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Mental Workload Assessment of Jeepney Drivers

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Abstract: **The mental workload of the fifteen jeepney drivers was measured. The researchers would like to assess the mental workload using subjective and physiological measurements and identify its relationship with the number of passengers and size of the jeepney. This paper contributes to the road safety and minimizing road accidents. This could also be used as a tool for decision making of the government officials in terms of implementing policies. This study differs from other researches because it uses a continuous testing of mental workload of jeepney drivers in terms of bandwidth such as the delta (0.1-4 hertz), theta (4-8 hertz), alpha (8-13 hertz), and beta (13-30 hertz) and gamma (30-100 hertz) while performing the actual task. Moreover, this study would open and encourage a lot of researches leading to the improvement of the design and other system implementation. The researchers obtained the high level of mental workload using NASA TLX and EEG. Setting of factors such as location, time, and variations are very important in conducting the experiment.**

Key Words: Mental Workload, EEG, NASA-TLX, Jeepney Drivers

1. Introduction

1.1 Background

The Global Status Report on Road Safety 2015 presents the information coming from 180 countries regarding the road traffic casualties which has been accumulated to 1.25 million per year. It focuses on the low-income countries like the Philippines. Actions are needed for every country to achieve the 2030 Agenda for Sustainable Development: halving the global number of deaths and injuries from road traffic crashes by 2020. Based on the report from the Philippines Department of Public Works and Highway Accidents Recording and Analysis System in the World Health Organization (WHO), the reported road traffic fatalities in 2013 was 1513 (77%male, 22% female). Given these data, WHO estimated the road traffic fatalities in the Philippines to 10,379. The estimated rate per 100,000 population is 10.5. Moreover, the estimated GDP lost due to road traffic crashes is 2.6%. Current data suggest that 300,00 Filipinos will die of road crashes by 2020 if preventive measures will not be taken (World Health Organizations 2015, 2015).

The Philippine National Police High Patrol

Group (PNP-HPG) shows an alarming increase in vehicular accidents across the country which that in 2014, there were 15572 vehicular accidents, which resulted in 1252 deaths. The number increased in 2015 with 24,565 which lead to 1040 deaths. In 2016, PNP-HGP has already recorded 10656 vehicular accidents in the whole country resulting in 549 deaths. This report is an alarming situation in the country (Ager, 2016).

In the Philippines, jeepneys, called as "jeep" is a very popular means of transportation. There are several people who are using jeepneys as a way of supporting their lives.

Jeepney drivers perform multi-tasking. They are focus on their driving activities, at the same time, they are also the ones performing the accounting functions of the business. At first, the driver needs to start the vehicle. Maneuvering tasks are being done such as the turning, passing, parking, and yielding to others on the road. Jeepney drivers are also responsible for collecting the fares of the passengers and doing mathematical computations while driving. They are also responsible for loading and unloading the passengers on their areas. Somehow, during the process of fare collection by the jeepney driver, a conflict may arise between the passenger and the driver. The basic actions are to stop the jeepney, ask the passengers' complaint, discuss the courses of action, and finally, identify the real problem.

Gonzales and Mark (2004) cited that multitasking and interruptions can affect the productivity, however this wouldn't have a direct consequence.

1.2 Mental Workload

Mental workload is a part of the capacity of the information that is needed to achieve the system demands, "(Eggemeier, Wilson et al. 1991)

It is a theory, it is not encompassing a one-to-one relationship with attentional capacity or resource of information processing theories (Colle and Raid, 1999). It is a concept which may differ from one perception to another. However, they meet at one point, to satisfy a certain system.

1.3 Subjective Workload Measurement

The National Aeronautics and Space Administration (NASA) Task Loading Index (TLX) is widely used when assessing mental workload (Noyes, J.M., and D.P. Bruneau, 2007). There are six sub-scales in NASA TLX. It includes the mental demand, physical demand, temporal demand, performance, effort level, and frustration level. A paired comparison task is being used for a weighting process.

When determining the kind of measurement to use, it would be better to understand that researcher must consider the ease of use and effect on performance (Tattersall & Foord, 1996). Subjective measures are considered the easiest way of assessing workload, however, it does not provide a continuous way of measurement.

1.4 Physiological Measurement

The researchers would like to consider a more sensitive and objective kind of measurement of mental workload. With the use of physiological measurement, there is a continuous assessment and provides a fine-grained analysis with a specific sensitivity to varying mental workload dimension (Kramer,1991).

