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인체 체취 평가시 감성평가를 위한 뇌파측정기의 적용

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Use of Electroencephalogram to Supplement Sensory Assessment for the Evaluation of Body Odor

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요 약: 피부변화에 대한 연구뿐 아니라 바디냄새 또한 중요한 이슈가 되었다. 인간은 성별과 나이에 따라 각각의 특정한 냄새를 갖는다. 또한 냄새는 인간의 사회적 관계에 영향을 미치는 것으로 알려져 있다. 본 연구에서는 기존의 전문가를 통한 냄새평가 방법에 새로운 뇌파 측정 평가법을 접목하여 체취를 평가할 수 있는 평가항목으로서의 가능성을 확인 하고자 하였다. 본 시험은 50 세에서 61 세 피험자 15 명을 대상으로 하였다. 체취 포집을 위하여 72 h 동안 면 티셔츠를 착용하게 하고 샤워를 금하도록 하였다. 전문가에 의한 냄새평가와 냄새를 맡는 동안 뇌파 변화를 측정하여 두 평가 사이의 상관관계를 분석하였다. Pearson 상관관계 분석결과 EEG 측정 파라미터중 '흥분'과 음의 상관관계($r = -0.649$, $p = 0.009$)가 나타났고 '스트레스' 항목과는 양의 상관관계($r = 0.704$, $p = 0.003$)가 나타났다. 결론적으로, EEG 측정을 통한 체취의 평가는 전문가에 의한 냄새평가를 보완하는 방법으로 사용이 가능할 것으로 생각된다.

Abstract: The body odor as well as the skin changes has become an important issue. Humans leave respective specific odors dependent on sex and age; The odor has been known to affect social relationship of human. In this study, we wanted to confirm the possibility as parameters to evaluate body odor into existing odor evaluation methods by experts. The 15 subjects, aged from 50 to 61 years wore cotton t-shirts for 72 hours and collected body odor. The cotton t-shirts containing body odor were used for sensory evaluation and EEG measurement by the odor experts. In order to evaluate body odors of each subject, an odor sensory evaluation and electroencephalogram (EEG) were conducted by odor exports and the correlation in between two assessments was analyzed. Pearson correlation analysis shows negative correlation of the sensory evaluation versus 'Excitement' in EEG parameter ($r = -0.649$, $p = 0.009$) and positive correlation of the sensory evaluation versus 'Stress' in EEG parameter ($r = 0.704$, $p = 0.003$). In conclusion, it is considered that the evaluation of body odor through EEG measurement can be used as a method to complement the odor evaluation by experts.

Keywords: *body odor, sensory evaluation, electroencephalogram (EEG)*

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1. Introduction

General human odors are generated during the process of decomposition of human sweats secreted from sweat glands by microorganisms or bacteria[1]. Types of the colorless, odorless, and tasteless sweat gland is distinguished into those of eccrine gland, the gland in charge of thermoregulation and discharge of waste materials, and apocrine gland, developed particularly in specific areas of human body including armpits etc. to discharge fat acid and organic materials. The eccrine glands regulate body temperature; approximately 2 ∼ 3 million eccrine glands can generate 2,000 ∼ 3,000 cc of sweat in an hour. The shape of eccrine gland, the secretory organ, lacks dendrites and resembles a sunken tube situated deep inside in the outmost layer of dermis covering almost all part of body surface. In particular, the eccrine glands distribute intensively in palm of the hand and sole of the foot.

As a method of assessing body odor, the gas chromatography (GC) is a representative method using an instrument for the quantitative evaluation of different body odors. The GC is widely used for the quantitative evaluation of diverse volatile organic compounds[2]. However, it requires a lot of time and expenses to be paid for the collection and analysis of volatile organic compounds.

To assess the intensity of body odor, the sensory evaluation is most frequently used. The well-trained odor expert smells and then evaluates the degree of intensity of object odor. Human nose can distinguish and evaluate various odors from diverse specimens without pretreatment in a rather shorter time[3]; however, since these evaluations are subjective ones of each examiner, they are not based on objective standards.

