Dynamic analysis of dorsal thermal image

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Abstract: A dynamic analysis was subjected to thermal images of dorsal of the foot in this study. A psychophysiological effect of a facial massage by aesthetician was evaluated. First, psychophysiological effects of facial massage were assessed on proprietary stress test. Physiological indices measured were alpha-wave power spectrum, dorsal skin temperature variations and high frequency component of heart rate variability. STAI, POMS (Brief Form) and amount of sensory awareness was administered to evaluate for psychological status. The aspects of the amount of sensory awareness were comfortable, awakening and effect of massage. Secondary, we assessed stress response on thermal image of dorsal of foot. Thermal image of dorsal of foot was measured by infrared thermography device.

Keywords: Thermal image, Peripheral skin temperature, Dynamic analysis, Comfort evaluation, Physiology meas urement, Stress test

I. INTRODUCTION

Comfort evaluation has been performed by sensory evaluation method or physiology index. Sensory evaluation method has been widely used to quantitatively evaluate the tendency of preference and feeling of the user [1-5]. Though the sensory evaluation method is easy-to-use, possible issues regarding examinee's individual variability on interpretation of evaluation words have been indicated; a temper of examinee affects the evaluation [6-8]. And unconscious mental stress isn't able to evaluate. Physiological index is provided by bioinstrumentation, which is measured by person. Physiological index is changed by physiology condition and mind condition. Physiology index is able to evaluate serial quantitative and objective in comfort evaluation. However, corporeity on electrode measurement such as electroencephalogram (EEG) and electrocardiogram (ECG) may give physical and mental stress. Noncontact and unconfined and noninvasive measurement can be measured by infrared thermography device. Measurement with infrared thermography device will be projected to reduce physical and mental stress. Peripheral of body is nasal, hand, foot and such. Peripheral skin temperature (PST) is regulated by the sympathetic nervous system. We have evaluated phychophysiological condition such as mental stress evaluation and comfort evaluation by peripheral skin temperature. Peripheral skin temperature was measured by infrared thermography device. In this study a dynamic analysis was subjected to thermal images of dorsal of the foot. A psychophysiological effect of a facial massage by aesthetician was evaluated. First, psychophysiological effects of facial massage were assessed on proprietary stress test. Physiological indices measured were alpha-wave power spectrum, dorsal skin temperature variations and high frequency component of heart rate variability. STAI, POMS (Brief Form) and amount of sensory awareness was administered to evaluate for psychological status. The aspects of the amount of sensory awareness were comfortable, awakening and effect of massage. Secondary, we assessed stress response on thermal image of dorsal of foot. Thermal image of dorsal of foot was measured by infrared thermography device

II. EXPERIMENTAL

Experimental equipment set-up and electrode arrangement for scalp EEG are shown in figure 1. Experiments were executed in a measurement room. An infrared thermography system (TVS–200EX, AVIONICS) was installed 1 m in front of subject. Thermograms of dorsal of foot were created with 1-s sampling periods. Image resolution of thermograms was 320×240 pixels, and room temperature was set at 26±1.0 degrees Celsius. Infrared emissivity of skin is _=0.98. The subject was in a seated position in a resting state. EEG was recorded at a sampling frequency of 200 Hz using a biological amplifier/sampler (5102 EEG HEAD BOX, NF Electronic Instruments) and digital

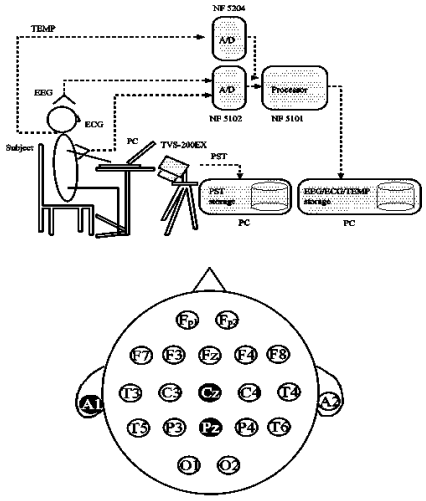

Fig.1. The measurement system and electrode arrangement for EEG.

