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Color Influences on Human Being Evaluated with Nasal Skin Temperature

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Abstract: Since colors affect human conditions physiologically and mentally, various studies about the color influences have been conducted. Most of the studies have been focused on psychological aspects. In this study, we investigate the color influences physiologically by use of infrared thermography. With this technique, subjects wear no devices, and objective values are expected to be obtained to evaluate the color influences. Nasal skin temperatures were measured by infrared thermography under yellow, red and blue illuminations. As a result, significant temperature change was observed under red illumination.

Keywords: color, nasal skin temperature, visual analog scale, infrared thermography

I. INTRODUCTION

Since colors affect human conditions physiologically and mentally, various studies about the color influences have been conducted [1,2]. For an example, long wavelength lights, such as red or yellow, excite human beings. These colors raise the awakening level or the grip strength. On the contrary, the short wavelength lights, such as blue or green, are the sedation colors. While a number of studies have been supporting these points, a lot of negative data have also been reported. The conclusion has not been clarified yet [3].

In our previous studies, mental work-loads (MWL) have been examined with physiological and psychological measurements under arithmetic calculation tasks.

It was shown that changes of nasal skin temperature are remarkable as a physiological index [4,5]. In generally, nervous systems about brain waves or the heartbeats respond quickly to change the tasks, but this reaction does not continue for long period. Living bodies tend to be adapted to tasks quickly. On the other hand, the nasal skin temperature changes more slowly along with the task. In nasal skin, there are many arteriovenous anastomoses (AVAs) which are sympathetic nervous systems. Nasal skin temperature changes slowly with increase and decrease of the bloodstream with the antagonism of a sympathetic and the parasympathetic nerve. This reaction continues for long period to stimulations which affect an autonomic nervous system. From this viewpoint, nasal skin temperature is more suitable for the evaluation for a long period for mental stimulations about MWL [4,5].

Nasal skin temperature can be measured by infrared thermography, which is featured with non-contact. When physiological and mental influences by color stimulation are measured, the non-contact device has an advantage that the subjects do not wear any sensors. Previous color influence studies have been conducted with brain wave or heartbeat measurements [1]. No studies about nasal skin temperature to evaluate color influences have been reported.

In this study, we investigated the color influences psychologically and physiologically by use of infrared thermography. The purpose of this study is to clarify nasal temperature changes in terms of color illuminations, and the relationship between psychological evaluation and nasal temperature.

II. EXPERIMENT

The relationship of physiological and psychological indices was investigated, when environmental color (red, blue, yellow) was changed.

1. An evaluation index

Visual Analogue Scale (VAS) was used as a psychological index, while nasal skin temperature was used as a physiological index. Figure 1 shows an example of VAS. Subjective senses and feelings can be measured by marking a position on 10cm long scale characterized by a pair of opposite words or phrases at the both ends. This method is featured with little individual differences in the understanding of the description, and shorter time to perform measurements. In this study, seven pairs of words for VASs were employed.

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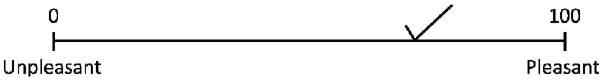

Fig.1. Visual Analogue Scale

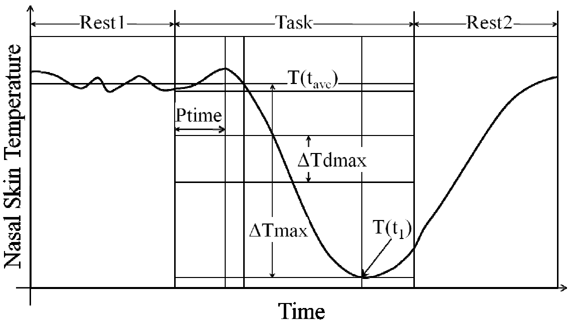

Fig.2. Nasal skin temperature

There were "Unpleasant-Pleasant", "Distracted-Concentrate", "Unhappy-Happy", "Fatigue-Vigor", "Cold-Hot", "Dark-Light" and "Sleepy-Awake". For the evaluation, we used the VAS value differences between before and after color illuminations.

Figure 2 shows a change of nasal skin temperature. As the physiological index, we used temperature differences between forehead and nasal skin. Nasal skin temperatures are well affected by the activities of autonomous nerves. In addition, forehead skin temperatures are little affected by the activities of autonomous nerves. Skin temperatures are affected by ambient conditions. The ambient influences can be reduced by subtracting forehead skin temperature from nasal skin temperature. Therefore, relationship of sympathetic system and the parasympathetic system can be measured indirectly with time changes of temperature differences between forehead and nasal skins. (Afterward, difference of forehead and nasal skin temperature is called NST.)

In previous studies, the time change of NST were employed for various evaluations [4-8]. As an example, a time changes of NST is shown in Figure 2. In this experiment, NST is denoted by T(t), and t is the time after starting color illumination.

