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Short Communication

Application of Specific Brain Function Evaluation by Optical Topography

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Abstract

Objectives: To use the evaluation of a specific brain function obtained by optical topography. This system uses a non invasive method to measure brain function, unlike other major systems.

Methods: Twelve optical fibers were attached to the subject's head. Hemodynamic changes in the motor cortex were measured during finger tapping before and after alcohol intake for each *ALDH2* genotype.

Results: Different hemodynamic changes in the motor cortex were observed among the *ALDH2* genotypes.

Conclusions: Optical topography is a useful tool for evaluating specific brain functions. Further research is needed on the relations between various environmental factors and brain functions by optical topography.

Key words: brain function, optical topography, finger tapping, alcohol, *ALDH2* genotypes

Introduction

An optical topography system, which is based on near-infrared spectroscopy (1–4), is a non invasive technique with high temporal resolution for imaging hemodynamic changes induced by brain function (1). It has become possible to measure brain functions under various conditions (1–6). The small size of the system means that subjects do not require as much restraint as with other measurement systems; e.g., electroencephalography (EEG), functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and magnetoencephalography (MEG). Therefore, optical topography could be more useful for measuring brain function than other major systems. It should be able to clarify specific brain functions under various environmental and lifestyle factors including the effects of alcohol. Recently, several studies examined how different genetic propensities to produce aldehyde dehydrogenase (*ALDH2*) modulate the acute effects of alcohol intake (7–9). *ALDH2* genotypes showed different effects of alcohol intake on EEG response, event-related potential (ERP) response, pulse rate, and facial flushing (10–13). However, alcohol intake influences specific brain functions such as the motor cortex (14) and task performance (15–17). We used an evaluation of brain function by optical topography to examine differences in the specific brain function caused by alcohol intake in *ALDH2* genotypes.

Materials and Methods

Subjects

After giving informed consent, two healthy adults (two females, 29 and 32 years old) participated in this study. Subjects completed a questionnaire concerning lifestyle. They did not drink alcohol on the day before the experiment. The two subjects had no major differences in lifestyle.

Near infrared spectroscopy recording

The Optical Topography system (ETG-100, Hitachi Medical Corporation, Tokyo, Japan) uses near-infrared laser diodes with two different wavelengths: 780±5 nm and 830±5 nm. This system can simultaneously detect changes in the concentrations of oxy-Hb, deoxy-Hb, and total-Hb. At each irradiation position, modulated at differing frequencies, light from the laser diodes arrives via an optical fiber: the total irradiation power in two wavelengths is 3.0±0.3 mW. Avalanche photodiodes detect dual wavelengths of reflected light. Their outputs are sent to lock-in amplifiers, and the derive intensity of the reflected light corresponding to the irradiation position and the wavelength.

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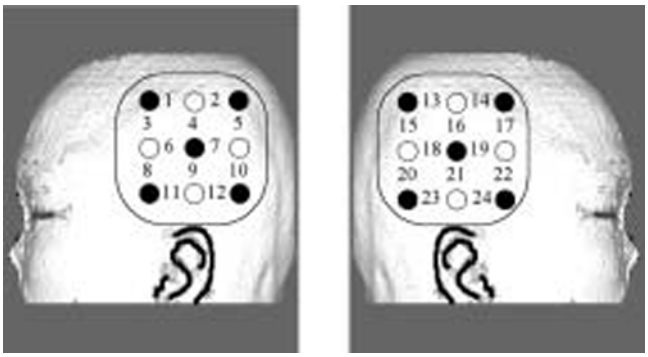

Fig. 1 Optical Topography measurement system.
Nos. #1–24 indicate the measurement position channels in each temporal lobe. Black circles indicate irradiating fibers and white circles indicate detecting fibers.

Thus separated, the signals are digitalized by A/D converters in the computer memory. We measured hemodynamic changes at 12 points in each temporal lobe (Fig. 1). The distance between irradiation and detection positions was 30 mm. The sampling rate was 0.1 s.

Procedure

To measure changes in oxy-Hb, deoxy-Hb, and total-Hb concentrations during the finger tapping task, we attached optical probes to the side of each subject's head. Thirty minutes before alcohol intake, the subjects were instructed about the finger tapping task. Each subject drank the same amount of beer that contained 0.37 ml/kg of pure ethanol. Each subject performed a sequential finger tapping task with the dominant hand by opposing the thumb to each finger in turn in a self-paced repetitive manner as fast as possible 30 min before alcohol intake, and immediately after, 30 min after, and 60 min after alcohol intake. The finger tapping task was done for 20 seconds, followed by for 30 seconds' rest. This cycle was repeated five times. For four of the measurement points, the subject's saliva was collected before the task to determine the salivary cortisol level.

