Effect of listening to Quran recitation on workload and driving performance: A car simulator study

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Abstract. Both mental overload and mental underload can affect driver performance and lead to traffic accidents. This study examined the effect of Quran recitation, one of the alternative voices often heard during driving, against the mental workload. The frontal lobe EEG, i.e., AF3 and AF4, was used as an indicator of the mental workload. Experiments were carried out in four scenarios, i.e., simple road with Quran recitation, simple road without Quran recitation, complex road with Quran recitation and complex road without Quran recitation. EEGLAB toolbox was used to process raw EEG and to perform statistical parametric test. Paired t-test statistics (p-value 0.05) were applied to compare the scenarios. The statistical test showed that there was statistically significant difference in the alpha and beta wave when the driver was given the Quran recitation both in simple and complex road. An increase in alpha wave was an indication of the increased in focus and relaxation, which can lead to improved driver performance. This finding can be used as an alternative of secondary task that is safe for drivers.

1. Introduction
Research showed that 40% of accidents were caused by inappropriate secondary tasks carried out during driving [1]. Inappropriate secondary tasks have an impact on increasing mental workload and lead to mental overload [2]. Humans have limited cognitive abilities, so that the occurrence of mental overload will result in a decrease in the performance of the main activities [3].

On the other hand, the absence of secondary tasks, can lead to mental fatigue, drowsiness and saturation which causes 30% of accidents [4]. Sleepiness and saturation have an impact on decreasing alertness [5], reaction time [6] and overall driver performance [7]. Research showed that the main cause of mental fatigue, drowsiness and saturation is mental underload [8].

As described above, mental overload and mental underload, both can lead to traffic accidents. If the driver is in a situation that leads to mental underload, the driver’s mental workload can be increased by active or passive intervention. However, inappropriate intervention performed by the driver, e.g., using mobile phone, can lead to mental overload and decreased driver’s performance [2].

Research in the field of traffic safety using driving simulator has been carried out extensively, where one of the objectives is to look for interventions that can lead to improved driver performance. Some studies tried to evaluate active interventions, e.g., drinking coffee, smoking, chewing candy, exercise, listening to audiobooks, listening to music and singing. Some studies also evaluate the impact of passive interventions, e.g., cabin lighting, alarms, music, air and aroma.

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This study aims to evaluate the effect of voice intervention on mental workload and driver performance. Voice intervention was chosen because most of the drivers listen to music or radio while driving [9]. Previous research has evaluated some types of voice intervention during driving, e.g., music [10], [11], [12], radio [4] and audiobooks [8].

This study evaluates the effect of the Quran recitation on workload and driving performance. The Quran intervention was chosen because the Quran recitation is an alternative voice that often heard during driving, especially in Muslim-majority countries. Based on the study literature performed, there are no studies that evaluate the effect of Qur'an recitation on driving. Research found that listening to Quran recitation can increase alpha wave and lead to relax condition compared with listening to slow and hard music [13]. This research evaluated the Quran recitation on two road conditions, i.e., simple and complex roads. A simple or monotonous road is a representation of a mental underload condition that leads to sleepiness and saturation. While the complex road is a representation of road conditions that require high concentration and focus.

2. Research method

2.1. Research participant

Five students, between the ages of 18-21 years, be involved as research participants. Participants were required to have a driving license for at least 1 year and driving average an hour per day. Participants were also required not to have hearing loss. From these requirements, it was assumed that all respondents had the same driving ability.

Before participants were involved in the experiments, they had to fill out a pre-experiment questionnaire. The questionnaire consisted of general respondents’ information, driving experience, and simulator sickness questionnaires (SSQ). The SSQ questionnaire was intended to obtain the SSQ symptoms experienced by respondents, before and after the experiment.

2.2. Experimental Design

This study used a combination of two treatments, i.e., without Quran and with Quran, each performed on two roads condition, i.e., simple and complex roads. The combination of the voice intervention and the road condition produced four experimental scenarios. For each scenario, participants were asked to drive for 35 minutes, referring to the previous research [8]. To avoid the possibility of a learning effect, the participants were randomly assigned to the certain route. The Quran recitation was run at a moderate sound level - 70 dBA. This number referred to the previous study which states that there is no significant difference between loud (85 dBA) and moderate (70 dBA) sound to driver performance [11].

Experiment was carried out at the Laboratory of Work Systems and Ergonomics, Industrial Engineering, UII. The experiment used a car simulator facility, which had the following specifications: Logitech G29, 49" monitor super ultra-wide 32: 9 curved, and simulation software City Car Driving 1.5.7. Emotive Insight, a wireless and 5 channel EEG tools, was used as a measuring devices of Electroencephalograph (EEG).

