The Effect of Highly Concentrated Oxygen(40%) on Heart Rate(HR) While Performing Addition Tasks in a Graphic Driving Simulator

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Abstract

In this study, it was observed how the supply of highly concentrated oxygen(40%) could affect HR while performing the addition tasks in a vehicle graphic simulator. The subjects of this study were 17 males in their twenties, and the addition tasks were performed in oxygen concentration(21%, 40%). For the performance of double-digit addition tasks in the straight course of two-lane road, its data was extracted by 30sec section from the start of the task and was analyzed. The test was proceeded in the order of Control (5min), Driving (2min), Driving + Task (1min), and Rest (10min). As a result of analyzing HR, there was a significant difference ($p<0.01$) between 21% oxygen concentration and 40% oxygen concentration, and HR increased during 21% oxygen concentration. Also, the significant difference between stimuli(Control, Driving, Driving+Task) was recognized, and as a result of the posteriori test, compared with Control, HR increased in Driving+Task, showing a significant difference($p<0.01$). That is, the sympathetic nerve of the drivers were activated while performing the addition tasks during driving performance. Especially, when highly concentrated oxygen(40%) was presented, HR reduced. And thus, it was found out that highly concentrated oxygen(40%) had a positive effect on performing addition tasks while driving.

Keyword : Vehicle Graphic Simulator, Oxygen, Addition Tasks, HR, Sympathetic Nerve

Introduction

Driving performance is a continuity of very complex process including the perception, decision-making, and motor skills of human beings. Because of the continuing high concentration and the characteristics of driving circumstances, drivers have to cope with the many stimuli presented by the external environment while driving with tension and attention, so they are apt to be tired. It is being reported that a long drive, lack of sleep, a boring driving situation, and traffic situations are the main causes of Driving fatigue [1], which may become the main causes of traffic accidents by reducing vehicle control, alertness, and attention of the drivers[2]. There used to be studies using highly concentrated oxygen in order to reduce Driving fatigue[1].

Oxygen is an essential material in maintaining human life. Oxygen has a characteristic of concentration(about 21%) in the atmosphere, 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 evoked[3]. However, there used to be a report of the study that highly concentrated oxygen over 21% plays a positive role in the human body[4]. In addition, there was a report that HR and blood oxygen saturation had a more positive effect on the space perception ability, addition task performance ability, language ability during exercise in the condition of highly concentrated oxygen than oxygen concentration(21%)[3,4,5,6]. Also, in Mental fatigue due to a monotonous driving, highly concentrated oxygen positively affects the effect of reducing fatigue [1].

Like the above, though there have been the study

reports that highly concentrated oxygen had a positive effect on the cognitive load, a variety of studies on the type of cognition are not enough yet[7]. And also, while there have been studies on the effect of highly concentrated oxygen on the physiological signal variations according to cognitive processing in static situation[5], there have not been enough studies on how highly concentrated oxygen could affect the physiological signal variations in arousal state caused in the dynamic environment, and in addition, there are no studies on the physiological signal variations in the process of cognitive processing in the dynamic environment.

There is difficulty in keeping safety when the test is conducted using a real vehicle[1]. Therefore, there have been many studies using a vehicle simulator[8,9,10]. However, when a driver uses a vehicle simulator for a long hour, there is a side effect like Simulator Sickness[9].

In this study, a driving circumstance was presented using the Graphic Driving Simulator, and to reduce Simulator Sickness, the driving was conducted under 5 min. The addition tasks were imposed to the subjects in the straight course while driving.

This study was aimed to examine how highly concentration oxygen(40%) could affect the human body during task performance while driving and the change in HR.

Method

Subjects

The subjects consisted of 17 males in their twenties with over 1 year of driving experience. Their average age was 23±1.97, 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 which could affect the autonomic nervous system of them.

Test Environment & Equipment

The internal temperature of the test room was 25±2.1°, and the internal humidity was maintained 36~43%. The driving simulators were GDS-300s manufactured by Gridspace Co. (Korea) and were installed inside the test room. GDS-300s provided the driving circumstance for 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) by connecting the oxygen connecting hose of Mowmedical (MN-251) to YAMATO(YR-88), a oxygen feeding control, oxygen(40%) was supplied to the nose of the subjects. The unexpected tasks presented while driving were double digits addition problems. The problems were to add the two numbers which came out by having random numbers between 1 and 40 happen using Microsoft office Excel 2007. By adding 0 or 1 to the added value(23+15=38+(0 or1)),true value and false value were made random. By presenting 10 addition problems verbally to the subjects who were driving, they were made to reply “true” or “false”with “O” or “X”.

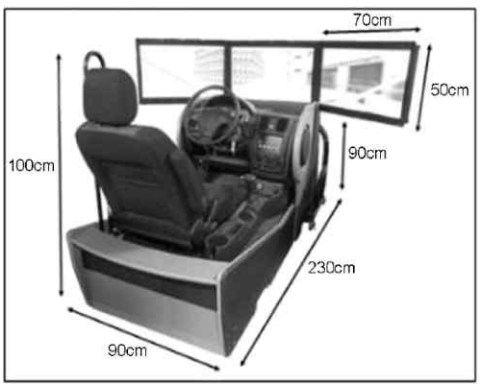

Figure1. Graphic Driving Simulator

Test Design & Procedure

In this study, test design was created to find out how highly concentrated oxygen could affect HR in conducting cognitive tasks(solving addition problems in the straight course of two-lane road) in the dynamic environment. Before implementing the test, an electrode was attached to the subjects in order to measure the heart rate of them, and they were made to have a practice driving for 5min for adapting themselves to the vehicle simulator. When the practice driving was done, HR was measured during a stable state of 5 mins. In the straight course which lasted for 1min while driving, the addition tasks were presented to them. The test was implemented in oxygen concentration 21% and 40% respectively. They were made to take a rest for 10mins to reduce the interference between the tests.

