Effect of Oxygen Concentration and Odors on the Driving Fatigue in a Graphic Driving Simulator

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Abstract

In this study, it was observed how 40% highly concentrated oxygen and lavender, peppermint affect the stress and fatigue which happen during driving performance and heart rate(HR). 12 male university students were selected as the subjects of this study. As a driving task, they were made to drive on the two-lane road for 5 minutes. While driving, addition tasks were added to increase the stress and fatigue. The driving performance like the above was implemented 6 times in total in the conditions of oxygen concentration (21%, 40%) and odors(normal, lavender, peppermint). For analysis, the findings were extracted by 30sec in three sections (Control, Driving, Driving + Task) and were compared. When the findings from three sections (Control, Driving, Driving + Task) were compared to identify driving fatigue , Driving +Task increased, showing a significant difference($p<0.01$), compared with Control, That is, the subjects were made tired by addition tasks while driving. When highly concentrated oxygen (40%) and lavender, peppermint were presented to them, all of them showed the reduction of HR. That is, it can be said that highly concentrated oxygen and lavender, peppermint reduced the Fatigue of the drivers. When highly concentrated oxygen and lavender, peppermint were given simultaneously, there was no synergy effect.

Keyword : Oxygen Concentration, Odor, Driving, Fatigue, Graphic Driving Simulator

Introduction

Driving performance is a continuity of very complex process including the perception, decision-making, and motor skills of human beings. Drivers are apt to be tired as they have to cope with the many stimuli presented by the external environment while driving with tension and attention because of the characteristics of high concentration and driving circumstances. It is being reported that long drive, lack of sleep, a boring driving situation, and traffic situation are the main causes of driving fatigue, which may become the main causes of traffic accidents by reducing vehicle control, alertness, and attention. Although there have been studies to assess and alleviate driving fatigue, they are not enough.

There used to be the reports that aroma therapy has a positive effect on alleviating fatigue. There used to be the reports that after lavender(67.7%), which is most used for aroma therapy, was inhaled, psychological, physical stress index, blood pressure and pulse rate reduced, and blood flow increased slightly. Furthermore, lavender reduced stress index and vital signs by relaxing sympathetic nerve, and stabilized autonomic nerve.

After implementing odors inhalation to middle-aged women under stress, the psychological, physiological responses of them were examined. As a result, they came to feel better and also, it was observed that autonomic nerve tended to be relaxed by good odors.

Also, the aroma hand massage had an effect on the lowering systolic pressure, stress perception level, and the reduction of cortisol level. It was observed by Kim Jang Soon that aroma inhalation was effective to relieve and prevent the stress. When this effect of aroma therapy is considered, it can be effectively used to relieve the stress and fatigue caused with driving performance.

The study result used to be reported that highly concentrated oxygen is effective to alleviate the fatigue. Oxygen has a characteristic of concentration

in the atmosphere (about 21%), and a partial pressure (about 159 mmHg). When lowly concentrated oxygen (under 21%) is intaken, as the supply to the energy demand by the activation of physiological function during physical, psychological activities is not fulfilled, Fatigue is triggered. It has been partially known that the oxygen supplied from the outside gives a positive effect on the cognitive competency and exercise capacity. When calculation tasks were conducted in highly concentrated oxygen (40%), performing competence improved and the increase in cognitive competence was positively affected with the increase of blood oxygen saturation, and HR was reduced. Also, the supply of highly concentrated oxygen (30%) increased the cognitive competency of language and space perception, and in cycle exercise, compared with oxygen concentration (21%), the supply of oxygen concentration (30%) reduced HR in the section of exercise and recovery. That is, the reduction of HR means that the energy demand of a heart itself can be reduced, and the same amount of oxygen as before can be supplied for human anatomy. The effect of odors and oxygen may be effectively used for reducing Fatigue and stress caused while driving.

Although it is proper to use a real vehicle in order to trigger the Fatigue of drivers, as there is difficulty in keeping safety and controlling in test environment, the studies have been conducted using the vehicle simulators which were placed in the test room mostly. However, when the test is implemented using a vehicle simulator for a long hour, there is a side effect like Simulator Sickness.

In this study, driving circumstances was presented using the vehicle simulator which was possible to keep safety and control the test. To reduce Simulator Sickness happening due to a long-term driving of a vehicle simulator, the test was implemented under 5 minutes. In addition, by implementing the unexpected tasks while driving, Fatigue and stress were increased.

This study was performed to find out how highly concentrated oxygen(40%) and stimulus of odors could affect driving fatigue in performing tasks while driving and to examine the synergy effect when oxygen concentration and stimulus of odors were presented simultaneously through change in Heart Rate (HR).

Method

Subjects

The subjects consisted of 12 males in their twenties with over 1 year of driving experience. Their average age was 23±3.1, and they had no trouble in heart system and olfactory sense and Simulation Sickness while driving the vehicle simulator. From the previous day of the test, they were made to prohibit drugs, drinking, smoking and the foods containing caffeine.