EEG waveforms are generally classified according to their frequency, altitude, shape and position of the electrodes on the scalp [14]. The familiar classifications of waveforms are based on signal frequency, such as delta (0.1-4Hz), theta (4-8 Hz), alpha (8-13 Hz), beta (13-30 Hz) and gamma (30-100 Hz). Brain wave frequency differs correspond to different behaviour and mental states of the brain. Delta wave is the slowest brain wave that represents stages of sleep. Theta wave is related to subconscious activity that founds in deep relaxation and meditation. Alpha wave indicates awake condition but relaxed. Beta wave occurred in conscious state such as talking, problem solving and decision making [15].

Center of awareness and alertness in the human brain is the most easily detected in the frontal lobe [17]. The frontal lobe controls human cognitive skills and their performance is influenced by the presence of fatigue [18], [19]. On this basis, recording and analyzing the EEG data in this study is focused on the frontal lobe, i.e., AF3 and AF4 channels. Data collection process using car simulator and Emotive Insight channels location are shown in Figure 1.
2.3. Data processing method
EEG data obtained, then processed using the EEGLAB toolbox. EEGLAB is a toolbox and graphic user interface that running under MATLAB environment used for processing raw EEG data. EEGLAB functions include channel and information importing, data visualization (scrolling, scalp map, ERP image plots), pre-processing (artefact rejection, filtering, epoch selection and averaging) Independent Component Analysis (ICA), as well as STUDY menu to analyse multiple data file. EEGLAB STUDY menu also provide a statistical analysis to compare multiple conditions. EEGLAB allows performing statistical parametric tests (paired t-test, unpaired t-test, ANOVA) on ERPs, power spectra, ERPs and ITSs [16].

The processing begins by importing raw EEG data in the EEGLAB and filtering unwanted frequencies, followed by removing the artifacts. EEG data was imported in EDF format and the importing process used the guidelines provided by previous research [20]. Furthermore, the initial power spectrum for the five channels are calculated. Independent component analysis and principal component analysis are applied to be able to analyze the power spectrum of each frequency band [16].

3. Result and discussion
3.1. Results
EEG signal filtering used EEGLAB toolbox was performed by filtering the desired frequency limit between 0.1 Hz to 60 Hz. Artifacts, arise due to eye blinking and low conductivity channels, are subsequently removed. The EEGLAB toolbox displays the entire channel signal, and the artifact can be seen in plain view and trim off manually.
EEG data processing in four experimental scenarios, i.e., (1) complex road without Quran; (2) complex road with Quran; (3) simple road without Quran and (4) simple road with Quran, was carried out using Study menu in EEGLAB. The result of statistical analysis using EEGLAB shown in Figure 2a-b and Figure 3a-b.

![Figure 2](image1.png)

**Figure 2.** (a) AF3 power spectra – complex road with vs without Quran; (b) AF4 power spectra – complex road with vs without Quran;

![Figure 3](image2.png)

**Figure 3.** (a) AF3 power spectra – simple road with vs without Quran; and (b) AF4 power spectra – simple road with vs without Quran
3.2. Discussion

Figure 2a-b and Figure 3a-b shows the result of paired t-test in both scenarios: scenario 1 (driving without Quran recitation) and scenario 2 (driving with Quran recitation). The result indicates that there is a statistically significant difference in Alpha (8-13 Hz) dan Beta (13-30 Hz) wave (p-value 0.05). T-test statistic was performed in the EEGLAB toolbox. Statistically significant differences in EEGLAB are shown in black color in the frequency axis (if there is no statistically significant difference, the color on the frequency axis remains white).

This finding is in line with prior research showing that the Quran recitation can generate Alpha wave [13]. As mentioned before, alpha wave was an indication of alertness, focus and relaxed condition. Compared to other voice intervention, i.e., audiobook and music, this study shows a different finding. Research found that audiobooks have an influence on driver performance only on simple or monotonous road [8]. However, in this study, the voice intervention used, i.e., Quran recitation, was able to influence the driver performance both in complex and monotonous road. The driver performance was increased due to the increased of focus, relaxed and alertness, as shown in the increase of alpha and beta wave.

4. Conclusion

The results showed that there were statistically differences in alpha and beta waves when Quran recitation was given to the driver, both in complex and monotonous road conditions. This finding can be used as an alternative of secondary task that is save for drivers. In the future research, research using wireless EEG tools are possible to be applied in real driving environment, especially when the scenarios are safe for the driver. EEG results in the real driving environment can be used as a comparison data with the results of driving simulator.

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6. References

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