The electroencephalogram (EEG) shows diverse waveforms in response to external stimuli and psychological states. For example, there was a study on whether the EEG system could be used instead of a child's auditory event-related potentials (ERP) record[4,5]. Other studies used emotional photography to observe changes in subjects' brain activity[6], and also to analyze EEG patterns such as relaxation and imaging by images[7]. EEG measurement is a technique used to measure the psychological state of a person by measuring electrical signals of the brain, and can detect emotional changes according to specific stimuli and situations. In particular, the beta (β) wave is also referred to as a 'stress wave' and is an active wave that is activated in anxiety and tension.

In the present study, the evaluation of EEG was carried out to supplement subjective evaluations of the well-trained odor expert with objective data. The instrument was mainly used in the present study to measure EEGs of odor experts during the sniffing and to develop a supplement evaluation of body odors.

2. Materials and Methods

2.1. Subjects

This study was conducted in accordance with Good Clinical Practice (GCP) regulations and the protocol was approved by DERMAPRO Ltd. IRB (Approved Number is 1-220777-A-N-02-DICN17033). All subjects prepared written informed consent before participation. For the study, subjects were excluded if subjects who have high blood pressure or chronic diseases, have active skin diseases in the examination area, have allergies to cosmetics, used antibiotics within the last week, who are smoker, and participated in similar cosmetic and/or pharmaceutical research within three months.

Fifteen subjects (1 male and 14 female, aged from 50 to 61 years, average 55.47 ± 2.95 yrs.) were participated the study. The subjects had 2 weeks wash-out period before start of the study. Throughout the course of the study, the subjects were not allowed to use detergents, deodorants or antiperspirants in the axillae. The subjects were not allowed to smoke, to use hair spray or other perfumed substances on sweat odor assessment days. Additionally, the subjects were instructed not to drink alcohol, and not to wear clothes washed with perfumed washing agent or fabric softener during the entire test period. Hard physical exercise with heavy sweating, sauna and swimming during the test period were also to be avoided.

2.2. Collection of Body Odor

The Cotton t-shirts were washed with a scentless detergent and dried without using a fabric softener. The 15 subjects wore cotton t-shirts for 72 hours and shower was prohibited during the test period. The collected cotton t-shirts were

sealed and used for odor sensory evaluation and EEG measurement by the odor expert.

2.3. Odor Sensory Evaluation by Expert

The odor expert was considered to have a higher than normal olfactory ability to detect and quantify human body odor. The selection of odor expert was made by diluting standard samples by concentration and finding the concentration in blind condition. This test was repeated three times and only those with a score of 90 or higher were selected. In addition, odor expert regularly trained olfactory evaluation test through standard reagents such as isovalelic acid and 2-nonenal.

Odor sensory evaluation performed a body odor with t-shirts of the subjects using odor scale from 0 to 5. The grade 0 corresponds to 'Absent odor' and grade 5 corresponds to 'Very strong odor' (Table 1).

Table 1. Scale of odor sensory evaluation

Grade	Odor intensity
0	Absent order
1	Barely perceivable order
2	Perceivable order
3	Moderate order
4	Strong order
5	Very strong order

2.4. Electroencephalogram Evaluation

EMOTIV Epoc® + (EMOTIV, USA) was used for EEG evaluation (Figure 1). The EMOTIV software was collected from the 14 channels and analyzes the EEG signals to six parameters by the algorithm and analyzes the physiological emotion signals. The six key parameters are 'Engagement', 'Excitement', 'Interest', 'Relaxation', 'Stress' and 'Focus' (Table 2).

In this study, EEGs of four trained odor experts were measured while sniffing from a total of 15 collected T-shirts. The trained odor expert wore a measuring device on the head and checked the reception of brain waves. The sample was measured after measuring the reference signal by sniffing a clean T-shirt for the first 30 seconds. The measured reference

Table 2. The EEG parameters

Parameters	Description criteria
Engagement	How immersed you are in what you are doing or experiencing
Excitement	Your level of emotional arousal
Interest	How much you like or dislike something
Relaxation	Ability to switch off and reach a calm mental state
Stress	How comfortable you are with the current challenge you are facing
Focus	Ability to concentrate on one task and ignore distractions

Figure 1. EEG measurement Instrument (EMOTIV Epoc® + (EMOTIV, USA)).

signal value was used as the baseline value. Also, considering the odor expert's condition, they had to take a refresh break in the middle of smelling. T-shirts were randomized to exclude bias according to the order. The temperature of the laboratory was 22 ± 2 ℃ and the humidity was 50 ± 5%.