Test Environment & Equipment

The internal temperature of the test room was 25±1.1°, and the internal humidity was maintained 36~40%. The driving simulators were GDS-300s manufactured by Grid space Co. (Korea) and were installed inside the test room. Driving circumstances was given to the subjects with three 32〃LCD monitors, and the handle, accelerator, brake pedal, turn signal, speedometer, and RPM meter which were necessary for driving performance were manufactured the same as those of the real vehicle.
For bio-signal, heart rate was measured using Biopac MP100 manufactured by Biopac System Inc.(USA). Electrocardiogram (ECG) was measured through CM5 inducing method where a reference electrode was attached to the right chest which was symmetric with + electrode, and +/-electrodes respectively were attached to the left chest and the top of breast bone. For data analysis, data were input and analyzed using Acqknowledge (3.9.1).

To supply oxygen and present stimulus of odors, YAMATO (YR-88), a oxygen feeding control, and the erlenmeyer flask where odors were contained were connected with an oxygen connecting hose, and then oxygen and odors were presented to the nose of the subjects by connecting the part inside the erlenmeyer flask with a hose where the blended oxygen and odors came out. Lavender and Peppermint were used for the odors of olfactory stimulation in the test.

Double digits addition problems were made the unexpected tasks presented while driving. The problems were the added two figures which came out by making random numbers between 1 and 40 happen using Microsoft office Excel 2007. By adding 0 or 1 to the added value((34+12=46+(0or1),the subjects were made to choose true value and false value randomly.10 addition problems were presented to the driving subjects verbally, and they were made to reply true or false with“O”or “X”.

Test Design & Procedure

In this study, test design was created to find out how highly concentrated oxygen and stimulus of odors respectively affect the stress and Fatigue and stress were increased. which occurred in performing the unexpected tasks while driving and to find out that there would be a synergy effect when odors and

oxygen were presented simultaneously.
Before implementing the test, an electrode was attached to the subjects in order to measure heart rate, and they were made to have a practice driving for 5mins for adapting themselves to vehicle simulator. When the practice driving was done, and HR was measured during a stable state of 5mins. In a straight course, which lasted for 1min, while driving, the addition tasks were presented to them.
Driving performance was implemented in oxygen concentration condition ((21%, 40%), olfactory stimulation (Lavender, Peppermint), and in the condition where olfactory stimulation was simultaneously given with 40% oxygen concentration (oxygen concentration(40%)+ Lavender, oxygen concentration(40%)+ Peppermint) 6 times repeatedly.
As for analyzing method, the Control(30sec), Driving(30sec), Driving + Task(30sec) were classified and measured respectively, and normalization was implemented based on oxygen concentration 21% Control. To find out how the types of oxygen concentration(21%, 40%) and the types of olfactory stimulation(Normal, Lavender, Peppermint) affect the stimuli(Control, Driving, Driving +Task) presented to the subjects, 2*3*3 three way-ANOVA analysis was conducted using spss 13.0 where HR was a dependent variable.

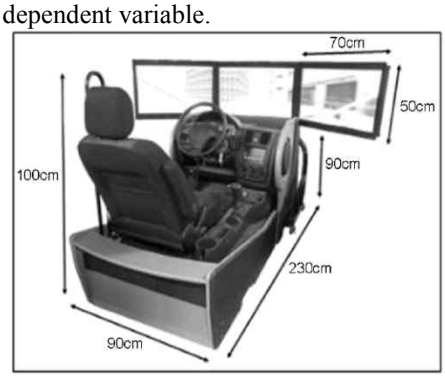

Figure1. Graphic Driving Simulator

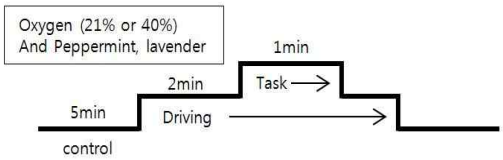

Figure2. Test Design

Results

The types of oxygen concentration(21%, 40%), stimulus of odors condition(Normal, Lavender, Peppermint), state condition(Control, Driving, Driving + Task) respectively showed a significant difference($p<0.01$, $p<0.05$, $p<0.05$) like <Table 1>, and there was a significant interaction effect between the types of oxygen concentration and stimulus of odors.

As a result of Post Hoc Test, in the types of oxygen concentration, 40% oxygen decreased compared with 21% oxygen concentration, and in stimulus of odors condition, like <Figure. 4>, Lavender condition decreased, showing a significant difference ($p<0.05$), compared with Normal condition. In state condition, like <Figure.3>, Driving+ Task condition increased, showing a significant difference, compared with Control and Driving conditions. With the emergence of interaction effect in the conditions of oxygen concentration and stimulus of odors ($p<0.05$), there was difference in the aspect of change in heart rate. When simple main effect was analyzed by the types of stimulus of odors, there was a significant difference between oxygen concentration ($p<0.05$) in normal condition like <Figure.5>. There was no difference according to oxygen concentration in stimulus of odors condition. That is, it means that there was no synergy effect when oxygen and odors were given simultaneously.