Subjects assessed their response to alcohol according to a questionnaire using the Subjective High Assessment Scale (18, 19) immediately after the task (immediately after alcohol intake), 30 min after alcohol intake, and 60 min after alcohol intake. The experimental protocol is shown in Table 1.

Data analysis

Changes in the oxy-Hb, deoxy-Hb and total-Hb concentrations during the task were averaged five times for each measurement point. The data during the task was corrected by averaging the data for the rest period. The most activated channel during the task was selected among the 24 measurement channels in the two subjects. Channel 8 in the left hemisphere, which relates to the motor cortex activation, was defined as the area activated by the task in both subjects (Fig. 1).

Results and Discussion

In this study, we used the brain function evaluation by optical topography to examine differences in brain function in *ALDH2* genotypes caused by alcohol intake. Hemodynamic changes during the task in channel 8 are shown in Fig. 2. The subject with the *ALDH2*1/*1* genotype showed increases in oxy-Hb concentration and decreases in deoxy-Hb concentration at four measurement points. The subject with the *ALDH2*1/*2* genotype showed similar changes at 60 min after alcohol intake. This suggests that the finger tapping task induced hemodynamic changes in the motor cortex. This result supported previous studies (1, 3, 20). Alcohol intake affects the motor cortex (14) and motor performance (15–17). In this study, oxy-Hb concentration showed decreases in the *ALDH2*1/*2* genotype at 30 min after alcohol intake. This result suggested that alcohol intake affects hemodynamic changes in the motor cortex in the *ALDH2*1/*2* genotype compared with the *ALDH2*1/*1* genotype at 30 min after alcohol intake.

The subjective effects of alcohol from the Subjective High Assessment Scale are summarized in Fig. 3. The subject with the *ALDH2*1/*2* genotype showed higher scores for alcohol effect than the subject with the *ALDH2*1/*1* genotype. The subject with the *ALDH2*1/*1* genotype showed decreases in alcohol effects after alcohol intake. The subject with the *ALDH2*1/*2* genotype retained high scores after alcohol intake.

Table 1 Experimental protocol

Time	Procedure	Measurement
30 min before alcohol intake	Finger tapping	hemodynamic changes
	Rest | Task | Rest	repeat this cycle five times
	0 10 30 50 (sec)	
	Alcohol intake 0.37 ml/kg	
Immediately after alcohol intake	Questionnaire	alcohol effects
	Saliva	salivary cortisol level
	Finger tapping	hemodynamic changes
30 min after alcohol intake	Questionnaire	alcohol effects
	Saliva	salivary cortisol level
	Finger tapping	hemodynamic changes
60 min after alcohol intake	Questionnaire	alcohol effects
	Saliva	salivary cortisol level
	Finger tapping	hemodynamic changes

Time indicates measurement points. Alcohol effects and hemodynamic changes were measured at each measurement point.

