IBM SPSS Statistics for Windows Version 23.0, Armonk, NY: IBM Corp) was used in the following statistical analysis. All data measurements were analyzed to identify the existence of correlation between variables and parameters. A repeated measures ANOVA were used as a tool to analyze the collected data.

## RESULTS

Among 40 Malaysian driving license holders, data were gathered consisting of 23 men (57.5%) and 17 women (42.5%). Participants' age ranges from 21 to 69, with average age (M) of 51.83 and standard deviation (SD) of 14.058. Participants were chosen from Malaysian driving license holders who met the following requirements: a) active drivers, b) understanding or speaking fundamental Malaysia and English languages, (c) signed informed consent, (d) have not been revealed or discovered to have no cognitive llnesses as recognized in the verbal interview and health screening questionnaire, and (e) have no other health issues that might interfere with their capacity to conduct hand response tests (e.g., palm ulcers) and foot reaction time tests (e.g., lower limb impairment). Ethical approval for the study was obtained from the University of Malaya Medical Centre Ethics Committee. Figure 2 shows the frequency of participants in each group.

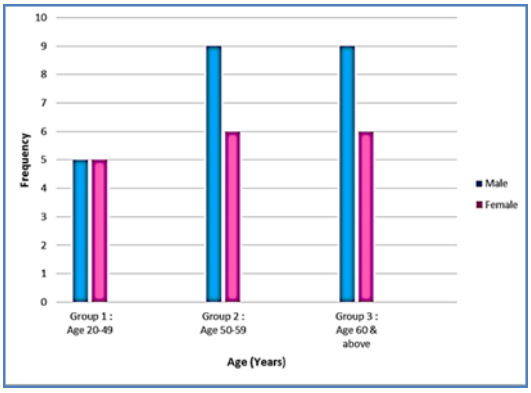



***Figure 2**. Frequency of the experimental participants*

**Performance Measure during Driving Task**

The driving task was carried out in four cycles within four types of distraction within the same route. Figure 3 shows an elderly during the driving task.

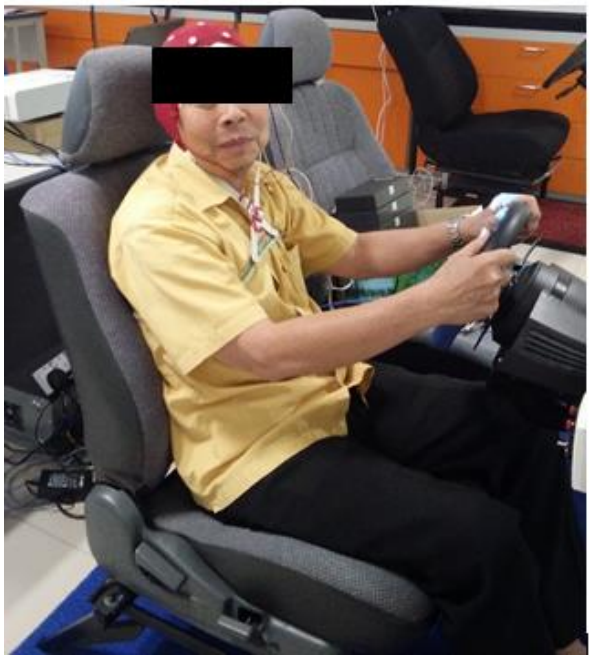
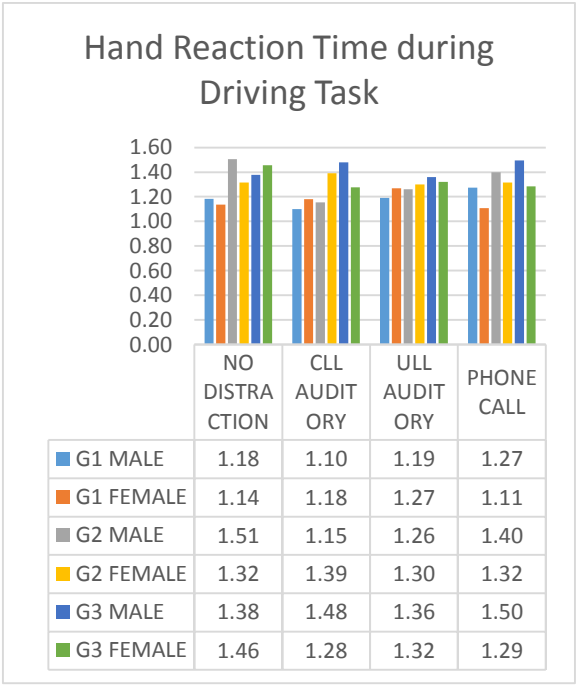


