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EVENT-RELATED POTENTIAL N100 VS. N170 WAVE RESULTS COMPARISON ON DRIVING ALERTNESS

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Abstract

Driver's attention, especially during long rides, is very crucial to avoid road accidents, which may lead to injuries and fatalities on the roadway. However, with modern technologies, the decline in driver's attention can be investigated through the electrical activity of the brain. Event-Related Potential (ERP) is the electrophysiological brain response measurement that related to the sensory, cognitive and motor events. By using simple averaging techniques, ERPs can give reliable result to measure the attentiveness of the driver during driving. In this paper, N100 and N170 wave results were presented, which obtained from temporal and occipital lobes respectively and been compared to measure the driver's attention. In term of attentiveness difference percentage, it is 0.09% and 38% differences were observed from N100 and N170 wave results respectively. From the results, it clearly can be seen that using N170 wave from occipital lobe is more significant to measure the driver's alertness compared to N100 wave that recorded from the temporal lobe.

Keywords: Averaging technique, Electrophysiological, ERP, N100, N170.

1. Introduction

Driving is a complex task that requires sensory, motor and higher-level cognitive components [1, 2]. The driver's attention is essential for a safe journey, but it may easily distract especially during a long time monotonous driving that may lead to serious injury. According to Bernama report on 28 January 2016, a total of 18 people were reported killed daily in road accidents nationwide in 2015.

In total, there was 2.74% spike in road accidents in 2015 compared in 2014. This figure is worrisome as the number of accident fatalities are increasing for every year. Impaired driving or been precise, risky driving is the main factor of road accidents in Malaysia [3]. The presence of assistance technology nowadays such as GPS, smartphone or even only thinking something while driving is just a few instances of activities that could be implied to the driver's distraction that may lead to road accident [4, 5].

The importance of the alertness monitoring is gaining better attention from the public, thus, the EEG (Electroencephalograph) monitoring, which able to perceive the sensory data, processed and interpret it to behavioural response is needed. The term of ERPs (event-related potentials) are measured by EEG by placing electrodes on the scalp to investigate the electrical activity of the brain over time.

Divis [6] explained that this technique is non-invasive, which does not require subjects to provide a motor or verbal response but able to measure the driver's alertness during driving. The ability of the ERP component is to measure the dynamics of brain processing through the sequence of ERP components, which made this technique a vigorous tool for analysis of perception, attention and cognition [7, 8].

ERP waveform consists of a series of peaks, which were crucially to distinguish between the observable and latent peaks in order to measure the ERPs. Thus, the average ERP waveform technique is one of the methods that simply attenuates the nonspecific EEG, which allows the single-trial waveform look-like for easier analysis [9]. This method is called simply an averaging method, which recovers the actual waveforms corresponding to the component to create the recorded ERP waveform.

ERP waveforms are typically described in both positive (P) and negative (N) peaks, which define as the time from stimulus onset. Figure 1 illustrates the simple EEG with the ERP component [10].

For visual ERPs, The P100 and N100 component are generated by the attention that reflected from the sensory processing [11]. In this research work, N100 (auditory) and N170 (visual) will become the references for the driver's performance during driving.

N100 wave refers to the negative peak that occurs between 80 and 120 milliseconds after the onset of a stimulus, which extracted from the temporal lobe while N170 wave is identified as the negative peak that occurs between 130 and 200 milliseconds after stimulus presentation from occipital area [12]. The attention will be considered as degraded when the peak of the amplitude is closer to the baseline.

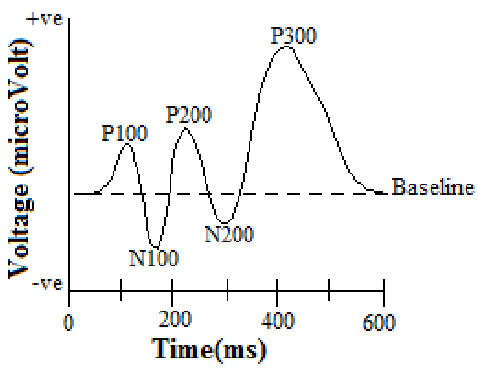


Fig. 1. Average ERP waveform component of EEG signal.

This research work will only focus on temporal-occipital lobes for comparison to detect the driver's alertness as both of the brain areas are related to the visual response, which is attention recognition other than common area, the parietal lobe. The illustration of the brain with its function is shown in Fig. 2 [13].