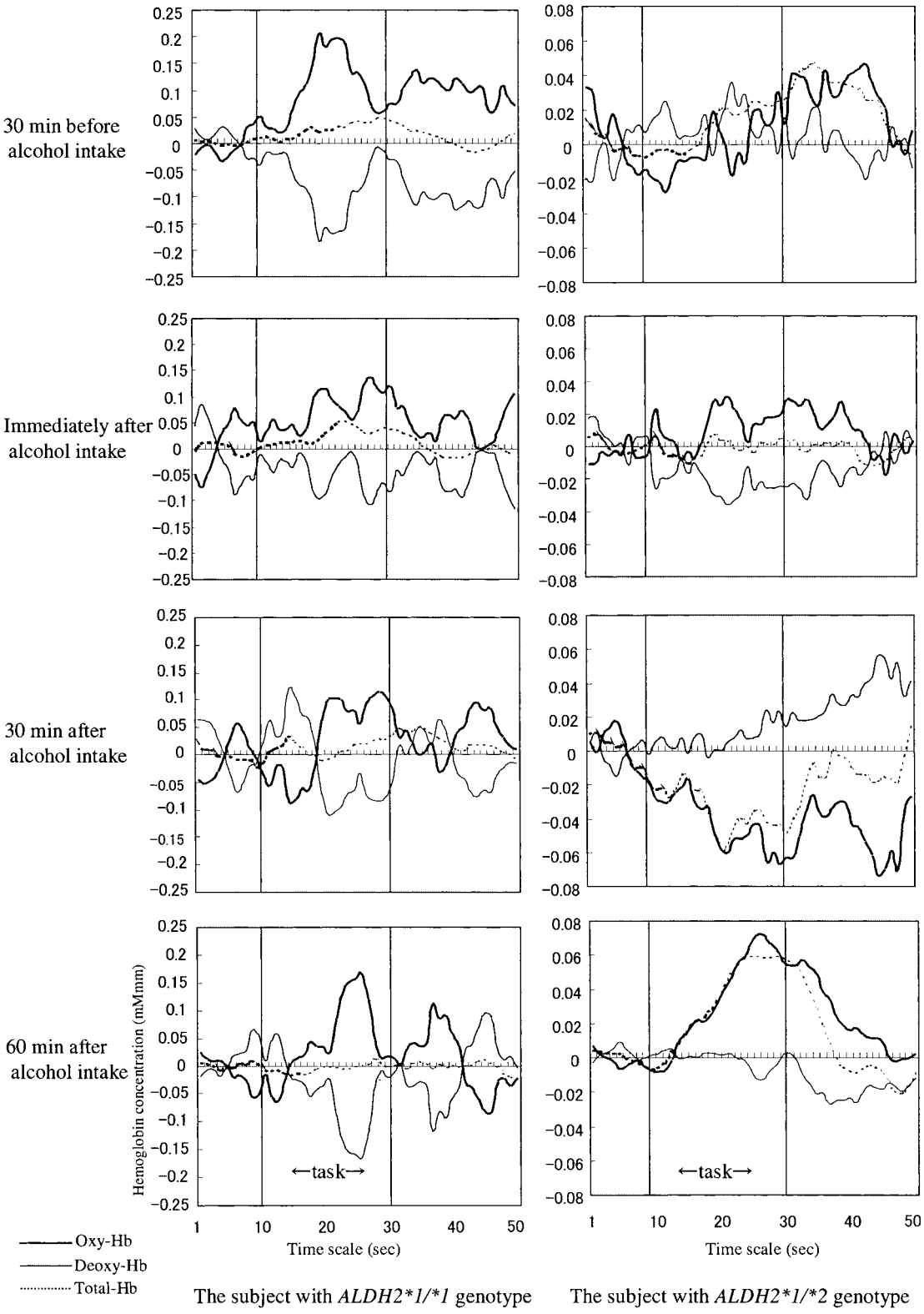

Fig. 2 Oxy-Hb, deoxy-Hb and total-Hb concentrations during the task at four measurement points in both *ALDH2* genotypes.

Wall et al. reported that alcohol effects differed for different *ALDH2* genotypes (10). The present results supported these previous findings (10).

The optical topography system could measure hemodynamic changes in the motor cortex in different *ALDH2* genotypes. It is suggested that optical topography can be used to evaluate changes in a specific brain function from this study. However, more studies are needed on the effectiveness of this system in some experimental conditions, the method of analyzing data such as removing noise from signals of the optical topography system, a standard method of setting optical fibers, coincidence with the inside of a brain region, the number task repetitions,

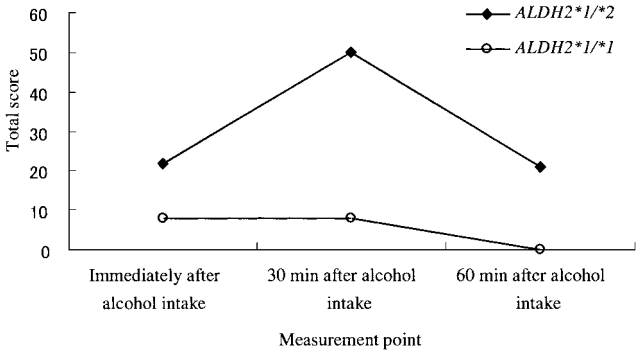

Fig. 3 The score for Subjective High Assessment Scale in both *ALDH2* genotypes.

and the validity of the data.

In future studies, we will obtain more data in order to discuss the effects of alcohol intake on the brain function in different *ALDH2* genotypes. In addition, it will be important to use it together with other markers like salivary cortisol levels and a questionnaire in order to use the optical topography data more effectively. This approach will provide new knowledge about the relations between various environmental factors and brain functions.

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References

(1) Maki A, Yamashita Y, Ito Y, Watanabe E, Mayanagi Y, Koizumi H. Spatial and temporal analysis of human motor activity using noninvasive NIR topography. Med. Phys. 1995; 22: 1997–2005.

(2) Watanabe E, Yamashita Y, Maki A, Ito Y, Koizumi H. Non-invasive functional mapping with multi-channel near infrared spectroscopic topography in humans. Neurosci. Lett. 1996; 205: 41–44.