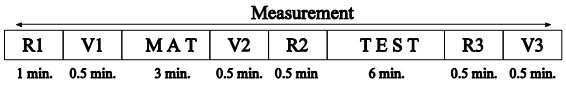

Fig.2. Protocol of the experiment.

signal processor unit (5101 PROCESSOR BOX, NF Electronic Instruments). Electrodes used for scalp EEG was Pz, based on the international 10-20 method, and a reference electrode was A1. Electrodes used for ECG were put on the superior margin of the sternum and the cardiac apex, based on modified Lead NASA, in order to reduce the artifacts of EMG from the ECG. A common electrode for both EEG and the ECG was put on Cz. An auditory stimulus of scratch sound was reproduced by PC as a control stimulus. The protocol of the experiment is shown in figure 2. Subjects were nineteen 18- to 23-year-old healthy women. Subjects were well-informed about the experiments and the objective of this study before participation for experiments. The experiment was performed once par a subject. The measurement was not begun until the subject had been in the room for at least 15 minutes in order to habituate to the room temperature. The measurement consisted of eye-closed resting periods (period R1, R2 and R3), eye-opened evaluation periods for evaluation of sensory awareness (period V1, V2 and V3), eye-opened period under the controlled stimulation of the mental work task (MAT) and eye-opened period under the facial massage operation (period TEST).

The power spectra time series were calculated as follows. The power spectrum time series of the EEG

Table.1. Overall evaluation results of indices in facial massage.

Indices	Interpretation	Significance
α -wave	Brain activity	n.s.
PST	Sympathetic acceleration	n.s.
HF	Parasympathetic acceleration	P**
POMS	Depressive moods	N+
STAI	Trait anxiety	P+
VAS #1	Comfortable	P**
VAS #2	Arousal	N+

lead from Pz was calculated every 5 s by FFT using 1024 data points at a sampling frequency of 200 Hz. The α-waves were defined as the frequency components of the EEG in the frequency range from 8 Hz to 13 Hz. The power of α-wave was created as the sum of the frequency components in the frequency range.

The PST time series was calculated as follows. Thermal images of the right first toe region of the foot were extracted from the thermogram of dorsal of foot time series. PST time series were created as a cascade of spatial average temperature for pixels in the interested area of each thermal image.

HF time series was calculated as follows. A source R-wave interval time series was extracted from ECG time series by using threshold processing. Temporally equidistant R-wave intervals (HRV) were derived by resampling process in frequency of 20 Hz after cubic spline interpolation. The power spectrum time series of HRV was calculated every 1 s by fast Fourier transformation (FFT) using 512 data points at a sampling frequency of 20 Hz. Finally, HF time series was created as a summation of discrete frequency components in power spectrum time series of HRV, in which the frequency range of HF was 0.15 Hz to 0.4 Hz.

POMS-short form, which had been shortened and translated into Japanese, was administered. The POMS-short form comprised of 30 questions about the current mood state. These 30 questions were classified in 6 sub-scales: T-A ('tension and anxiety'), D ('depression and dejection'), A-H ('anger and hostility'), V ('vigor'), F ('fatigue'), and C ('confusion'). The subjects selected the raw score from one of five values (0, 1, 2, 3 and 4, where 0 = no such mood state and 4 = extreme mood state). These raw scores in each sub-scale were then added to generate each sub-scale score.

The STAI is a 20-item scale that measures acute level of anxiety. The subjects selected the raw score from one of four values (1, 2, 3, and 4, where 1 = not at all and 4 = very much). A summary score is obtained by adding the weight of each item. The STAI scores indicate an increase in response to situational stress and a decline under relaxing conditions. In this study, STAI-JYZ, which regards Japanese cultural factors better, was used. The STAI-JYZ exhibits acceptable internal consistency and test-retest reliability. The aspects of the amount of sensory awareness were comfortable, awakening and effect of massage. Each data was expressed as 'means ± standard error (SE)'. Wilcoxon signed-rank test was performed to evaluate them.