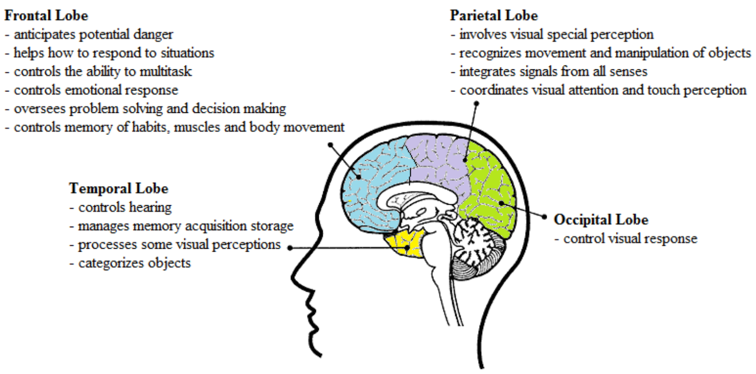


Fig. 2. Brain topo maps with its function during driving.

Until now, there are several researchers have used ERP in a more specific domain for attention recognition [14]. Fu et al. [15], in their research, found that both attentional orienting and focusing modulate at early ERP components (P100 and N100) indicates that the allocations of visuospatial attention are intervened by different neural processes. Huang et al. [16], showed the changes in terms of the subject performance by distinct changes in tonic alpha band EEG spectrum in bilateral posterior independent EEG components. The transient alpha was significantly elevated during the drowsy condition compared when the subjects are alert.

The latest research by Huber-Huber et al. [17] investigates the attention shifts prior to and during saccades with the help of ERPs. Huber-Huber et al. [17], in their study, show that ERP amplitude and the saccade latency results are consistent in terms of attention shifted using the method of temporal alignment ERPs compared to ICA-based EEG technique.

This paper is consisting of four chapters including this introductory chapter. Section 2 is concerned with the detailed descriptions of the methodology that been applied in this research work. The comparison between N100 and N170 wave results are presented in Section 3. Finally, the research findings will be concluded in Section 4.

2. Research Method

2.1. Participants

A total of fifteen subjects in age between 18 to 25 years with driving license participated in the experiment. All subjects were students at the Universiti Teknikal Malaysia Melaka and participated on a voluntary basis and received kudos for the participation. The data of five subjects have to be excluded due to lack of intelligibility. All subjects signed informed consent to take part in the experiment.

2.2. Stimuli and experimental design

The experiment was conducted on a high fidelity in-lab driving simulator based on virtual reality technology to build the 3D highway-driving scene to the subjects for visual stimulation. A 4-channel EEG recording system was applied and attached to the subjects in order to store the raw EEG data during driving. Concerning the EEG recording setup, The BIOPAC Inc framework, Mp150 EEG 100c and machine programming (Acknowledge 4.2) is used to record the EEG signal [18]. Surface Electrodes (Ag/Agcl) are set on the occipital lobe. The impedance is guaranteed underneath 5 kΩ. The recorded EEG data were segmented into response extending from 0 to 1s post-stimulus. These responses were filtered using a digital filter (bandpass 1-15 Hz). Stimulus Event-Related Potential (ERP) were computed by averaging across 10 subjects for each condition. Figure 3 shows the design of the experiment with the EEG system, raw EEG data collection and in-lab driving simulator.

Fig. 3. Design of apparatus for in-lab experiment purpose.

2.3. Task and procedure

All experiments were conducted during daytime inside the research lab in Universiti Teknikal Malaysia Melaka. Subjects were seated comfortably in front of the driving simulator as driving the real car. The subjects are required to take the ten minutes training course prior to the experiment in order to get used to the driving simulator. Then, the subjects are given the two scenarios (with and without listening to speech) as stimulations during the long monotonous driving around twenty minutes respectively. Figure 4 presents the procedure of EEG data acquisition during driving.

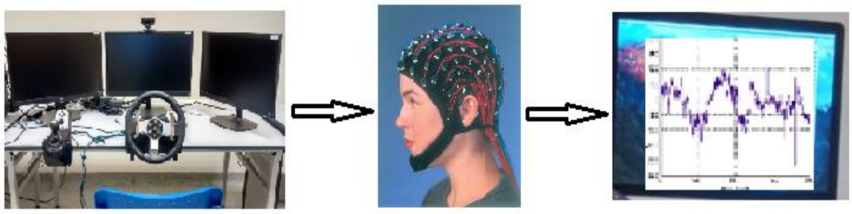


Fig. 4. Basic procedure of data acquisition.

