Chapter 23
Basic Study on the Effect of Scent on Arousal Level Using Multi-Channel Near-Infrared Spectroscopy (MNIRS)

Shun'ichi Doi
Faculty of Engineering, Kagawa University, Japan

Takahiro Wada
Faculty of Engineering, Kagawa University, Japan

Eiji Kobayashi
Faculty of Engineering, Kagawa University, Japan

Masayuki Karaki
Faculty of Engineering, Kagawa University, Japan

Nozomu Mori
Faculty of Engineering, Kagawa University, Japan

ABSTRACT

Long term monotonous driving has been often found to decrease the driver's arousal level and effect his hers property of perception, cognition and judgment. It is preferable to apply arousal assist for the driver instead of huge stimulus such as warning sound and vibration to the driver while driving. On the other hand, the effect of the scent is also reported as an environmental stimulus for driver.

In this study, the seven kinds of scent were used as olfactory stimulation and the influence of scent on the driver's psychosomatic state was examined using a fixed-based driving simulator by measuring biological measurements including electrocardiogram and finger plethysmograph. As for brain activity of olfactory cortex, the multi-channel near-infrared spectroscopy (MNIRS) has been shown to enable the evaluation of changes in hemodynamic. The MNIRS was also used to monitor the activity of the frontal cortex as mirrored by hemodynamic responses subjected to olfactory stimulation.

DOI: 10.4018/978-1-60960-559-9.ch023

As a result, it is verified that not only characteristics of the scent but also the driver's preference and subjective judgment of scent changes affect on the each driving performance. The brain activity change by olfactory stimulation and the brain blood flow change by other stimulation were also investigated. The effects of the functional brain imaging of olfactory activity were measured and the comfortable scent for the individual subject was verified to be effective for maintaining the arousal level.

INTRODUCTION

Monotonous and drowsy driving is a major cause of accidents in situations involving long-term highway driving. To assist the driver and prevent an accident, the use of arousal assistance for the driver is preferable to a huge stimulus such as a warning sound or vibration. There are various reports concerning the effects of arousal upon a driver and its role in maintaining his or her awareness of traffic environments. (Hirata, 2001).

In this study, we examined the effect of scent on the driver's psychosomatic state by using a driving simulator and measuring biological indicators by methods such a electrocardiogram, electrooculogram and finger plethysmograph. With respect to brain activity in the olfactory cortex, the multi-channel near-infrared spectroscopy (MNIRS) system can be used to evaluate changes in hemodynamics(Kobayashi et al. 2007). The MNIRS system was used to monitor the activity of the frontal cortex as mirrored by the hemodynamic responses in response to olfactory stimulation. In addition, changes in brain activity in response to olfactory stimulation and changes in blood flow in the brain in response to other stimuli were investigated.

Table 1. Experimental overview

	Experiment 1: driving simulator	Experiment 2: seated position
Task	Simulated drive (Straight road)	Sitting with eye-mask
Test duration	20 minutes	10 minutes 45 seconds
Measurement items	Subjective judgment • Electrocardiogram	
	Finger plethysmograph • Lateral displacement on DS	Electroencephalogram Blood flow
Subjects	11(Sub.A–K) Average age 23.0 10 males 1 female	5 (Sub.A–E) Average age 22.4 4 males 1 female
Supplying Timing	For a duration of 15 seconds after the vehicle in the DS oversteps the lateral line	Cycle (supplied for 15 seconds and shutoff for 45 seconds)
Scent	Four scents were selected through subjective judgment	

EXPERIMENTAL PROCEDURE

1. Experiment 1 on Driving Simulator

In this study, two kinds of experiments were executed, as described in Table 1. In experiment 1, the subject drove along a straight road for 20 minutes at 60 km/h using a driving simulator (DS) (DS-2000, Mitsubishi Precision co. Ltd) (Figure 1). Under this condition, almost all subjects tended to become somnolent. We attempted to maintain

Figure 1. Driving simulator

wakefulness by supplying scents to the subject. Four kinds of scents were used in the experiments, which were selected individually using a preliminary questionnaire. The generator of the scents was 'Aromax silent' (Air-aroma Inc). To remove lingering scents, the subject used a nasal cannula. When the subject became sleepy, as indicated by the vehicle behavior on the DS and watching the overstep of the sideline, the experimenter supplied a scent for 15 seconds.

2. Experiment 2 on Seating Condition

Blood flow was measured to estimate the effect of the scent on the driver's psychosomatic state. The measuring device was a multi-channel near-infrared spectroscopy (NIRS) system (Hitachi Medical Corporation) with 22-channel electrodes. Both the generation of scent and variety of scents were the same as in Exp. 1. The supply time was 15 seconds, and the shutoff time was 45 seconds (Figure 2).

3. Variety of Scents

In this experiment, a variety of scents were used. These scents were peppermint, lavender, lemon, sandalwood, vanilla, rose, and jasmine. The filtering of the scents was based on earlier studies.

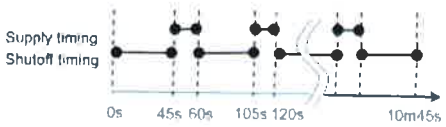
4. Subjects

The subjects included 11 adults (10 males and 1 female) ranging in age from 20 to 25 (average age = 22.6). The study was conducted during the same period of the day to account for circadian rhythms.

5. Measuring Items

In addition to subjective judgment, lateral displacement of the vehicle in the DS, electrocardiogram, finger plethysmograph, electroencephalogram and blood flow were measured.

Figure 2. Supply timing (Experiment 2)



Electrocardiograms were measured using PowerLab (AD Instruments, Inc.) The heartbeat interval (RRI) was determined over a 180-second period as a moving average for every 18-second segment, and the RRI time-series for each subject was compared with those for the other subjects. In addition, LF/HF was calculated using a wavelet transform. A large LF/HF value indicates stress. Finger plethysmograph (CCI, Inc.) was used to measure blood flow changes at the forefinger. The recorded signals were analyzed by chaos analysis, which calculates the Maximum Lyapunov exponent. Considered a measurement for stress, a larger Maximum Lyapunov exponent value indicates increased levels of stress in the subject. Electroencephalograms were measured using FM-515A (FUTEC, Inc.) The α, β and θ waves were measured and compared as a ratio to the total wave amount, which was taken as a moving average for every 18 segment over a 180-second period sliding period.

TASTE FOR SCENT

1. Subjective Judgment

Subjective evaluations were performed by having the subjects sniff seven scents and fill out a seven-stage questionnaire that categorized his or her response to each scent as Comfortable/Uncomfortable and Excitement/Remission. There was variation in the taste of each subject for each scent. The average of the subjective judgment for each of the 11 subjects is shown in Figure 3, with the X-Y plane as Comfortable–Excitement. (Min et al. 2005, Min et al. 2003)