III. RESULTS AND DISCUSSION

1. Psychophysiological effects of facial massage

Table.1 shows the result of the statistical test representing the psychophysiological effect of the facial massage. "P" means positive response for the interpretation of each index, and "N" means negative response. Each physiological index was normalized by period R2. R2 was a baseline for the statistical test and was compared with period R3 by the test. α-wave ratio was 0.067±0.054 which indicates that a brain activity had been maintained by having performed a facial massage. PST ratio was 0.631±0.490 which represented that had no significant changes in the massage. It is considered that this is because of rather large standard error between subjects. HF ratio was 1.406±0.094 and increased remarkably after the massage (p<0.01). This shows that the parasympathetic activity was enhanced by the facial massage. POMS score was compared in each scale before and after experiment. Most scores, which indicate negative feeling, tended to decline after the experiment. Especially, T-A ('tension and anxiety') significantly declined from 42.68±1.747 to 39.58±1.294 (p<0.05), A-H ('anger and hostility') dropped 38.05±0.609 to 37.16±0.158 (p<0.1), and also F ('fatigue') was decreased 40.47±1.035 to 37.32±0.769 (p<0.05). Similarly, the score for anxiety in the STAI significantly declined from 43.79±1.829 to 40.32±2.013 following the massage (p<0.1). Amount of sensory awareness was compared before and after TEST. 'Comfortable' gathered from 0.503±0.015 to 0.621±0.029 (p<0.01). 'Awakening' declined from 0.563±0.033 to 0.517±0.045 (p<0.1). The 'Anxiety' in the STAI and negative moods in POMS were

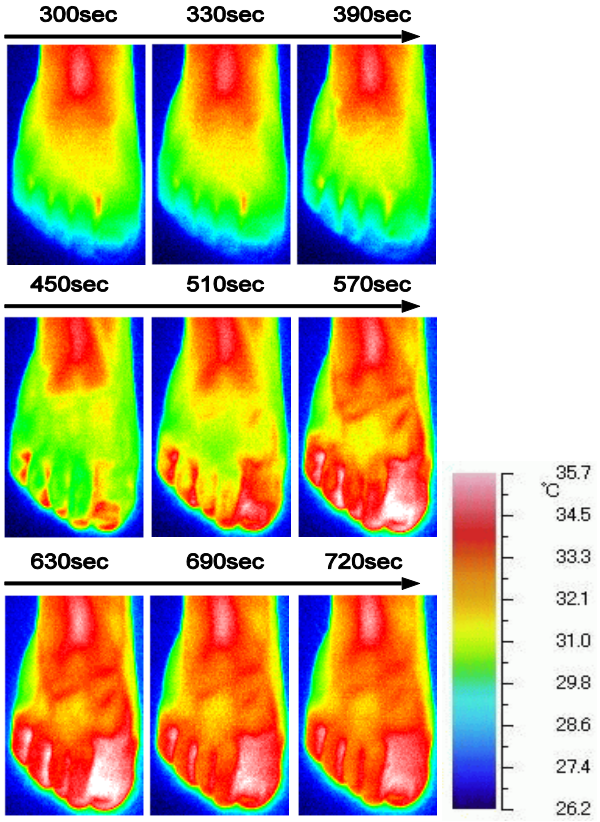

Fig.3. Thermal image of dorsal of right foot

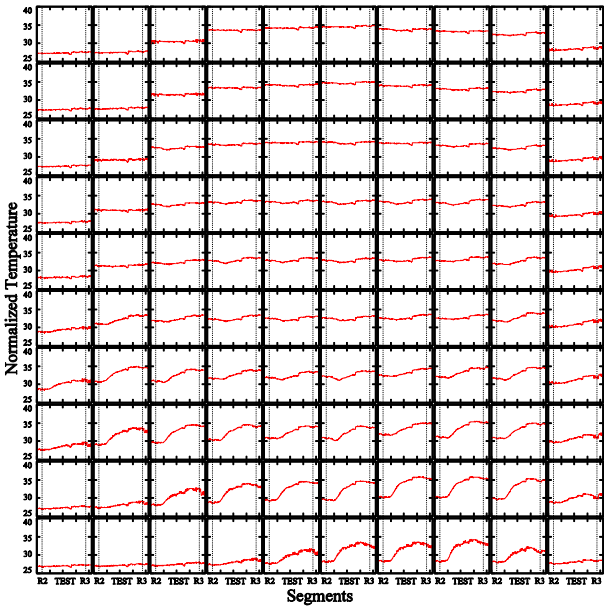

Fig.4. A temperature change in each area.

