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A Study of Driver Brain Wave Characteristics through Changes in Headlamp Brightness

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Abstract

In this study, tests of brain waves were carried out to investigate the physiological characteristics of drivers during a change of headlight brightness. The participants were 20 males in their 20s. Twenty-three different conditions combining the waveform of light, voltage, and alteration time were used. The measurement of brain waves was performed by an internationally standardized 10-20 method using LXE3232-RF.

The results were as follows.

1. From the results of the brain wave map analysis, it was suggested that waveform A increases mental stress and waveform B affects mental and visual stress. The longer the stimulation time, the more stress level was detected.
2. The voltage alteration time of the B waveform should be kept to less than 1500msec, while the voltage should not fall below 11.5[V].

Key Words : Iphysiological Characteristics Of Drivers, Brain Wave Map, Mental And Visual

1. Introduction

The function of headlights is very closely related to driver safe and the change of light intensity is a critical factor. This function could be an important indicator of the efficiency of the whole system.

In this study, brain waves of people driving at night were measured as light intensity changed to establish a limit for preventing mental and physical driver stress.

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2. The process of research

Twenty males who had been driving for at least one year were selected as test subjects. Subjects had an average height of 175.46[cm], a seated height of 129.13[cm] andeye level of 116.31[cm]. Wave shape, changing time and electric pressure were conditions of the experiment.

Table 1. Experimental Conditions

No	Condition name	Pattern	Time(Δt)	Voltage (V)
1	A11	A	100msec	11
2	A12	A	100msec	12
3	A13	A	100msec	13
4	A21	A	300msec	11
5	A22	A	300msec	12
6	A23	A	300msec	13
7	A31	A	500msec	11
8	A32	A	500msec	12
9	A33	A	500msec	13
10	B11	B	1.5sec	10
11	B12	B	1.5sec	10.5
12	B13	B	1.5sec	11
13	B14	B	1.5sec	11.5
14	B15	B	1.5sec	12
15	B16	B	1.5sec	12.5
16	B17	B	1.5sec	13
17	B21	B	3sec	10
18	B22	B	3sec	10.5
19	B23	B	3sec	11
20	B24	B	3sec	11.5
21	B25	B	3sec	12
22	B26	B	3sec	12.5
23	B27	B	3sec	13

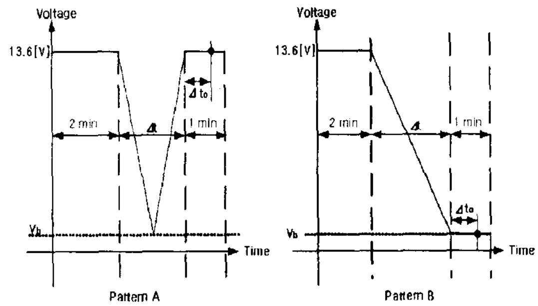

Fig. 1. Definition of voltage patterns

A 10-20 method, which is most common for attaching electrodes, was used. A Lax-THAWEEG-32 SYSTEM was used as a wave tester. A Power Spectrum Analysis was used as the method of analysis. This research tests the statistical propriety of frequency change by determining if there are statistically significant differences between the frequency value of the stimulus through a t-test.