**Figure 3.** A participant performing driving task

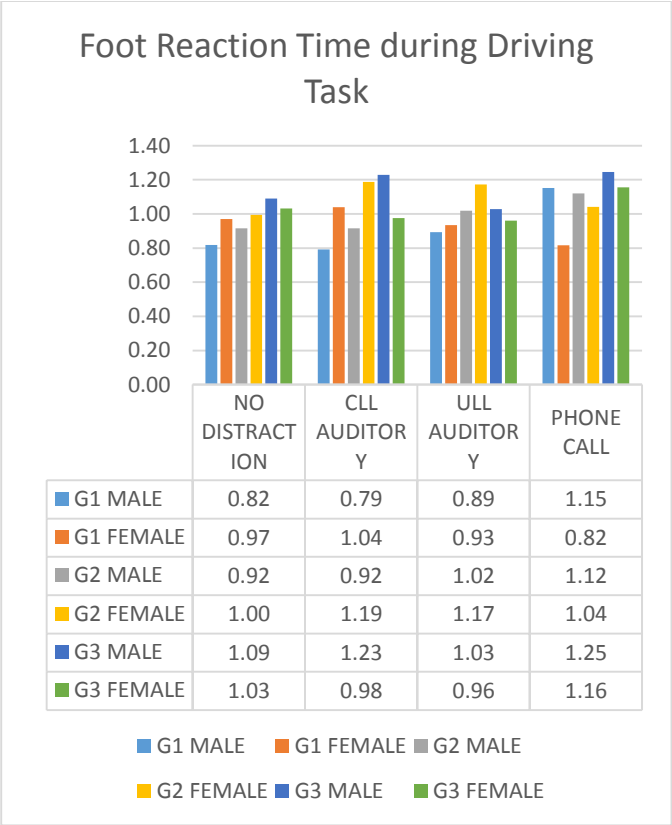
The hand reaction time was taken three time during driving task. Figure 4 shows the overall performance of hand reaction time by the participants within all types of distraction.




| | NO DISTRACTION | CLL AUDITORY | ULL AUDITORY | PHONE CALL |
|---|---|---|---|---|
| G1 MALE | 1.18 | 1.10 | 1.19 | 1.27 |
| G1 FEMALE | 1.14 | 1.18 | 1.27 | 1.11 |
| G2 MALE | 1.51 | 1.15 | 1.26 | 1.40 |
| G2 FEMALE | 1.32 | 1.39 | 1.30 | 1.32 |
| G3 MALE | 1.38 | 1.48 | 1.36 | 1.50 |
| G3 FEMALE | 1.46 | 1.28 | 1.32 | 1.29 |

**Figure 4.** Hand reaction time at different distractions during driving task

The foot reaction time was taken three time during driving task. Figure 5 shows the overall performance of foot reaction time by the participants within all types of distraction.




| | NO DISTRACTION | CLL AUDITORY | ULL AUDITORY | PHONE CALL |
|---|---|---|---|---|
| G1 MALE | 0.82 | 0.79 | 0.89 | 1.15 |
| G1 FEMALE | 0.97 | 1.04 | 0.93 | 0.82 |
| G2 MALE | 0.92 | 0.92 | 1.02 | 1.12 |
| G2 FEMALE | 1.00 | 1.19 | 1.17 | 1.04 |
| G3 MALE | 1.09 | 1.23 | 1.03 | 1.25 |
| G3 FEMALE | 1.03 | 0.98 | 0.96 | 1.16 |

**Figure 5.** Foot reaction time at different distractions during driving task

**Hand reaction time between different types of auditory distractions during driving task**

A two way repeated measures ANOVA was conducted to evaluate the differences in the hand reaction time between four types of distractions (no distraction, CLL auditory, ULL auditory, phone call) and three hand reaction event within the driving task (at minute 0.07, 1.35 and 4.13), for three age group of subjects (young, ageing and elderly). Based on the two way repeated measures ANOVA, with a Greenhouse-Geisser correction, it was found that the hand reaction time differed insignificantly between the distractions. According to these results among all covariates, only the interaction between hand reaction event, age and gender was significant ($p<0.05$). Meanwhile distraction, hand reaction event and other source of variations shows insignificant differences. The interactions between distraction and hand reaction is significant difference. Table 4 summarized the details of repeated measures ANOVA of hand reaction during driving task for both within and between subjects effect.

