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# DRIVER'S MENTAL WORKLOAD: TASK PERFORMANCE AND MENTAL WORKLOAD

Ahmad Khushairy Makhtar[a*], Makoto Itoh[b]

[a]Department of Risk Engineering, University of Tsukuba, Ibaraki, Japan
[b]Faculty of Engineering, Information and Systems, University of Tsukuba, Ibaraki, Japan

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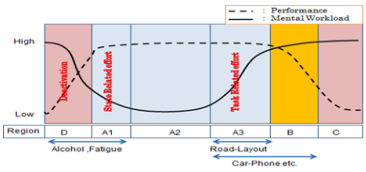
*Corresponding author
khushairy@css.risk.tsukuba.ac.jp

## Graphical abstract




## Abstract

It is known that unnecessary increase of driver's mental workload may be a cause of road traffic crashes. In the recent decades, mental workload's level detection has been one of the major interesting research subjects in today's society. This paper discussed the relationship between driver's performance and mental workload level. The results reveal that there is a significant effect on driving task performance to participants' mental workload while performing different level of secondary task and driving task.

*Keywords*: Mental workload, performance measurement, safety, driver assistance



## 1.0 INTRODUCTION

A comprehensive accident data in Japan recorded the number of road traffic crashes for the year 2013 reported a decrease of 5.4% compared to in 2012 [1]. When looking for causes of the crashes, distracted driving, which includes 'looking-away' and 'thinking of something other', was 24.8% of traffic crashes in 2013 [1]. It shows that distracted driving is an important issue to be solved in order to reduce the number of road accident fatalities. Aggravating the problem, various in-vehicle devices, such as mobile phones and car navigation systems used in vehicles, have become a trend nowadays. In addition, there are several studies concluded that the negative effects of using a phone may not result from operating the telephone, but mainly from make a conversation on the phone itself which can relate to 'mental workload' [2][3].

The basic concept known about human mental workload is when opposing more mental workload, performance will deteriorate. A model developed by Meister [4] can explain the correlation between mental workload level and task performance. Later, De Waard [5] has further divided the model from three regions into six regions as shown in Figure 1. As presented in the model, optimum performance is in Region A2. The operator can easily meet the needs of the task demands and achieve a satisfactory level of performance. Whereas the performance in region A1 and the A3 remains unaffected but the operator has undertaken efforts to maintain performance levels. In B region, operators are unlikely to maintain and performance begins to deteriorate. The degradation of performance in B region could be interpreted as the workload is high. While in C region, the operator is interpreted as overload and performance at a minimum, while in D region, state of the operator is affected [5].

As it is worth to estimate the state before the performance start to deteriorate, this research is particularly interested in the region B, i.e., to find the situation where the mental workload is high and performance start to deteriorate. Ideally when we are able to estimate the mental workload region especially on Region B, we can design a support system such as a warning system before the performance start to deteriorate.

However, there is also concern of interest on how to measure the mental workload. As measuring mental workload is challenging part of this research. According to O`Donnell & Eggemeier [6] cognitive distraction measurement could be divided into three

measurement groups: *(1)Physiological measures (2)Subjective measures, and (3)Performance measures* This paper will focus on subjective and performance measurement of drivers' mental workload.