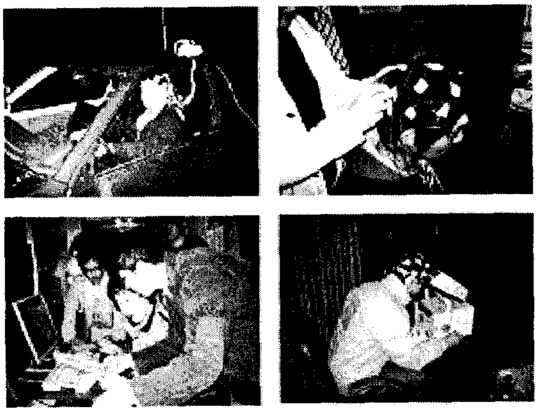

Fig. 2. Research site

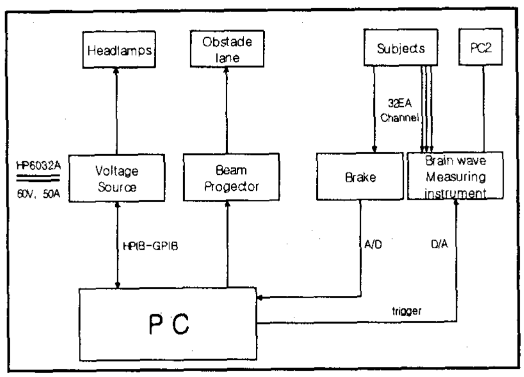

Fig. 3. Block diagram of measurement system

3. Results and analysis

Brain waves were measured at the following times: ① beginning and end of stimulus, ② a baseline and post-stimulus of pattern A, ① before stimulus and the status of descending electric pressure, ② descending electric pressure, ③ ascending and descending electric pressure, ④ before/after stimulus of pattern B.

3.1 The wave analysis of waveform

Table 2. The brain wave analysis of waveform

No	pattern	Δt	ΔV	analysis
1	A	0.1	11	①no significance ②α wave
2	A	0.1	12	no significance
3	A	0.1	13	no significance
4	A	0.3	11	no significance
5	A	0.3	12	no significance
6	A	0.3	13	no significance
7	A	0.5	11	no significance
8	A	0.5	12	①αwave ②αwave, βwave
9	A	0.5	13	①βwave ②αwave, βwave
10	B	1.5	10	no significance
11	B	1.5	10.5	①αwave, βwave ②αwave ③nosignificance④no significance
12	B	1.5	11	①αwave ②αwave ③, ④no significance
13	B	1.5	11.5	①αwave ②αwave ③αwave ④αwave
14	B	1.5	12	①, ③no significance ②αwave, βwave ④αwave
15	B	1.5	12.5	①, ④no significance ②αwave,βwave③αwave,βwave
16	B	1.5	13	no significance
17	B	3	10	①αwave, βwave ②αwave, βwave ③αwave, βwave ④αwave, βwave
18	B	3	10.5	①βwave ②βwave ③αwave, βwave ④αwave, βwave
19	B	3	11	①αwave, βwave ②αwave, βwave ③αwave ④αwave
20	B	3	11.5	①βwave ②αwave, βwave ③α wave, βwave ④no significance
21	B	3	12	no significance
22	B	3	12.5	no significance
23	B	3	13	①no significance ② αwave ③αwave ④αwave

pattern A : ①beginning and end of stimulus
② baseline and post-stimulus
pattern B : ① before stimulus and the state of descending electric pressure,
② descending electric pressure
③ electric pressure ascending and descending,
④ before/after stimulus

As a result of the wave shape measurement, pattern A had a few points that displayed meaningful differences while pattern B had many. Therefore, the headlight electric pressure fluctuation of pattern B is no better than waveform A.

3.2 The wave analysis of voltage

Table 3. Pattern B analysis of voltage

No	Pattern	Δt	ΔV	analysis
16	B	1.5	13	no significance
23	B	3	13	①no significance ②αwave ③αwave ④αwave
15	B	1.5	12.5	①no significance ②αwave, βwave ③αwave, βwave ④no significance
22	B	3	12.5	no significance
14	B	1.5	12	①no significance ② αwave, βwave ③no significance ④αwave
21	B	3	12	no significance
13	B	1.5	11.5	①αwave ②αwave ③αwave ④αwave
20	B	3	11.5	①βwave ②αwave, βwave ③α wave, βwave ④no significance
12	B	1.5	11	①αwave ②αwave ③no significance ④no significance
19	B	3	11	①αwave, βwave ②αwave, βwave ③αwave ④αwave
11	B	1.5	10.5	①αwave, βwave ②αwave ③no significance ④no significance
18	B	3	10.5	①βwave ②βwave ③αwave, βwave ④αwave, βwave
10	B	1.5	10	no significance
17	B	3	10	①αwave, βwave ②αwave, βwave ③αwave, βwave ④αwave, βwave

pattern B : ① before stimulus and the state of descending electric pressure
② descending electric pressure
③ electric pressure ascending and descending
④ before/after stimulus