3. Results and Discussion

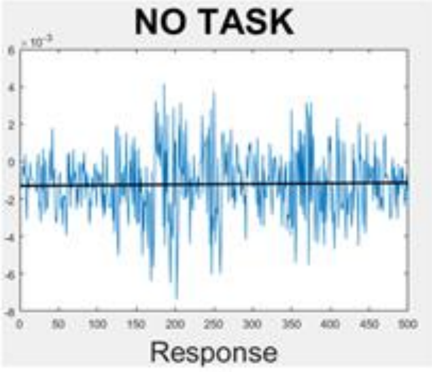
In order to analyse the N100 and N170 waves, as mention before the simple data averaging method is applied, which is the simplest signal processing technique that able to produce the results from the non-modified data signal. There are also other methods that can be used for signal processing such as wavelet function but the result from this method is unconvincing. The result of wavelet function is not from the actual data instead it was calculated between the value of wavelet function and the actual data. In other words, the result of the wavelet function is calculated from the smoothed version of extracted data [19].

To analyse the attention condition of the subjects, the amplitude of the waveform (as the physiological parameters) was investigated. As known that the reduction in amplitude of N100 shows that the subject has low perception processing, which related to attention [20].

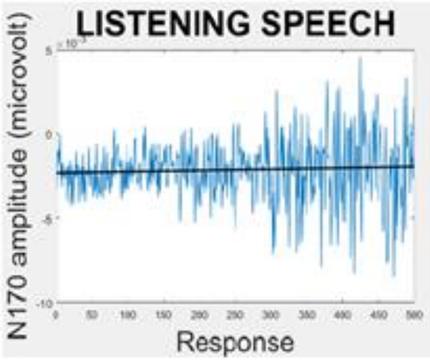
However, instead of the amplitude values, this research paper used the morphology or the behaviour of the waveform to find out in which, waveform is more useful as attention recognition. This is because the data is collected from ten subjects have differed magnitude of ERP. In the future, more subjects are needed to determine the threshold of the attention value to reduce the variability amongst the subjects.

Figures 5(a) and (b) represent the N100 wave results, which extracted at 80 to 120 ms post-stimulus due to jittering for both scenarios. It clearly showed that driving during the monotonous environment while listening to the speech help to increase the alertness of the driver slightly compared to no task during driving.

The calculated percentage of different between no sound with listening to the speech is 0.09%. The number is quite small to see the difference in the driver’s attention through these results, but it still gives some number that the subjects are more vigilance during driving while listening to the speech compared to the silent environment.



(a) N100 wave results with no stimulation (no speech).



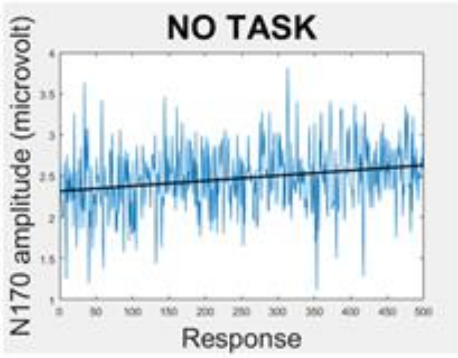
(b) N100 wave results with stimulation given (listening to speech).

Fig. 5. Average N100 wave result of 10 subjects over both scenarios stimulation during driving.

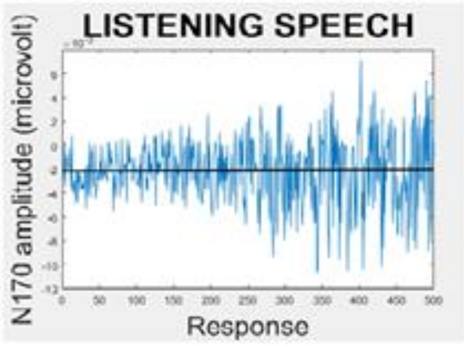
While in Figs. 6(a) and (b), N170 wave results are presented, which extracted at 150-210 ms post-stimulus due to jittering for both scenarios. As known by Kafshgari et al. [21], that N170 wave is identified as negative peak thus, the increment in the graph of no task while driving means that the amplitude of N170 wave is decreasing over responses.

