Changes in the autonomic nervous system between normal sleep state and sleep deprivation state while driving

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1. Introduction

Due to the invention of the light bulb, people have been able to work at night as if it were day. This advantage of people being able to utilize night time like day time caused the side effects of sleep deprivation. This sleep deprivation is known to cause accidents in industry, especially in the transport sector (Philip et al., 2006).

Odors are sensed by olfaction, which is the most sensitive sensory receptors in the human body, and studies have investigated whether odor affect the central nervous system and the autonomic nervous system (Min, 2001).

So we conducted an experiment to investigate changes in the autonomic nervous system between the normal sleep state and sleep deprivation state while driving and to know the effect of natural fragrance in lack of sleep on the autonomic nervous system.

2. Method

2.1 Participants, Test Environment, and Equipment

The participants were 10 male drivers between 20 and 45 years old with an average age of 30.9±7.7 years who had been driving for 7±6.6 years. The participants had normal or corrected vision, had no trouble in perceiving the image of a simulator, and were free of any sleep disorder and simulation sickness.

As for the lab environment, room temperature was maintained at 25±2°C, and the humidity was 35~52%. The driving simulator was GDS-300S, manufactured by Grid Space Co. (Korea), and the front and left/right visual information was provided through three 32” LCD monitors. The driving devices (handle, accelerator and brake pedals, etc.) and display devices (turn signal lamp, speedometer, RPM meter, etc.) were the same as those of a real vehicle. Vital Meter, which is manufactured by TAOS Institute in Japan, was used to measure the pulse wave. The sampling frequency was 1 kHz. Vital Meter measures earlobe pulse waves and is wireless. The odors used in this test were manufactured by KIMEX Co. (Korea). Two natural oils were used: 100% lavender oil and 100% peppermint oil. Lavender oil is effective in inducing relaxation and sleep, and peppermint oil has the effect of creating arousal and tension in the human body (Min, 2001).

2.2 Test Procedure

This test was designed to find out whether there were differences when comparing the autonomic nervous system before and while driving in the normal state, the sleep deprivation state, the lavender oil exposed state, and peppermint oil exposed state using a driving simulator. Before the test, in order to minimize the factors that may affect the test, the participants had sufficient sleep, and heavy alcohol and caffeine intake was prohibited before the test day. The test was conducted from 5 p.m. to 7 a.m. the day after the participants’ arrival at the laboratory. A brief questionnaire asking the current degree of sleepiness, age, driving experience, and so on was filled in and driving practice was conducted to get the participants used to the driving simulation environment.

Test procedure was as shown in Figure 1. After a 10-minute break, the first driving simulation in the normal state was conducted for 5 minutes, and the autonomic nervous system was measured for 10 minutes. This measurement was started 5 minutes earlier than the driving. To create a sleep deprivation state, the participants rested in in the lab from 5 p.m. to 7 a.m. the next day. The second driving simulation in the sleep deprivation state was conducted for 5 minutes at 5 a.m., and the autonomic nervous system was measured for 8 minutes. Driving simulations like the one described above were conducted in the lavender and peppermint oil exposed states, respectively. To reduce the effect on the previous test, there was a 10-min break in the middle of the test. The odor was placed 20 cm away from the nose of the participants, the lid of
the odor was open for one minute to take in the smell, and the test was carried out with the odor remaining in air. After each test, the odor in the air was removed by adequate ventilation.

Figure 1. Test procedure.

3. Result

In analyzing the LF/HF ratios, there was a significant difference (p<0.01) between "before driving" and "while driving" in the sleep deprivation state, as shown in Figure 2. But there was no significant difference in other groups such as normal, lavender, and peppermint group.

Figure 2. LF/HF ratios at each state between before driving and while driving (** p<0.01).

4. Conclusion

Monotonous driving environments, such as highways, may cause micro-sleep and can lead to fatal traffic accidents (Lavie, 1986; Dement and Carskadon, 1982). In comparing the LF/HF ratios between "before the driving" and "while driving" at each state, the LF/HF ratio while driving is higher than that of before driving in the normal sleep state. But in the sleep deprivation state, the lavender oil exposed state, and peppermint oil exposed state, the LF/HF ratio while driving is lower than that of before driving. Especially there was a significant difference between "before driving" and "while driving" in the sleep deprivation state. This result means that, in the sleep deprived state, the intensity of the driving performance could be lowered.

References

Philip, P., and Åkerstedt, T. 2006. “Transport and industrial safety, how are they affected by sleepiness and sleep restriction?” Sleep medicine reviews 10(5), 347-356.