Table 4. The brain wave analysis by timeline

No	Pattern	Δt	ΔV	analysis
3	A	0.1	13	no significance
2	A	0.1	12	no significance
1	A	0.1	11	①no significance ②αwave
6	A	0.3	13	no significance
5	A	0.3	12	no significance
4	A	0.3	11	no significance
9	A	0.5	13	①βwave ②αwave, βwave
8	A	0.5	12	①αwave ②αwave, βwave
7	A	0.5	11	no significance
16	B	1.5	13	no significance
15	B	1.5	12.5	①no significance ②αwave, βwave③αwave, βwave ④no significance
14	B	1.5	12	①no significance ② αwave, βwave ③no significance ④ αwave
13	B	1.5	11.5	①αwave ②αwave ③αwave ④ αwave
12	B	1.5	11	①αwave ②αwave ③no significance ④no significance
11	B	1.5	10.5	①αwave, βwave ②αwave ③no significance ④no significance
10	B	1.5	10	no significance
23	B	3	13	①no significance ②αwave ③αwave ④αwave
22	B	3	12.5	no significance
21	B	3	12	no significance
20	B	3	11.5	①βwave ②αwave, βwave ③αwave, βwave ④no significance
19	B	3	11	①αwave, βwave ②αwave, βwave ③αwave ④αwave
18	B	3	10.5	①βwave ②βwave ③αwave, βwave ④ αwave, βwave
17	B	3	10	①αwave, βwave ②αwave, βwave ③αwave, βwave ④αwave, βwave

pattern A : ① beginning and end of stimulus
② baseline and post-stimulus
pattern B : ① before stimulus and the descending state ofelectric pressure
② descending electric pressure
③ electric pressure ascending and descending
④ before/after stimulus

As a result of a phasing analysis of the voltage, pattern A was not measured because the A wave had few significant differences. It can be seen as well that pattern B should change more than 11.5[V] voltage since pattern B had a few significantly different values. At greater than 11.5[V] but less than 11.5[V], the values appeared the same on almost every point of analysis. The fact that with the same voltage change, the shorter the length of time for changing the voltage is,the smaller the extent of reaction could be seen.

3.3 The wave analysis by timeline

As a result of the pattern A brain wave by timeline, voltage change of less than 500msec could be ignored because pattern A had no meaning at under 300msec. At 500msec or more, meaningful values appeared.

As a result of the pattern B by timeline, significant data appeared at both 1.5 sec and 3 sec. The wave is therefore effected not by amount of voltage but by voltage change. Because the waves have the tendency to react following voltage change (② descend, ④ recover) timeline(①~④) of the change were focused on.

3.4 Stress of the brain as waveform

An α-wave appears when a person is relaxed. The amplitude rises as he/she relaxes more. Stable α-waves appear when the subjects close their eyes and become calm, and is suppressed when they open their eyes to stare at an object or are mentally excited.

β-waves appear when a person is doing a conscious action such as waking or speaking. β-waves primarily appear when the subject feels uneasy, nervous, or is performing complex calculations. So it can be said that the subject is under stress when the amplitude of the β-wave is greater than that of the α-wave. In this study, analysis concentrated mostly on α- and β-waves.

As a result of comparing α and β by timeline, pattern B tends to have more stress than pattern A. When voltage change (② descend, ④ recover)occurred, in particular, the reaction also occurred and, among other points, the strongest reaction was observed at complete points (②, ④ timeline of pattern B) of the change.

3.5 The analysis of the brain wave map

The main source of brain waves is the cerebral cortex, where millions of nerve cells are complexly connected. The cortex is composed of the frontal lobe, parietal lobe, temporal lobe, and occipital lobe, which all function differently.

The frontal lobe controls highly perceptive, emotional, or mental functions. The parietal lobe controls functions of physical movement. The temporal lobe controls the sense of hearing, while the occipital lobe at the back of the head controls the primary management of visual information.

Attention here is given to the brain wave data from the frontal and occipital lobes.

3.5.1 The brain wave map sorted by shape

The αwave and βwave of pattern A reacted in the frontal lobe. It could be seen that pattern A rather was processed as mental information (the frontal lobe) rather than visual information (the occipital lobe) because it is a stimulus of a very short time, less than 0.5 sec.

The αwave and βwave ofpattern B reacted in the contract location of the brain showing meaningful differences. This shows that the brain experienced both mental and physical stress.