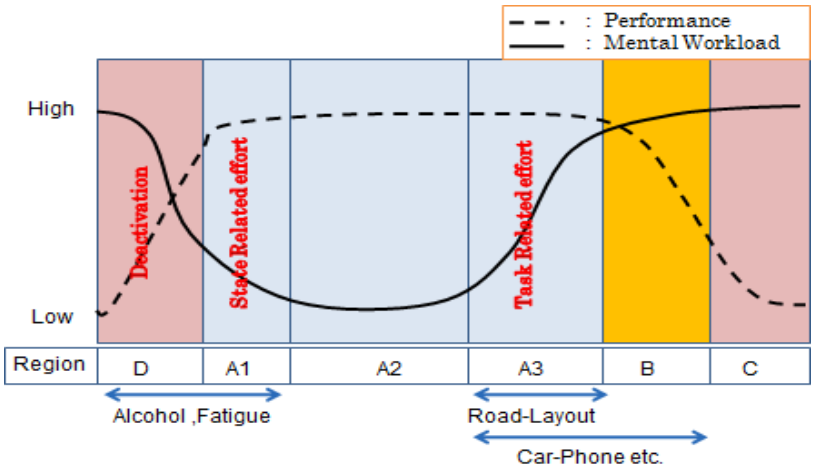



**Figure 1** Workload and performance in 6 regions [5]

## 2.0 METHOD

The process of data collection of drivers' mental workload was done using a fixed-base driving simulator. While traffic scenario development and measurement of the movement of vehicles, software produced by Honda Motor was used. Measuring maximum Lyapunov Exponent was done by using plethysmogram's *BACS Detector II*'s from CCI Company.

There were four males and four females with a mean age of 23.8 and Standard deviation of 5.44 have participated in the data collection process. Every participant holds a valid driver's license and drives almost daily.

The main task is to drive safely in the left lane. Every participant had two types of traffic conditions, a) None Hazardous Condition (NHC) and b) Hazardous Condition (HC). Under both conditions, the participants were also asked to follow a lead vehicle (LV).

Figure 2 describes how the driving task was given to each participant in NHC. A Following Vehicle (FV) is located behind the HV to help participants maintain a following distance. In this traffic condition, FV drove at 65km/h (constant speed) throughout 7 minutes trial. Some vehicles also exist in the right (passing) lane.

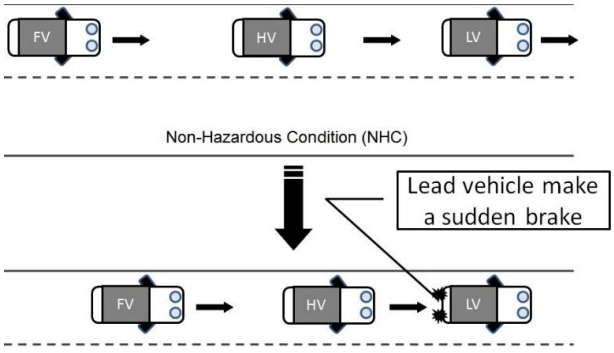



**Figure 2** Hazardous condition (HC)

While under HC participants were also asked to maintain distance between LV and FV. At this time, both LV and FV cruise between speed of 65kmph and 85kmph. Intentionally LV and FV will make an abrupt braking of 0.35g and also a quick acceleration. The period to make an abrupt brakes and quick acceleration has been set at random (relatively twice the speed changes for each 500 meter run). The participants were told to keep a safe following distance and to be alert to sudden changes in the speed of both vehicles (Figure 2). If they meet with a crash during a trial, the participants had to start a new

trial all over again. This way, the participants tried their best for not involving with a crash.

For the secondary task the participants were asked to carry out a two-minute Mathematical Arithmetic Task (MAT) in a 7-minute run, three minutes after the start and two minutes before the run is completed (Figure 3).

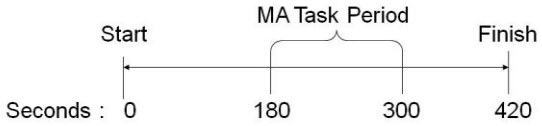



**Figure 3** MAT period in a trial

MAT requires the participants to recall the numbers presented before as well as solve the calculation. This is a kind of so-called PASAT (Paced Auditory Serial Addition Test). Arithmetic mathematics task is divided into two levels, namely the easy one (MAT1) and the difficult one (MAT2). In MAT1, the participants have been given single-digit numbers (from 1 to 9) in every three seconds through voices from a computer. The participants had to give answer summation of last two numbers orally as in Figure 4. While in MAT2, the participants were given two-digit numbers between 11 and 49. As in MAT1, the participants had to answer total of the last two numbers orally.