2.5. Statistical Analysis

Statistical analysis was conducted using the SPSS® software program (IBM, USA). In the odor sensory evaluation, the average was used for the analysis if there is statistically significant in Intraclass Correlation Coefficient (ICC) value between researchers over 0.8. Each parameters value is expressed as a percentage (%) of increase or decrease compared to the baseline. Correlation analysis was performed using Pearson correlation analysis. $P < 0.05$ indicated that the difference was statistically significant.

3. Results

3.1. Odor Sensory Evaluation by Expert

The sensory evaluation of body odor was measured by trained odor expert using a T-shirt that was worn for 72 hours after the shower. The odor expert scored from 0 to absent odor to 5 to very strong odor. The odor sensory evaluation was scored an average of 2.93 ± 0.99.

3.2. Electroencephalogram Evaluation

The changes of brain activity of the odor expert measured while sniffing each subjects' T-shirts. The EEG measured by EMOTIV Epoc® + (EMOTIV, USA) was analyzed with six EEG parameter values ('Engagement', 'Excitement', 'Interest', 'Relaxation', 'Stress' and 'Focus') in the professional software and each value are expressed as a percentage (%) of increase or decrease compared to the baseline. The average value of each parameter tended to increase relative to the baseline. 'Engagement' was 0.91 ± 0.09%, 'Excitement' was 1.45 ± 0.49%, 'Interest' was 1.24 ± 0.14%, 'Relaxation' was 1.54 ± 0.28%, 'Stress' was 2.70 ± 0.81% and 'Focus' was 1.55 ± 0.25% (Figure 2).

3.3. Correlation between the Odor Sensory Evaluation and Electroencephalogram Evaluation

The correlation between body odor score and EEG evaluation of the odor expert was analyzed to confirm the

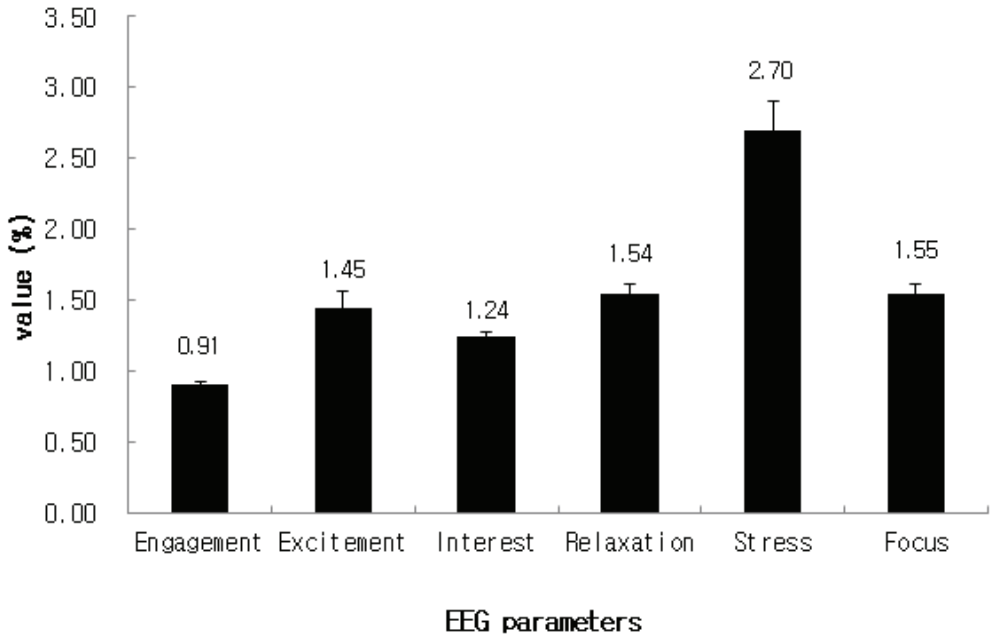
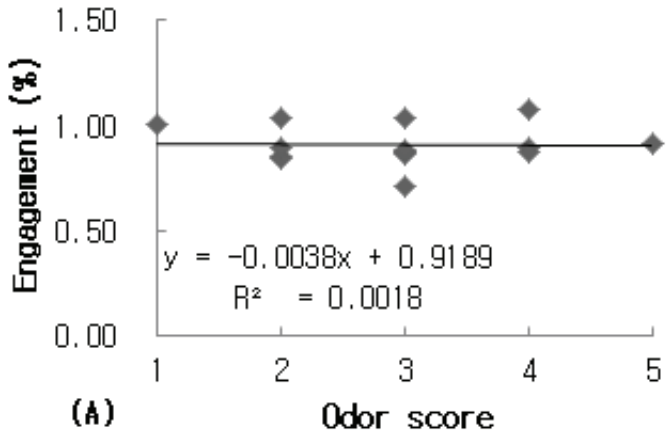
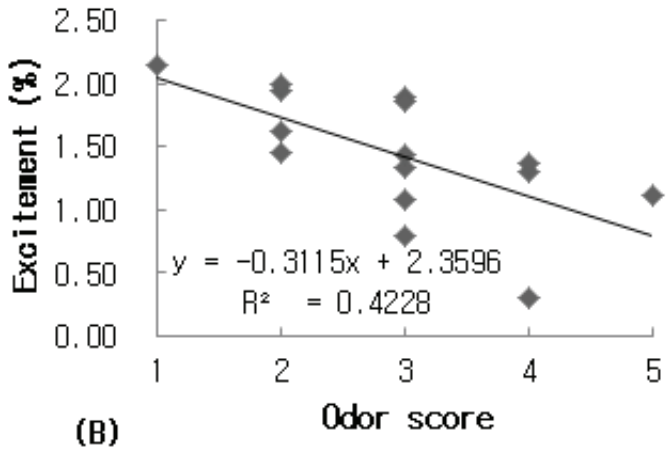