As seen in Fig. 6(a), the graph shows the increment, which means that the amplitude of the N170 wave is decreasing over responses (modulus of N170 amplitude). Since N170 is a negative peak of amplitude, thus, the increment of the graph means that the amplitude of the N170 wave is decreasing over responses. This result claims that the driver's attention is degraded when no task during driving. This may lead to the road accident for longer driving with the silent environment. While in Fig. 6(b), it is almost no significant changes in the driver's attention when listening to the speech. It interprets that the driver is able to maintain the alertness and keep alert while listening to some voice during driving. In terms of percentage, there is 38% difference between both stimulus scenarios and this number gives solid proof that listening to something meaningful sound helps the drivers to avoid boredom especially during the long monotonous driving hours.

These results gave the concrete justification that the recorded data at occipital lobe is reliable and beneficial for attention recognition.



(a) N170 wave results with no stimulation (no speech).



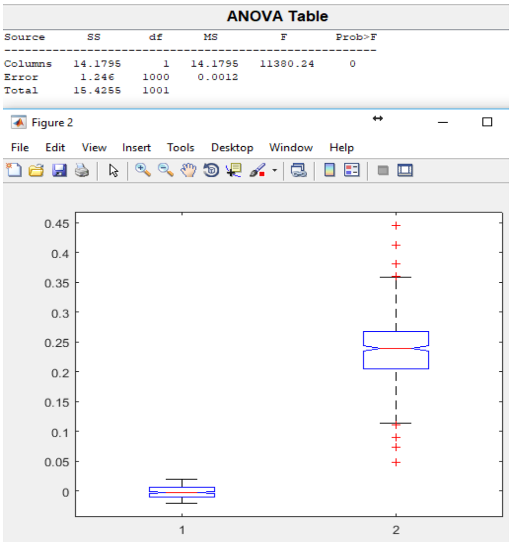
(b) N170 wave results with stimulation given (listening to speech).

Fig. 6. Average N170 wave result of 10 subjects over both stimulation during driving.

As mention in the methodology section, the stimulation given to the subject is twenty minutes respectively for each stimulus. At first task, the subject is required to drive with no speech and at that time the subject might still vigilance or become more focus but as time goes by, the subject might have started to lose focus. After 20 minutes, the subject will be listening to the speech during driving and this might able to help the driver to increase their focus to the road. This situation can answer why the amplitude level between 100 to 250 scales of no speech is similar to the amplitude level with speech between 300 to 400 scales in Fig. 5 and can be observed in Fig. 6 as well.

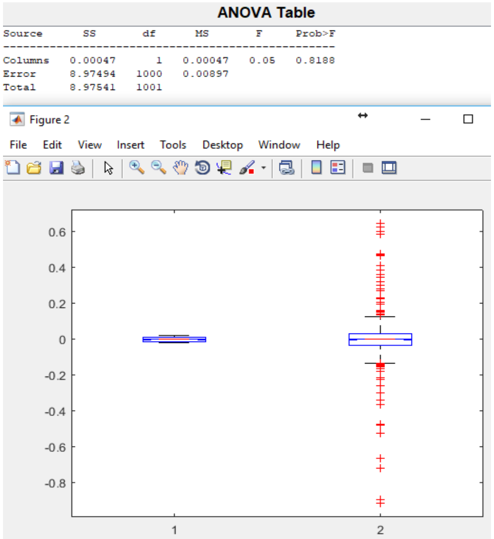
The ANOVA statistical analysis has been done to see the significant difference between N100 and N170 waves. The independent factors between subject are measured as shown in Fig. 7, while for measuring the within-subject variability, which focusing on both stimulation shown in Fig. 8. The calculation results are referred to the 'Prob' (probability values), which is, if the Prob is less than 0.05 (indicates the statistical values of 5% of measured value), then there should be a significant difference between the factors. This also can be done using t-Test statistical analysis.

In Fig. 7, N100 wave is denoted as '1' and N170 wave is denoted as '2'. The analysis above shows that with no task during driving (Fig. 7(a)) shows a significant different between N100 and N170 waves as the 'Prob' is less than 0.05, which is the result shows the prob is 0 but Fig. 7(b) illustrates both waves have no significant difference when listening to a speech during driving (prob is 0.8288>0.05).