***Table 4**. Analysis of Variance of hand reaction during driving task*

| Source of variation | dF | F-value | P-value | Partial Eta squared |
|---|---|---|---|---|
| Distraction | 2.34 | 0.58 | 0.59 | 0.02 |
| Distraction*age group | 4.68 | 0.43 | 0.81 | 0.03 |
| Distraction*gender | 2.34 | 1.23 | 0.30 | 0.04 |
| Distraction*age group*gender | 4.68 | 1.34 | 0.26 | 0.07 |
| Time | 2 | 0.25 | 0.78 | 0.01 |
| Time*age group | 4 | 0.95 | 0.44 | 0.05 |
| Time*gender | 2 | 1.45 | 0.24 | 0.04 |
| Time*age group*gender | 4 | 2.07 | 0.09 | 0.11 |
| Distraction*time | 4.10 | 1.36 | 0.25 | 0.04 |
| Distraction*time*age group | 8.20 | 0.90 | 0.52 | 0.05 |
| Distraction*time*gender | 4.10 | 1.23 | 0.30 | 0.04 |
| Distraction*time*age group*gender | 8.20 | 1.31 | 0.24 | 0.07 |

**Foot reaction time between different distractions during driving task**

Comparison of the foot reaction time was analysed. A two way repeated measures ANOVA was conducted to evaluate the differences in the mean of foot reaction time between four types of distractions (no distraction, CLL auditory, ULL auditory, phone call) and three foot reaction event within the driving task (at minute 0.33, 0.56 and 4.30), for three age group of subjects (young, ageing and elderly). The results of repeated measures ANOVA of foot reaction during driving task for both within and between subjects effect is presented in Table 5.

According to these results among all covariates, only the interaction between hand reaction event, age and gender was significant ($p<0.05$).The main effect for distraction yielded an F ratio of $F(3, 89.23) = 1.53$, $p = 0.21$, partial $\eta 2 = 0.04$, indicating an insignificant difference between four types of distractions. The main effect for foot reaction event yielded an F ratio of $F(2, 1.85) = 0.96$, $p = 0.39$, partial $\eta 2 = 0.03$ indicating that the effect for gender was also insignificant, The interaction effect between distraction and foot reaction event were also insignificant, $F(6, 185.56) = 0.103$, $p = 0.22$, partial $\eta 2 = 0.04$.

***Table 5**. Analysis of Variance foot reaction during driving task*

| Source of variation | dF | F-value | P-value | Partial Eta squared |
|---|---|---|---|---|
| Distraction | 3 | 1.53 | 0.21 | 0.04 |
| Distraction*age group | 6 | 0.62 | 0.72 | 0.04 |
| Distraction*gender | 3 | 2.05 | 0.11 | 0.06 |
| Distraction*age group*gender | 6 | 1.37 | 0.24 | 0.07 |
| Time | 2 | 0.96 | 0.39 | 0.03 |
| Time*age group | 4 | 2.23 | 0.08 | 0.12 |
| Time*gender | 2 | 0.91 | 0.41 | 0.03 |
| Time*age group*gender | 4 | 0.36 | 0.82 | 0.02 |
| Distraction*time | 6 | 1.40 | 0.22 | 0.04 |
| Distraction*time*age group | 12 | 0.75 | 0.70 | 0.04 |
| Distraction*time*gender | 6 | 0.57 | 0.76 | 0.02 |
| Distraction*time*age group*gender | 12 | 1.26 | 0.24 | 0.07 |