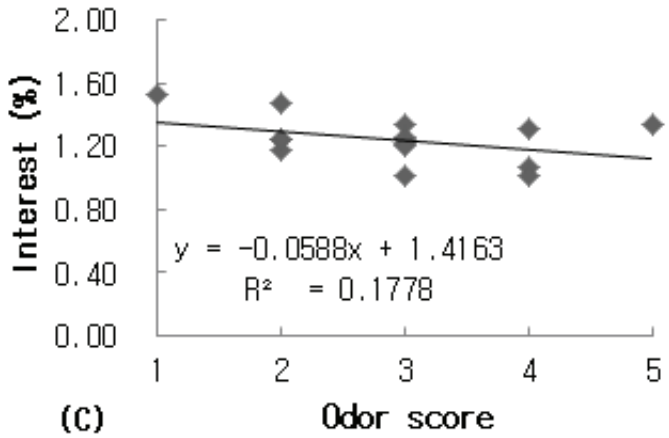
Figure 2. The value of change in EEG parameters due to subjects' body odor. Each value is expressed as a percentage (%) of increase or decrease compared to the baseline.

Table 3. Correlation between the body odor score and the EEG parameters

EEG Parameters		Engagement	Excitement	Interest	Relaxation	Stress	Focus
Body odor score	Pearson correlation	-.055	-.649	-.425	.420	.704	.000
	Sig. (2-tailed)	.845	.009*	.114	.119	.003*	1.000