(3) Watanabe E, Maki A, Kawaguchi F, Takashiro K, Yamashita Y, Koizumi H, Mayanagi Y. Non-invasive assessment of language dominance with near-infrared spectroscopic mapping. Neurosci. Lett. 1998; 256: 49–52.

(4) Sato H, Takeuchi T, Sakai KL. Temporal cortex activation during speech recognition: an optical topography study. Cognition. 1999; 73: B55–66.

(5) Koizumi H, Yamashita Y, Maki A, Yamamoto T, Ito Y, Itagak, H, Kennan R. Higher-order brain function analysis by transcranial dynamic near-infrared spectroscopy imaging. J. Biomed. Opt. 1999; 4: 403–413.

(6) Miyai I, Tanabe HC, Sase I, Eda H, Oda I, Konishi I, Tsunazawa Y, Suzuki T, Yanagida T, Kubota K. Cortical mapping of gait in humans: a near-infrared spectroscopic topography study. Neuroimage. 2001; 14: 1186–1192.

(7) Takeshita T, Morimoto K, Mao XQ, Hashimoto T, Furuyama J. Phenotypic differences in low Km aldehyde dehydrogenase in Japanese workers. Lancet. 1993; 341: 837–838.

(8) Harada S, Agarwal DP, Goedde HW. Isozymes of alcohol dehydrogenase and aldehyde dehydrogenase in Japanese and their role in alcohol sensitivity. Adv. Exp. Med. Biol. 1980; 132: 31–39.

(9) Mizoi Y, Tatsuno Y, Adachi J, Kogame M, Fukunaga T, Fujiwara S, Hishida S, Ijiri I. Alcohol sensitivity related to polymorphism of alcohol-metabolizing enzymes in Japanese. Pharmacol. Biochem. Behav. 1983; 18: 127–133.

(10) Wall TL, Thomasson HR, Schuckit MA, Ehlers CL. Subjective Feelings of Alcohol Intoxication in Asians with Genetic Variantions of ALDH2 Alleles. Alcohol Clin. Exp. Res. 1992; 16: 991–995.

(11) Wall TL, Gallen CC, Ehlers CL. Effects of Alcohol on the EEG in Asian Men with genetic variations of ALDH2. Biol. Psychiatry. 1993; 34: 91–99.

(12) Wall TL, Ehlers CL. Acute effects of alcohol on P300 in Asians with different ALDH2 genotypes. Alcohol Clin. Exp. Res. 1995; 19: 617–622.

(13) Nishimura FT, Fukunaga T, Nishijo H, Ono T, Kajiura And H, Yokomukai Y. Electroencephalogram spectral characteristics after alcohol ingestion in Japanese men with aldehyde dehydrogenase-2 genetic variations: comparison with peripheral changes. Alcohol Clin. Exp. Res. 2001; 25: 1030–1036.

(14) Kahkonen S, Kesaniemi M, Nikouline VV, Karhu J, Ollikainen M, Holi M, Ilmoniemi RJ. Ethanol modulates cortical activity: direct evidence with combined TMS and EEG. Neuroimage. 2001; 14: 322–328.

(15) Clarici A, Fabbro F, Bava A. Effects of moderate doses of ethyl alcohol on cerebral lateralization of language and on hand movements. I: A dual-task paradigm study. Boll. Soc. Ital. Biol. Sper. 1995; 7–8: 213–220.

(16) Valeriote C, Tong JE, Durding B. Ethanol, tabacco and laterality effects on simple and complex motor performance. J. stud. Alcohol. 1979; 40: 823–830.

(17) Lindenschmidt R, Brown D, Cerimele B, Walle T, Forney RB. Combined effects of propranolol and ethanol on human psychomotor performance. Toxicol. Appl. Pharmacol. 1983; 67: 117–121.

(18) Judd LL, Hubbard RB, Huey LY, Attewell PA, Janowsky DS, Takahashi KI. Lithium carbonate and ethanol induced “highs” in normal subjects. Arch. Gen. Psychiatry. 1977; 34: 463–467.

(19) Schuckit MA. Subjective responses to alcohol in sons of aocoholics and control subjects. Arch. Gen. Psychiatry. 1984; 41: 879–884.

(20) Hirth C, Obrig H, Villringer K, Thiel A, Bernarding J, Muhlnickel W, Flor H, Dirnagl U, Villringer A. Non-invasive functional mapping of the human motor cortex using near-infrared spectroscopy. Neuroreport. 1996; 7: 1977–1981.