Table1. Results of analysis by oxygen concentration and odors stimulus (*$p<0.05$, **$p<0.01$)

Source	Type III Sum of Square	df	Mean Square	F
Oxygen	0.089	1	0.089	7.712**
Smell	0.077	2	0.038	3.327*
Phase	0.072	2	0.036	3.126*
Oxygen* Smell	0.108	2	0.054	3.788*
Oxygen* Phase	0.005	2	0.002	0.181
Smell* Phase	0.016	4	0.004	0.263
Oxygen* Smell* Phase	0.021	4	0.005	0.370

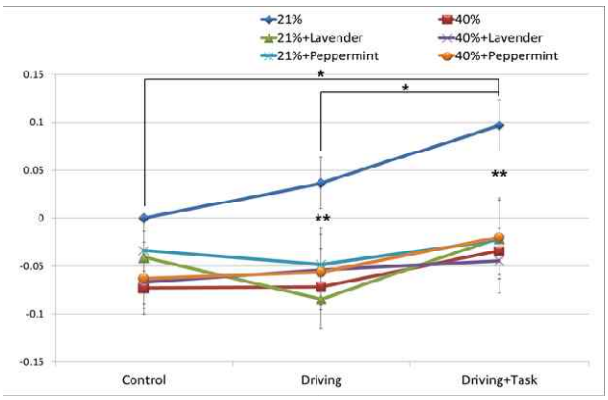

Figure3. Results of analysis by oxygen concentration and odors stimulus (*$p<0.05$, **$p<0.01$)

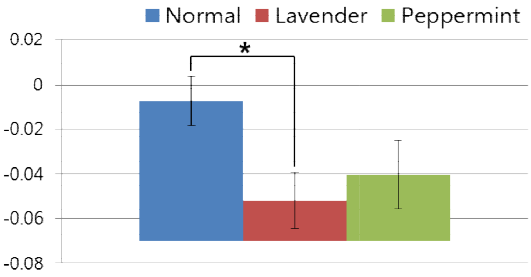

Figure4. Comparison between stimulus of Odors (*p<0.05)

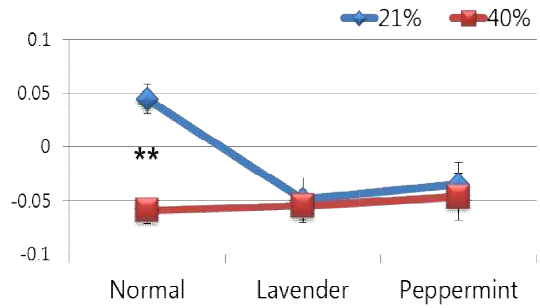

Figure5. Comparison between of odors stimulus by oxygen concentration (**p<0.01)

4. Conclusion

his study was aimed to find out how highly concentrated oxygen(40%), lavender and peppermint affect the stress and fatigue which happened while driving, and observe if there was a positive synergy effect when highly concentrated oxygen and odors were presented at the same time through HR. In this study, a significant difference was observed only between the Driving + Task condition and Control, Driving conditions in the stimuli (Control, Driving, Driving +Task) in order to observe driving workload, stress and fatigue. That is, it is thought that fatigue was triggered to the drivers with the performance of cognitive tasks. There was no significant difference between Control and Driving. That is, fatigue was not triggered by driving performance.

It is thought that the results above showed that driving performance hour considering simulator sickness was not enough to trigger driving fatigue. When highly concentrated oxygen (40%) was injected, heart rate decreased, showing a significant difference in both Driving and Driving +Task Conditions. That is, it is thought that the stress and fatigue triggered by stimulus were reduced by the parasympathetic nerve activated by highly concentrated oxygen. The results above correspond with the precedent studies. There was no difference in HR between when lavender, peppermint were presented to the subjects in oxygen concentration (21%) and when lavender, peppermint were presented to them in oxygen concentration (40%). That is, when highly concentrated oxygen and the stimulus of odors were given at the same time, there was no synergy effect. In this study, though highly concentrated oxygen (40%) and lavender, peppermint positively affected in performing the addition tasks while driving, there was no synergy effect of oxygen and odor. Henceforth, it is considered that it will be required to study how highly concentrated oxygen and the stimulus of odors affect the driving stress and fatigue by presenting various vehicle driving scenarios. Also, it is judged that it will be necessary to study how highly concentrated oxygen and the stimulus of odors affect the stimulus of a short–term driving performance as well as a long-term driving performance effect.

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