An Electroencephalogram (EEG) will be used in the study. EEG is an equipment where in the electrical activities of the brain will be recorded and measured. It is noninvasive and it measures the fluctuations of the voltage resulted from the ionic current within the brain's neuron. It records the brain's activities over a period. EEG has a lot of strength to be considered. It can detect variations in milliseconds. It is also being presented in by means of rhythmic activities and transients. The rhythmic activity is separated by bands and by frequency. Using EEG software, frequency bands are normally extracted with the use of spectral methods. Waveforms are being separated into bandwidths such as alpha, beta, theta, and delta and gamma for the purposes of data analysis (Tatum, 2014).

Different literatures identify several observations using the EEG and power spectral analysis for assessing various cognitive states. EEG has been suggested also to be one of the important tools to assess mental workload by evaluating whether it could estimate the attention in forecasting the success or failure of solving math problems. (Galan and Beal,2012).

Activities of theta and beta in brain frontal lobes are correlated with the processes of cognition like judgment, problem solving, working memory, decision making and mathematical problem solving. The increasing amplitudes of these bands are often a result of brain engagement in such activities. It has been proven from literatures that an increase in EEG power spectra in the theta band throughout the tasks

involved sustained attention and multi-tasking (Lin, et al., 2011).

2. METHODOLOGY

This research section talks about the research methodology specifically the data collection and experimentation processes. The experiment was conducted on jeepney drivers. It consists of observing and recording the activities and actions of the 15 jeepney drivers on a specific road track. The experiment was done in some of the urban areas in Laguna.

Fifteen jeepney drivers participated in the study. They agreed that they will undergo a process of experimentation. The sample of participants was comprised of 15 male drivers. Participants ranged in age is 35-45 years old.

The vehicle used in the study were all jeepney vehicles. The seating capacity of the vehicle ranges from 16 to 20 seaters. Next, the researchers chose the location where to conduct the experiment. The desired location is in an urban area because aside from having busy streets, there are also a lot of passengers riding in and out of the jeepney. The researchers oriented the jeepney drivers about the objective, procedure, and outcome of the study. Before the experiment, the researchers ride on a jeepney near the driver and inquired their profile. The tasks involved in driving were discussed. It involves the processes of what an operator is required to do in order to achieve the goal. Below are the different driving tasks.

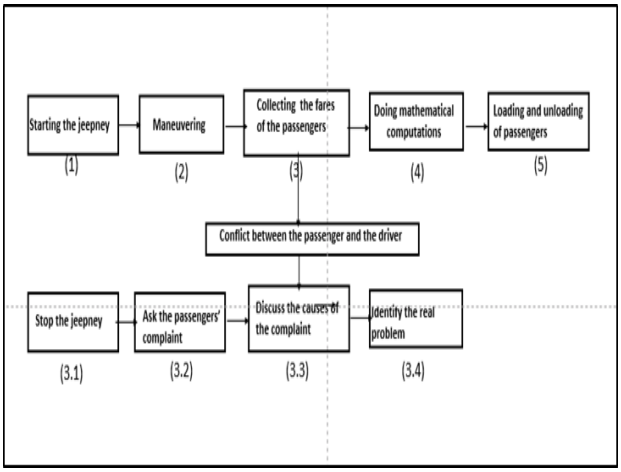

Fig. 1. Tasks involved in driving

Next, the researchers explained the procedure of the experiment and the function of the electroencephalogram (EEG) to be positioned on the head of the driver.

The device which was utilized is a mobile EEG, a single channel MindWave produced by NeuroSky, Inc. It contains 8 important parts which are the ear clip, flexible ear arm, battery area, power switch, adjustable head band, sensor tip, sensor arm, and the inside thinkgear chipset. There are two dry sensors which were used to detect and filter EEG signals. They are the sensor tip which perceives the electrical signals from the forehead of the brain. This measures the raw signal power spectrum (alpha, beta, delta, gamma, and theta).

Before the first run, the researchers count the number of passengers inside the jeepney and recorded it. After placing the EEG on the driver's head, the researchers conducted the pilot run until the driver become comfortable. After the first run, they monitor the movement of the mind waves while the driver is performing his tasks.

The different movements of the driver were observed while having the experiment. Once the trials are complete, the data are being transferred to the computer.

The raw data which were extracted from the EEG need to be translated in frequency. This can be executed with the use of a Fourier Analysis utilizing Matlab.

After each experiment, the researchers conduct the subjective mental workload assessment using the National Aeronautics and Space Administration (NASA) Task Loading Index(TLX) measurement to ensure that the driving experience can still be recalled by the drivers. First, the aims of the analysis must be clearly defined. Next is clearly defining the scenario or the task under obevation, the task goals and the environment within which the task is to takes place.

The researchers focus on maneuvering task, loading and unloading of the passengers, and doing mathematical computations. Because these are the tasks which are usually being done by the jeepney drivers simultaneously and cause of distractions based on other studies (Kandemir C. et.al., 2016).