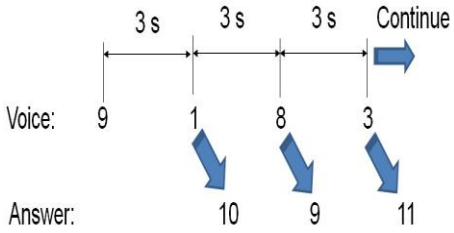



**Figure 4** MAT1 (Easy Level)

In each run, the number of correct answer was accumulated and the outcome was notified to participants after the end of a run.

All participants were randomly divided into two groups respectively as presented in table 1. Every participant experienced six days of experiments with six sets of run each day. In the table, BD is the 'Baseline Driving', there was Non Hazardous traffic condition and no secondary task has been opposed to the participants on those days. After completing all trials, the participants were asked to answer subjective rating of mental workload with NASA-TLX.

**Table 1** Experimental procedure

| Group 1 | | Day | Group 2 | |
|---|---|---|---|---|
| Task | Traffic Condition | | Task | Traffic Condition |
| | BD | **One** | | BD |
| MAT1 | NHC | **Two** | MAT2 | HC |
| MAT1 | HC | **Three** | MAT2 | NHC |
| MAT2 | NHC | **Four** | MAT1 | HC |
| MAT2 | HC | **Five** | MAT1 | NHC |
| | BD | **Six** | | BD |

## 3.0 RESULTS AND DISCUSSIONS

### 3.1 Driver Performance Measures

#### *3.1.1 Driving performance*

Figure 5 presents the standard deviation of steering wheel movements according to the day of traffic condtion and secondary task. According to the graph, the steering controlled of the participants was depend on traffic condition. Under NHC, the steering movement was relatively smaller than under HC. For the first day the steering movement was the highest among other days even though there was no hazardous condition. This would be on account of the participants needed some times before getting familarized with the driving simulator. Nevertheless, there was no significant difference in the variation in standard deviation of steering movement among days.

#### *3.1.2 Secondary Task Performance*

Figure 6 exhibits the percentage of correct answers for MAT. As shown in the figure, the percentage of correct answer for MA task declined as the participant experienced a tougher task. The performance worst under MAT2 task where the participants were asked to answer double digit numbers of mathematical arithmetic task and under a hazardous condtion.

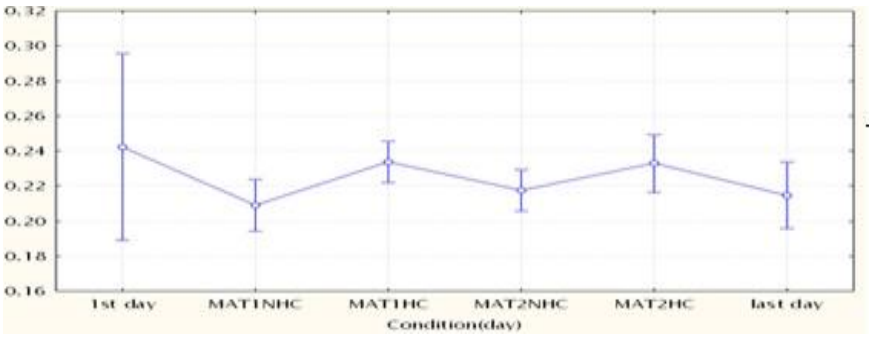



**Figure 5** Standard deviation of steering movements

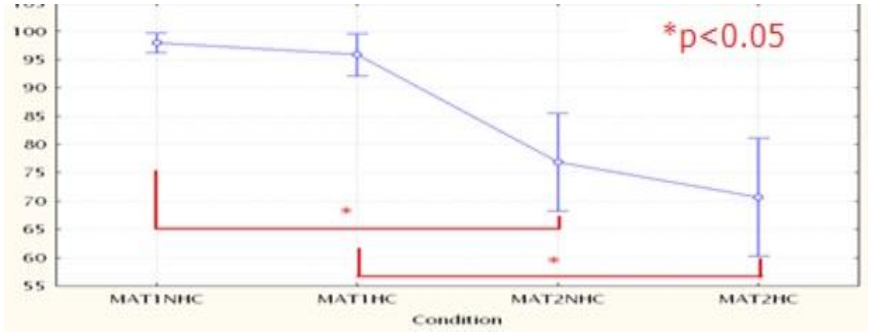



**Figure 6** Percentage of correct answer on MAT

According to statistical analysis, there was a significant difference between MAT1NHC and MAT2NHC. Interestingly, significant difference was also found between MAT1HC and MAT2HC.. The results suggest that there was a significant difference between the types of secondary task regardless the traffic conditions. The more difficult the secondary task was, the performance of the task deteriorate.