For analysis, Control(30sec), Driving(30sec),

Driving + Task(30sec) were classified respectively and measured. To find out how the types of oxygen concentration(21%, 40%) could affect the stimuli(control, Driving, Driving+Task) presented to the subjects, 2*3 mixed ANOVA analysis was conducted using spss 13.0 where HR was a dependent variable. To find out the difference among the stimuli(control, driving performance, and addition tasks while driving) presented to the subjects, Two-Way ANOVA was conducted.

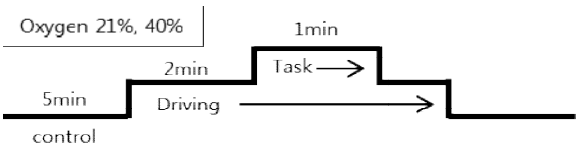

Figure2. Test Design

Results

Like <Figure 3>, HR increased in the stimuli of Driving, Driving + Task. This illustrates that the sympathetic nerve of the drivers was activated while performing addition tasks during driving performance. The change in HR in the stimuli of Driving, Driving + Task according to the difference in oxygen concentration(21%, 40%) is shown in <Figure 4>. That is, HR reduced in oxygen concentration(40%) more then in oxygen concentration(21%). Like <Table 1>, ANOVA analysis was conducted, in which oxygen concentration(21%, 40%) and the stimuli(Control, Driving, Driving + Task) were an independent variable. As there was a significant difference between oxygen concentration($F=16.360$, $df=1$, $p<0.01$) and the stimulus($F=4.452$, $df=2$, $p<0.05$), it was observed that there was a difference in the size of HR among the stimuli according to two types of oxygen concentration. Furthermore, there was no effect of interaction between oxygen concentration and stimuli, and there was no difference in the aspect of change in HR according to two types of oxygen concentration(($F=0.485$, $df=2$, $p>0.05$).

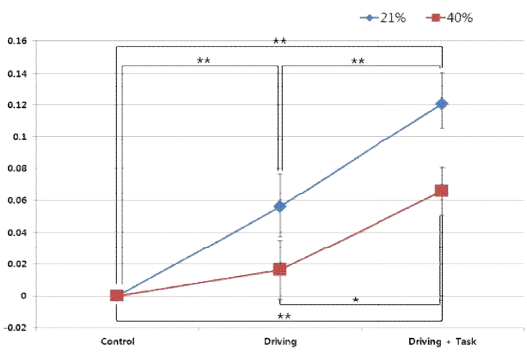

Figure3. Change in HR Between Stimuli (*p<0.05, **p<0.01)

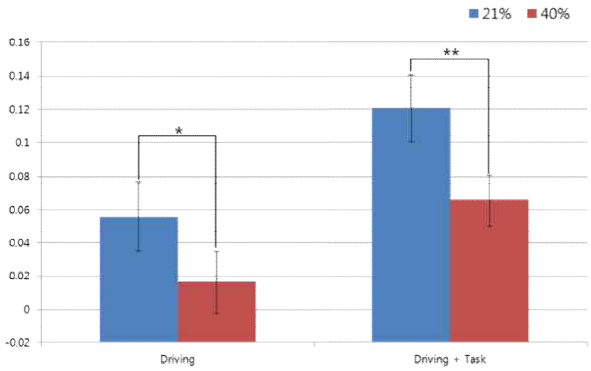

Figure4. Change in HR Between Stimuli according to difference in oxygen concentration (*p<0.05, **p<0.01)

Table1. Comparison of Stimuli(Control, Driving, Driving+Task) According to oxygen concentration(21%, 40%) (*p<0.05, **p<0.01)

Source	Type III Sum of Square	df	Mean Square	F
Oxygen	1775.344	1	1775.344	16.360**
Phase	966.238	2	483.119	4.452*
Oxygen * Phase	105.216	2	52.608	0.485

4. Conclusion

The purpose of this study was to observe how the supply of oxygen concentration(40%) could affect the arousal state while performing the cognitive tasks during driving performance.

In this study, HR while driving and performing the addition tasks during driving performance used as stimuli increased, compared with Control situation, and the performance of the addition tasks while driving increased showing a statistically significant difference, compared with Control. These findings corresponded with those of the precedent studies that the higher respiration volume and oxygen demand increase, and the bigger of the request of cognitive processing gets, the bigger of physiological change gets [1,5,7]. In this study, HR decreased in highly concentrated oxygen(40%) more than in 21% oxygen concentration. That is, it can be seen that the arousal state which happened by Driving and Driving+Task stimuli reduced. The results above corresponded with those of precedent studies[5,7].

From this, the fact was drawn that highly concentrated oxygen(40%) had a positive effect on

performing the addition tasks while driving. Hereafter, it will be necessary to study how highly concentrated oxygen could affect the arousal state of driving by presenting various driving scenarios, and how highly concentrated oxygen could affect the stimulus of a long-term driving performance as well as a short-term effect. And it is considered that it is necessary to have verification on the negative effect as well as the positive one of the supply of highly concentrated oxygen on the cognitive function.

Acknowledgements

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