The procedures of the measurement processes as well as the different questions on the questionnaire were explained clearly to the drivers. After the orientation, the tasks are performed. The experiment is being recorded using the software simultaneous with video recording.

After the completion of the task, the procedure on the NASA-TLX procedure begins. It includes the completion of the interval scale. The participants were asked to select a pair from each scale that has the most effect on the workload during driving. This is the pairwise comparison which is a weighting procedure that presents 15 pairwise combinations to the participants.

After completing the weighting procedure, participants were provided with a pro-forma and requested to rate between 9 (low) and 20 (high). Ratings must be based only on the judgment of the participants based on the task given. Next is the computation of the scores by multiplying the rating by the given weight on the sub-scale by the participant. The score would be divided by 15 (total weight). These data can normally be analyzed across participants, tasks, and sub-scales. It can also be presented simply as mean overall scores and mean ratings for every subscale.

3. RESULTS AND DISCUSSION

The NASA-TLX was administered to the 15 jeepney drivers in one of the urban areas in Laguna. After answering each area of the questionnaire, the participants need to give the reasons which will support the answers. During the time of the experiment, it shows that the highest contributor of workload is the mental demand (24.71), followed by physical demand (20.71), performance (19.53), temporal demand (12.60), Effort (11.02), and lastly frustration (4.87). These data were presented in Figure 2.

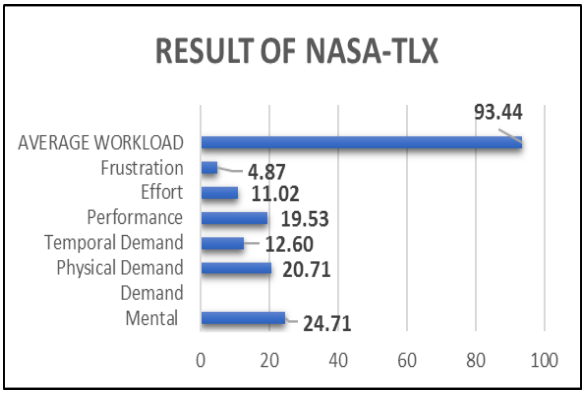

Fig. 2. Result of NASA-TLX

The researchers measured the mental workload of the jeepney drivers using the EEG. To translate the data, the researchers make use of Neuro-Sky, Brain-Computer Interface Technologies. Neuro-Sky has a ThinkGear technology which enables the equipment to interact with the brainwaves of the users. It has a sensor that touches the forehead, the contact and the reference points which are located o the ear pad, and the onboard chip which processes the data to software and application in digital form. Using the ThinkGear chip, both the raw brainwaves and the eSense meters are calculated.(NeuroSky Incorporated, 2015).

J.L.Harter (2014), discussed that in measuring mental workload using EEG, the value is being reported in terms of bandwidth, the delta (0.1-4 hertz), theta (4-8 hertz), alpha (8-13 hertz), beta (13-30 hertz), and gamma (3-5 hertz or higher). The typical amplitude for delta is 100 to 200 μV. This state can be achieved during deep stage of sleep. Deep sleep is associated in an increase in delta power. This means that if the person is awake, expect a decrease or a low delta band power. Too much delta (>200 μV) means that there are brain injuries, learning problems, inability to think, and severe ADHD. Too little delta (<100 μV) means inability to rejuvenate the body, inability to revitalize the brain, and poor sleep.

Theta's typical amplitude is more than 30 μV. An increase in theta activity means that there is a decrease in performance. When the band power increases, there is an increase in fatigue. This has something to do with the mental workload and working memory. Too much theta (too high from 30 μV) means that the person has an ADHD, hyperactivity, impulsivity, and inattentiveness. Too little theta (>30 μV) means the person is under the state of anxiety, poor emotional awareness, and stress.

Alpha's typical amplitude is 30 to 50 μV or higher. It is the state of bridging the gap between conscious thinking and unconscious mind. Too much alpha (>50 μV) means that the person is under the state of daydreaming, inability to focus, and to relax.

Too little (>30 μV) alpha means that the person is experiencing anxiety, high stress, and insomnia.

Beta, having the band power of 2-20 μV or higher, means that if the beta power increases, the person is on the state of being tired, anxious thinking, and active concentrations. If the beta power decreases, the person is experiencing depression and poor cognition.

Gamma's typical amplitude is 3 to 5 or higher than 5. It is under the state of cognition, information processing, learning, and perception. Too much gamma means that the person is under the state of high arousal and stress while too little gamma means that the person is under the state of depression, and learning disabilities.

The researchers gathered the following data and figure using the results of EEG.