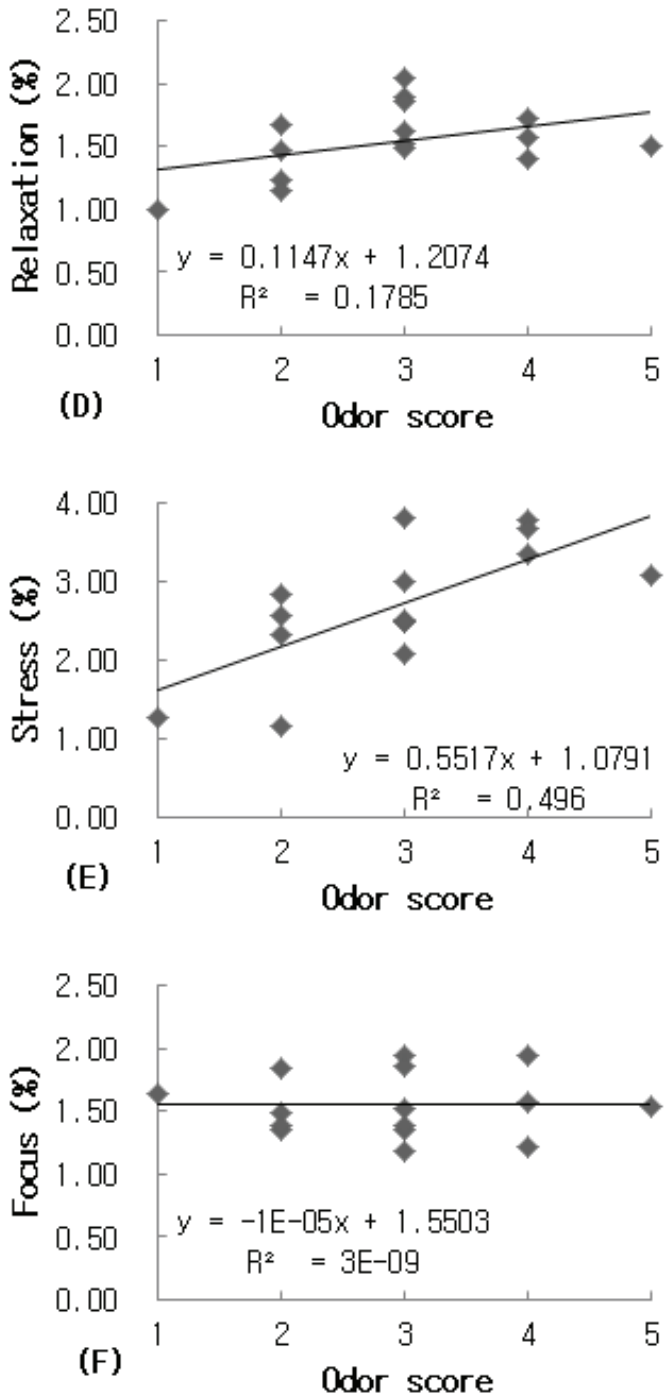


Figure 3. Line represents linear regression between the body odor score and the EEG parameters (A) Engagement (B) Excitement (C) Interest (D) Relaxation (E) Stress (F) Focus.

items suitable for evaluating the human body odor (Table 3). Pearson correlation analysis shows a significant negative correlation of the body odor score versus 'Excitement' in EEG parameter (Pearson correlation = -0.649; p = 0.009, N = 15). Line represents linear regression of data (y = -0.3115x + 2.3596; R^2 = 0.4228)(Figure 3B). Pearson correlation analysis shows a significant positive correlation of body odor score versus 'Stress' in EEG parameter (Pearson correlation = 0.704; p = 0.003, N = 15). Line represents linear regression of data (y = 0.5517x + 1.0791; R^2 = 0.4960)(Figure 3E). While 'Relaxation' showed a tendency to increase but, as correlation analysis results there was no significant difference.

4. Discussion

Like animals, humans can distinguish ages of other people with a smell of body odors of other people[8]. The body odors appear differently like fingerprints of respective people; humans have been used diverse deodorants to cover up different odors unpleasant to other people[9]. Recently, the concerns on diverse body odors beyond those of typical armpits have been increasing[10].

An evaluation of odors conducted by odor expert has been used frequently in previous studies; it is thus a well-known method. However, the subjective evaluations resulted therefrom may affect experimental results easily. The subjective evaluations of odor expert may be supplemented with objective measurements of EEG parameters. In the present study, the measurements of EEG were analyzed with the software embedded in the "EMOTIV EPOC+"to obtain values of the 6 parameters. The parameters; 'Interest', 'Excitement', 'Engagement', 'Focus', 'Stress', and 'Relaxation'; respectively signify the degree of likes and dislikes, degree of emotional stimuli, degree of absorption in stimuli, degree of concentration on stimuli, degree of discomfort of stimuli, and degree of reaching stabilized mental state, respectively. The scores resulted from sensory evaluation on the intensity of odor conducted by odor expert and measurements of the six parameters were examined to analyze the correlation in between. As a result, the correlation between measurements of EEG and results of sensory evaluation was found. Excitement and stress are correlated with body odor, but in the case of relaxation it tends to increase slightly but was not classified as relevant parameter because it is not statistically significant. This is assumed to be an error caused by a small number of subjects.

It is difficult to achieve various objectives in this study mainly because the small number of subjects studied in the elderly class, with narrow age range, and sex distribution was uneven. However, if more research is carried out in the future, it may be possible to classify the type and intensity of body odor according to age and sex, and to study body odor changes due to aging. In conclusion, in this study, we suggest that the evaluation of body odor through EEG measurement is useful as a way to supplement sensory evaluation.

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