significantly decreased following the massage. These results suggested that the facial massage had strong effects on stress alleviation or psychological relaxation.

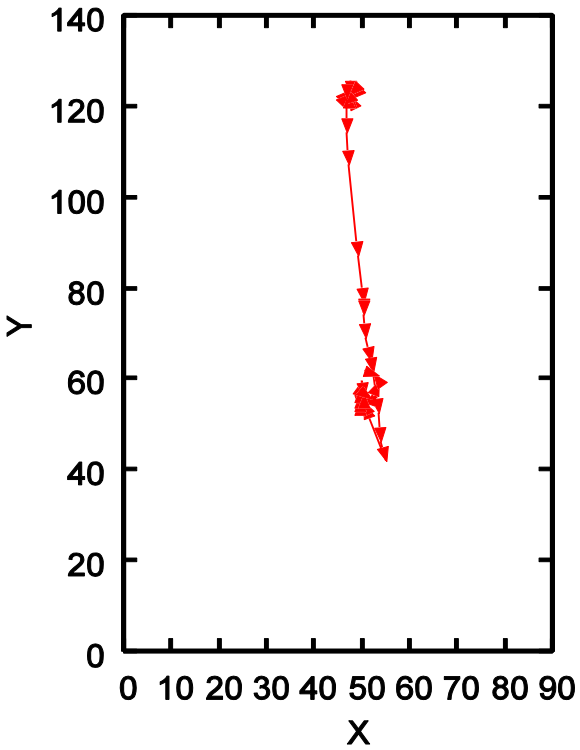

Fig.5. A trail of the center of gravity of the interested area in PST.

2. Dynamic analysis of dorsal thermal image

Thermal image of the measured dorsum of the right foot is shown in Fig.3. Images were recorded at 300 s, 330 s, 390 s, 450 s, 510 s, 570 s, 630 s, 690 s, 690 s and 720 s each. The ankle, which is not peripheral part, had small variations in temperature, while the temperature in tiptoe changed rather large. These variations in temperature were analyzed in detail. Thermal images of the dorsum of the right foot were divided into squared areas of 9 x 14 pixels each. Fig.4 shows time evolution of variations in temperature of each divided area. Large variations in temperature were shown in the areas of tiptoe, while there were a small temperature changes in the areas of ankle. It was indicated that the variations in temperature were different in parts. However, similar changes in temperature were seen generally. And the time in which has greatest value in temperature of each area was different. Fig.5 indicates a trail of the center of gravity of focused area of a certain temperature in range from period R2 to period R3. The range in temperature was defined as follows. Highest temperature was tracked in each area from period R2 to period R3. The maximum and the minimum values were collected from the tracked highest temperatures of each area. Then, the range in temperature was defined as rank in the top 20% from the maximum to the minimum. In the trail, a center of gravity was in the part of the ankle at the beginning. The ankle has little variations in temperature which is shown in figure 3. And the temperature of the ankle tends to be high. The center of gravity of the interested area moved towards a tiptoe in the middle of period TEST.

IV. CONCLUSION

In this study, an activity of the autonomic nervous system was evaluated by dynamic analysis in peripheral skin temperature which shows activity of the autonomic nervous systems. Peripheral skin temperature in the dorsal of the foot was measured by infrared thermography. A facial massage was used to promote comfort. The rise of peripheral skin temperature by the inhibition of the sympathetic nerve activity was found in the area of tiptoe. Variations in temperature were greatest in the area of tiptoe. A similar change in temperature was seen in the area except the ankle.

V. REFERENCES

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