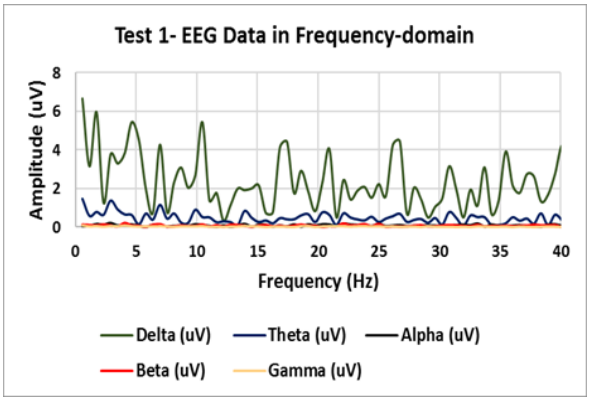

Fig. 3. Sample EEG Result

The data gathered from the EEG is a continuous data. Figure 3 presents a sample result of the EEG test from the driver. The amplitude is located on the y-axis while the frequency is on the x-axis. Based from the figure, the data show the decreased value of delta. This indicates that while driving, the driver is under the condition of poor sleep, inability to revitalize the brain, and inability to rejuvenate the body. The value of theta from the figure is too little meaning, the person has poor emotional awareness and mentally stressed. Too little alpha value is shown in the figure. It indicates the state of having anxiety and high stress. The data also show the beta value which is also too little. These values present a state of cognition.

The researchers correlated the mental workload in terms of bandwidth to the number of passengers. This is done in order to know the relationship or connection of the two factors. The researchers used the result of the EEG on the mental workload measurement and the intermittent number of passengers. The result of the correlation is r=-0.0520 for delta, r= -0.1900 for theta, r=-0.1857 for alpha, r=-0.1088 for beta, and r=-0.2053 for gamma.

The researchers correlated the delta, theta, alpha, beta, and gamma to the seating capacity of the jeepney. The researchers obtained the result of r= 0.0119 (delta), r= 0.1487(theta), r= -0.0328 (alpha), r= -0.0074 (beta), and r= 0.0203 (gamma).

4. CONCLUSIONS

An average of 24.71 was measured using the NASA-TLX on the mental demand of the jeepney drivers. Moreover, all EEG results from the 15 samples show that most of the drivers used in the study present a state of poor cognition and mentally stressed.

In relation to the number of passengers, the data show a weak negative correlation for delta, alpha, and beta and gamma. However, a weak positive correlation was obtained for theta and gamma.

For the seating capacity of the jeepney related to the result of the EEG, the data show a weak positive correlation with delta and theta, and gamma while a weak negative correlation was obtained from alpha and beta.

The setting of the experiment is very important such as the location, the specific time, as well as the process of conducting the experiment. These factors might affect the result of the study.

The data used in the study are limited only on the urban area where the study was conducted and on the number of sample used.

For future research, the researchers would like to suggest to consider specifically the area of the experiment and also the specific time of the study, the weather temperature, specific location, for this may affect the result. Increasing the number of samples may also be considered to

improve the study.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Ager, M. (2016). 10,000 vehicular accidents in first 4 months of 2016 — police. Inquirer.Net. Retrieved May 20, 2017

Colle, H.A. and Reid, G.B. (1999). "Double trade-off curves with different cognitive processing combinations: Testing the cancellation axiom of mental workload measurement theory." Human Factors 41(1): 35-50

Eggemeier, F. T., Wilson, G. F., Kramer, A. F., & Damos, D. L. (1991). Workload assessment in multi-task environments. In D. L. Damos (Ed.), Multiple-task performance (pp. 207–216). London: Taylor & Francis.

Gonzalez, V. M., & Mark, G. (2004). Constant, constant multi-tasking craziness: managing multiple working spheres. CHI Letters, 6(1), 113–120.

J.L.Harter. (2014). Awakening from Dream. The Ministry of Connected Consciousness Fountain Valley, CA.

Kandemir, C., et al., A workload model to evaluate distracters and driver's aids, International Journal ofIndustrial Ergonomics (2016), http://dx.doi.org/10.1016/j.ergon.2016.09.004

Kramer, A. F. (1991). "Physiological metrics of mental workload: a review of recent progress," in Multiple-Task Performance, ed. D. L. Damos (London: Taylor and Francis), 279–328.

NeuroSky Incorporated. (2015, May 7). Mindset Communication Protocol.

Shinar, D. (1993). Traffic safety and individual differences in drivers' attention and information processing capacity. Alcohol, Drugs and Driving.

Tattersall, A. J., & Foord, P. S. (1996). An experimental evaluation of instantaneous self-assessment as a measure of workload. Ergonomics, 39(5), 740-748.

Tatum, William O. (2014). "Ellen R. Grass Lecture: Extraordinary EEG.". Neurodiagnostic Journal 54.1: 3–21.

World Health Organizations 2015. (2015). Global Status Report on Road Safety 2015.