ANOVA Table

Source	SS	df	MS	F	Prob>F
Columns	14.1795	1	14.1795	11380.24	0
Error	1.246	1000	0.0012		
Total	15.4255	1001			

(a) ANOVA test for both N100 and N170 waves with no stimulation (no speech).

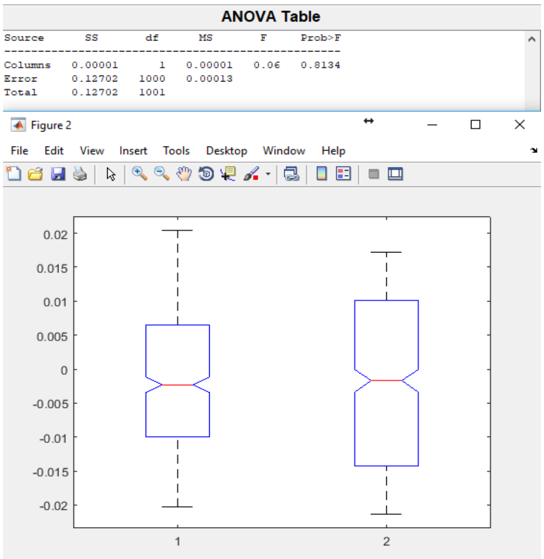

ANOVA Table

Source	SS	df	MS	F	Prob>F
Columns	0.00047	1	0.00047	0.05	0.8188
Error	8.97494	1000	0.00897		
Total	8.97541	1001			

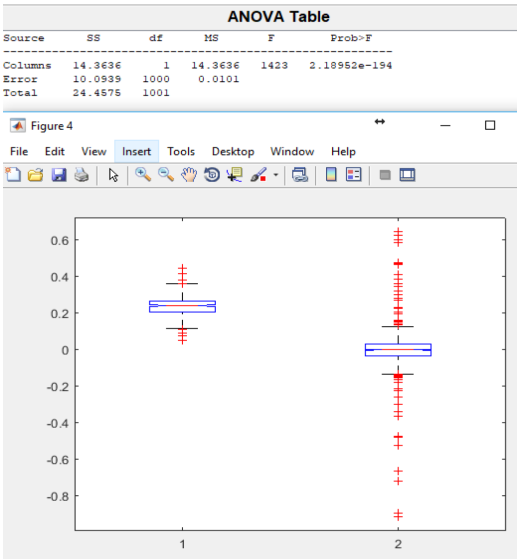
(b) ANOVA test for both N100 and N170 waves with stimulation given (listening to speech).

Fig. 7. ANOVA statistical analysis between subjects for both N100 and N170 waves.

Figure 8(a) shown the ANOVA results of N100 wave, while Fig. 8(b) interprets the ANOVA results of N170 wave for both stimulations (no task and listening to speech). As can be seen, the result of N170 wave (Fig. 8(b)) for both stimulation shows a significantly different that can prove that the changes in the N170 waveform can be clearly observed the driver performance.



(a) N100 waves ANOVA test for both stimulus.



(b) N170 waves ANOVA test for both stimulus.

Fig. 8. ANOVA statistical analysis between stimulation for both N100 and N170 waves.

Based on N100 and N170 results, it verifies that both waves are beneficial for driving attention recognition but between these two methods N170 amplitude observation through occipital lobe is much more accurate for detecting of driver's alertness. It noticeably displayed the changes on the driver performance in both stimulus scenarios for N170 amplitude over the response.

4. Conclusion

The objective of this research paper is to find out the feasibility of the N100 and N170 waves as attention recognition. Thus, the value of the amplitude is not necessary and the morphology or the behaviour is crucial to consider the attention condition of the subject. Based on the results, both N100 and N170 amplitudes, which extracted from the temporal and occipital lobes respectively able to provide good results for attention recognition during driving. N170 amplitude though presents better and convincing results on driver's alertness during monotonous driving for both stimulus scenarios. The stimulation of listening to speech while driving is able to increase the vigilance of the drivers and avoid road accidents due to the driver's distraction. Both N170 wave as attention recognition and on how to increase the attention state of the driver during driving is found. In-depth research on the cause of driver's distraction and to find out the magnitude, threshold value of attention will be carried out in future work.

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Abbreviations

ERP	Event-Related Potential
EEG	Electroencephalograph
NACA	National Advisory Committee for Aeronautics
WHO	World Health Organization

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