In the driving task, drivers have to repeat the same driving route with four type of distraction. The designated task were no distraction, CLL auditory distraction, ULL auditory distraction and phone call distraction. It was observed that hand and foot reaction time increase along with the task difficulty for all groups. The rate of the responses in hand reaction time increases from young, ageing to elderly drivers. The group comparison revealed that in the ageing drivers outperformed the elderly group, demonstrating a specific effect of ageing impact of reaction time. The scores of hand reaction time is shortest for CLL distraction followed by no distraction, ULL distraction and phone call distraction. Comparing aging and elderly group, the ageing male performed the shortest reaction time is driving task with CLL distraction scored 1.15s while the hand reaction time with phone call distraction scored 1.40s. While for foot reaction time, comparing ageing and elderly group, the optimum value obtained from the initial experiment was in the range of 0.91s scored by ageing female and the greater of 1.09s by ageing male. While within four types of distraction, the rank of performance is greater from no distraction, followed by CLL,

ULL and phone call distraction during the driving task. The ageing male performed the shortest foot reaction time with 0.92s for both no distraction and CLL distraction and the elderly male scores 1.25s during phone call distraction.

**Relationship between hand and foot reaction time**

The correlation analysis was done for age, gender, hand and foot reaction time for four types of distractions. The significant correlations ($p<0.05$) were found in the most of the results except for soundless distraction. Table 6 shows the significant correlations for hand and foot reaction time.

***Table 6**. Correlations among hand and foot reaction time for each distraction*

| Distraction | Pearson Correlation | Sig. (2-tailed) |
|---|---|---|
| CLL distraction | 0.647** | .000 |
| ULL distraction | 0.490** | .001 |
| Phone call | 0.464** | .003 |

The Pearson's coefficient of correlation above indicated as medium and high since most of the variables shows r-values higher than 0.5 ($r>0.5$). The results indicated the hand reaction time were affected by that the foot reaction time while performing the driving task varying for different types of distraction. Meanwhile Table 7 summarizes the correlation analysis between the hand and foot reaction time for the entire driving task regardless of the types of distraction.

***Table 7**. Correlation among the hand and foot reaction time*

| Correlated Variables | | Pearson Correlation | Sig. (2-tailed) |
|---|---|---|---|
| Hand RT | Foot RT | 0.665** | 0.000 |

It can be clearly seen in the result that hand reaction time correlates with foot reaction time ($r = 0.665$). It was discovered that the execution time for foot movements for the corresponding arm motion is usually about twice as long as that. Thus both reduced conductive speed in the lower limb nerves and difference in motion moment could have resulted in enhanced reaction time for the auditory recognition of the foot compared to the hand 13.

## DISCUSSION

In the driving task, drivers have to repeat the same driving route with four type of distraction. The designated task were no distraction, CLL auditory distraction, ULL auditory distraction and phone call distraction. It was observed that hand and foot reaction time increase along with the task difficulty for all groups. The rate of the responses in hand reaction time increases from young, ageing to elderly drivers. The group comparison revealed that in the ageing drivers outperformed the elderly group, demonstrating a specific effect of ageing impact of reaction time. The scores of hand reaction time is shortest for CLL distraction followed by no distraction, ULL distraction and phone call distraction. Comparing aging and elderly group, the ageing male performed the shortest reaction time is driving task with CLL distraction scored 1.15s while the hand reaction time with phone call distraction scored 1.40s. While for foot reaction time, comparing ageing and elderly group, the optimum value obtained from the initial experiment was in the range of 0.91s scored by ageing female and the greater of 1.09s by ageing male. While within four types of distraction, the rank of performance is greater from no distraction, followed by CLL, ULL and phone call distraction during the driving task. The ageing male performed the shortest foot reaction time with 0.92s for both no distraction and CLL distraction and the elderly male scores 1.25s during phone call distraction.

In the ageing group, differences in both hand and foot reaction times were different, which most likely reacted faster under the four experimental conditions than the elderly group. Motor and sensory slowing with aging are correlated with some histological modifications, such as horn cell degeneration in the spinal cord and neuromuscular junction10. This likely led from the reality that, during normal automobile driving, foot reaction is strongly resembled those actually experienced. Strong connections between road signs and engine reactions with foot could have been constructed. This likely led from the reality that, during normal automobile driving, foot reactions were strongly resembled those actually experienced. Strong connections

between road signs and engine reactions with foot could have been constructed. Rather than experimenting with fresh sensorimotor associations between sensory data and the reaction of foot motors, respondents may have recalled the perception-action associations built through the experience of driving in their lifetime 11. As the limbs were in contact with the hand signal for upper limb and brake pedal for the lower limb, the difference between RTs from the upper and lower limb trials could possibly originate from two other factors. First, neural pathways from the spinal cord to hand muscles are shorter. Since the conduction velocity in the motor pathways and peripheral nerves can reach several tens of meters per second, RT may slightly increase if the response requires distal body segments. Under the conditions of hand and foot contact with the timer 12.