## 3.2 Subjective Measurements

### *3.2.1 NASA-TLX [7]*

After completing a 7-minutes run, participants were asked to evaluate the workload they felt along the run. Fig. 7 presents an average of rating for mental workload for all eight participants.

According to the graph in Fig. 7, the value was the highest under MAT2HC. The mental workload rating was also considered as high for MAT1HC and MAT2NHC. Statistical analysis was performed and a significant different were found between the first and the last day of experiments. Again, the participants may have evaluated the first day of experiment as in a high mental workload since they need to be familarized with the driving task. After experiencing all of tasks, and they become acquinted with the driving simulator, the mental workload was evaluated as the lowest.

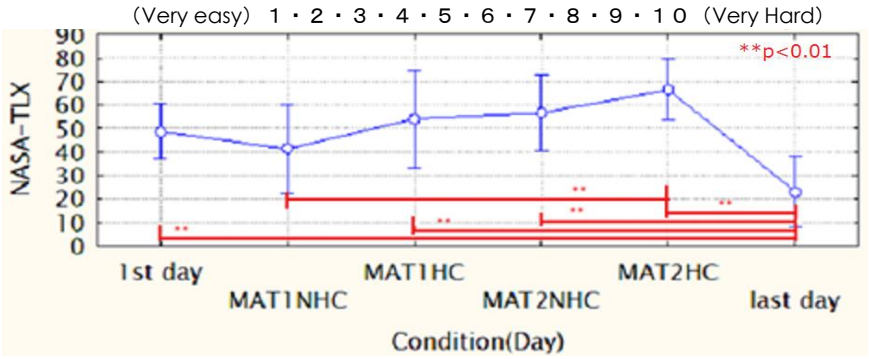



**Figure 7** Rating for NASA-TLX

### 3.2.2 Subjective measurement (Questionnaire)

After completing all trials, every participant was asked to evaluate their impression regarding the type of secondary tasks and driving tasks they experienced on the experiment. Questions such as; …"Regarding the mental arithmetic task, evaluate the task." were asked.

Figure 8 indicates the average of subjective ratings for task difficulties . Participants rated MAT2 task as the toughest among other secondary task and traffic conditions.

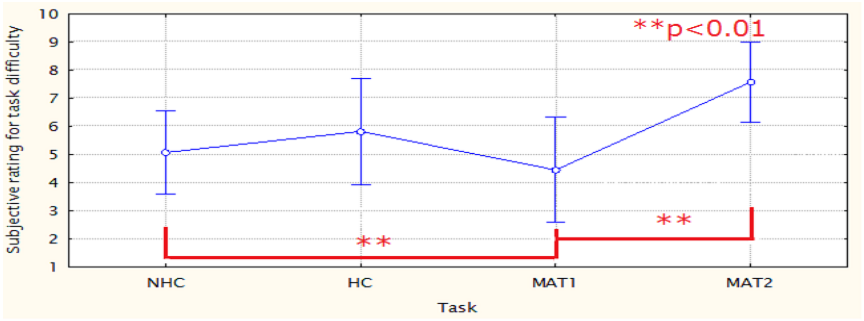



**Figure 8** Average of subjective rating for task difficulties

## 4.0 CONCLUSION

The present study was designed to investigate drivers' mental workload by focusing on performance and subjective measurements. An experimental work was performed to evaluate driver's mental workload. Result of subjective measurement and performance measurement was significantly affected by the level of task. We concluded that the participants were trying their best to maintain the performance of the driving task while doing the difference level of difficulties for secondary task.

### 4.1 Future Works

For future works, there is a need to determine a threshold where the participants are trying their best and the performance is start to deteriorate.

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