3.5.2 Shape of pattern B sorted by the voltage

By analyzing pattern B of the brain wave map for each voltage, it could be seen that the reaction point in the frontal and occipital lobes at less than 11.5[V] is overwhelmingly greater than over 12[V]s. On the same timeline, meaningful differences for both αwave and βwave occurred only at less than 11.5[V].

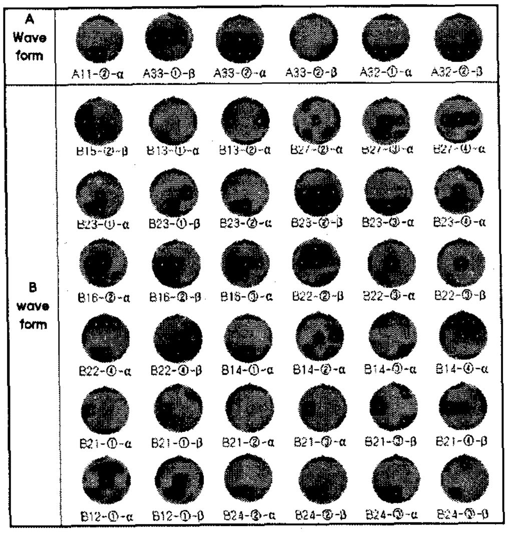

Fig. 4. Brain wave map sorted by shape

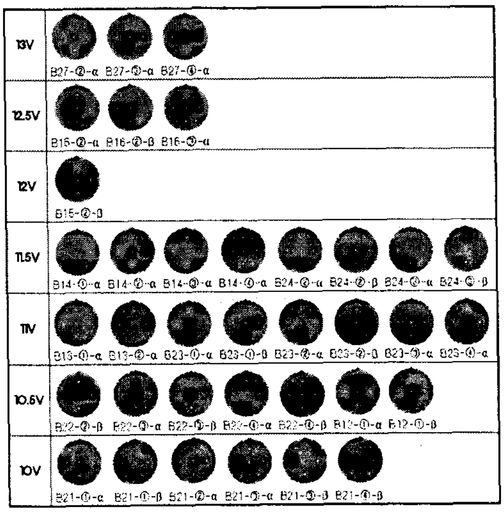

Fig. 5. Shape of pattern B sorted by the voltage

3.5.3 Pattern B sorted by timeline

By observing the wave map of each timeline, the wave was more in the frontal lobe than the occipital lobe at 1.5sec. It was more in the occipital lobe than in the frontal lobe or was in both places at 3.0sec.

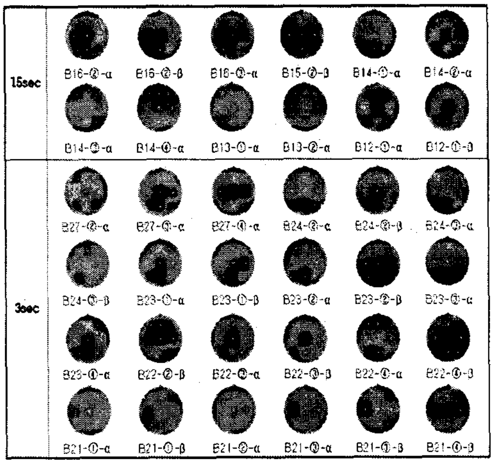

Fig. 6. Pattern B sorted by timeline

4. Conclusion

Brain waves were studied to understand the physiological characteristics of drivers as related to headlight brightness. The following are the conclusions of that study.

1. As a result of the brain wave map analyzed by brain area, pattern A imparted mental stress while pattern B imparted both mental and physical stress. The longer the length of the stimulus, the stronger the stress was.
2. The alteration time had to be less than 1500msec and more than 11.5[V].

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References

[1] Joung-Su Yoon, Brain waves science, Pub. Go ryeo, 1999.

[2] Min-Chul Hwang, Eun-Kyung Ryu, Chul-Joung Kim, A study on Discrimination Sensitivity between EEG Patterns under IAPS (International Affective Picture System) Stimuli, Journal of the Ergonomics Society of Korea, Vol.17, No.1, 1998.

[3] Jung-Yong Kim, Chang-Soon Park, Evaluation of Car Interior Noise by Using EEG, IMS, Vol.24, No.65, 2001.

[4] Cooper, R., Osselton, J.W., Show, J.C., EEG Technology, 3rd Edition, Butterworths, 1980.

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