Findings reveals there is a statistically significant between the hand reaction time, age group and gender. And also a statistically significant between foot reaction time and age group. It was noted that the auditory stimulus evoked a faster response of the foot compared to the side based on the outcomes acquired. The most significant finding of this study was the distinction in group efficiency with various types of auditory diversion. The study finding disclosed that, owing to the internal setting of the automobile and also the human body rhythm, reaction time for auditory stimuli was found to be the shortest in CLL diversion compared to soundless auditory distraction for each group.

## CONCLUSION

The findings stated that the reaction time for the foot in both the limbs was considerably shorter than the hand could be due to the difference in the velocity of nerve conduction and the time of motion. Elderly drivers show longer reaction for both hand and foot reaction times than ageing drivers.

## ACKNOWLEDGEMENT

This work is financially supported by the University of Malaya under the University Malaya Research Grant (Project title: Driving Behaviour and Reaction Rate of Ageing Malaysian Automobile Drivers.), Postgraduate Research Grant (PPP) grant no.: PG131-2015B.

## REFERENCES

1. Pettitt, M., Burnett, G., & Alan S. 2005, Defining Driver Distraction. World Congress on Intelligent Transport Systems, San Francisco. 44:31–40.

2. Anderson, E., Bierman, C., Franko, J., & Zelko, A. 2012, The Effects of Audio and Visual Distractions on Reaction Time.

3. Dixit, V. V., Chand, S., Nair, D. J., Payre, W., Cestac, J., Delhomme, P.,Koppa, R. 2014, Autonomous Vehicles: Disengagements, Accidents and Reaction Time.

4. Miles, D. E., & Johnson, G. L. 2013, Aggressive Driving Behaviors: Are there psychological and attitudinal predictors? Transportation Research Part F: Traffic Psychology and Behaviour, 6(2), 2013, pp 147–161.

5. De Waard, D., Van der Hulst, M., & Brookhuis, K. A. 1999, Elderly And Young Drivers' Reaction To An In-Car Enforcement And Tutoring System, Applied Ergonomics, 30(2): 147–157.

6. Balakrishnan, G., Uppinakudru, G., Singh, G. G., Bangera, S., Raghavendra, A. D., & Thangavel, D. 2014, A Comparative Study on Visual Choice Reaction Time for Different Colors in Females.

7. Magister, T., Batista, M., Krulec, R., & Bogdanović, L. 2006, Measurement Of The Driver Response Time In The Simulated And Real Emergency Driving Situations. Promet - Traffic – Traffico, 18(1): 23–32.

8. Tsyganov, A, Machemehl, R., & Easa, S. 2005, Investigation of Driver Behaviour and Reactions in Traffic Safety Research. Proceedings, Annual Conference - Canadian Society for Civil Engineering

9. Bazilinskyy, P., & de Winter, J. 2015, Auditory Interfaces In Automated Driving : An International Survey. PeerJ Computer Science, 1(1):1–28.

10. Verdú, E., Ceballos, D., Vilches, J. J., & Navarro, X. 2000, Influence of Aging on Peripheral Nerve Function and Regeneration. Journal of the Peripheral Nervous System, 5(4):191–208.

11. Salvia, E., Petit, C., Champely, S., Chomette, R., Di Rienzo, F., & Collet, C. 2016, Effects of age and task load on drivers' response accuracy and reaction time when responding to traffic lights. Frontiers in Aging Neuroscience

12. Pfister, M., Lue, J.-C. L., Stefanini, F. R., Falabella, P., Dustin, L., Koss, M. J., & Humayun, M. S. 2014, Comparison of Reaction Response Time between Hand and Foot Controlled Devices in

Simulated Microsurgical Testing. BioMed Research International, 1–8.

13. Balakrishnan, G., Singh, G. G., Velkumary, S., Uppinakudru, G., Raghavendra, A. D., & Thangavel, D. 2013, Comparison Of Hand And Foot Reaction Times Among Females- A Methodological Study Using Recognition Auditory Reaction Time. International Journal of Current Research, 5(12):4272–4274.