Ptime is the time when NST reaches the maximum between starting color illumination and the time when NST is less than NST average in Rest1. Ptime is the time which is from starting color stimulation to appearance of physiological human changes. We defined maximum temperature displacement by ΔTmax ($\Delta Tmax = T(t_{ave})-T(t_1)$). This ΔTmax is a total variation which is influence by the color illumination. In addition, we defined the maximum of the greatest temperature decrease by ΔTdmax. ($\Delta Tdmax = \max(T(t)-T(t+60s))$).

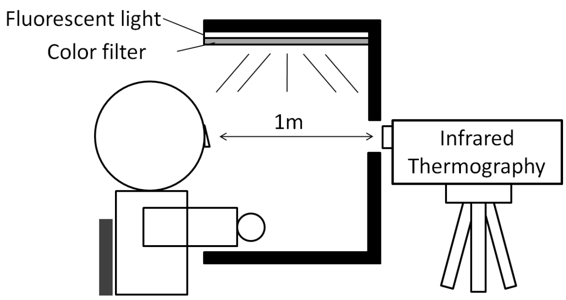

Fig.3. Experimental environment

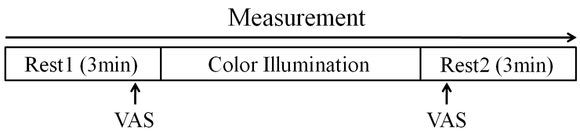

Fig.4. Experimental protocol

This ΔTdmax is the maximum value which is affected by the color illumination for minutes. In this experiment, we used these Ptime, ΔTmax and ΔTdmax as evaluation measures. In addition, NST data were statistically analyses to study individual differences. NSTs were normalized as follows: Dispersion=1 and Average=0.

2. Experiment method

The experimental system is shown in Figure 3. A subject sat in front of a gray booth. In this booth, ambient colors were changed by LEE Filters (Dfilter (yellow (104), red (166) and blue (161))) and fluorescent lamps (Toshiba (FLD6500)) on the ceiling of the booth. Horizontal illuminations of all colors were 500 ± 10% (lx) in the booth. Infrared thermography device (NEC/Avio TVS-200EX) was placed at 1m horizontal distance from nose of the subject. The thermal image size was 320 × 240[pixel], and the temperature resolving power was 0.08 degree centigrade. Skin emissivity was 0.98, and sampling period was 1sec.

Figure 4 shows the experimental protocol. A subject took rest (REST1) for three minutes, sitting and opening the eyes. After this rest, color illumination started and continued for five minutes. After color illumination, another rest (REST2) for three minutes was taken in the booth. The booth inside was illuminated by white light during the rests. VAS was carried out under the color illumination in first and last one minute. This protocol was performed with each color three times. The subjects were normal male adults aged from 21 to 24. This experiment was based on Helsinki Declaration (1964) for ethical consideration.

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Table.1. Results of VAS (VAS Value (SD))

VAS	Yellow	Red	Blue
Unpleasant-Pleasant	0.4(1.1)	-0.1(1.4)	0.1(2.0)
Distracted-Concentrate	-0.1(1.5)	-1.1(1.6)	0.7(1.5)
Unhappy-Happy	0.1(1.3)	-0.4(1.3)	0.7(1.4)
Fatigue- Vigor	0.5(2.0)	-0.7(1.0)	0.1(1.7)
Cold-Hot	0.4(1.9)	0.5(1.8)	0.0(1.1)
Dark-Light	0.5(1.6)	-0.2(2.0)	0.2(2.3)
Sleepy-Awake	-0.1(1.8)	-1.5(2.7)	0.9(1.5)

3. Result and Discussion

Table 1 shows averages and standard deviations of VAS values of all subjects. Most of the VAS values were positive under blue and yellow illuminations, and 6 of the 7 VAS values were negative under red illumination. An analysis of variance and multiple comparisons (Bonferroni method) were performed statistically to test significant difference in each item of VAS values by the colors. In two VAS values of “Distracted-Concentrate” and “Sleepy-Awake”, there was a significant differences were shown in red and blue (p<0.05). From this result, it is understood that colors affect human conditions mentally. In particular, Red affects the VAS values of negative side among the three colors.

Figure 5-7 show average of NSTs of all subjects. The NSTs were maintained or increased for Ptime after starting color illuminations, and decreased after Ptime. Each NST was slightly different in the change by a color. The NST changed after starting each color illumination. The t-tests of statistical analysis were performed between temperatures of the starting and temperatures of the ending at the tasks under all color illuminations. As a result, in the both temperatures, there was a significant difference (p<0.001). From this viewpoint, it was shown that color illuminations affect human conditions physiologically.

Table 2 shows averages and standard deviations of Ptime, ΔTmax and ΔTdmax. Red was the most effective color physiologically, since Ptime was short, ΔTmax and ΔTdmax for red were the biggest of three colors. Although, NSTs of several subjects obviously were affected for color illuminations, the statistical significant differences were not observed between NST and colors. It is thought that there were no significant difference for state of subjects about the physical condition, mental condition and the taste color illuminations.

Table 3 shows the results of correlations between

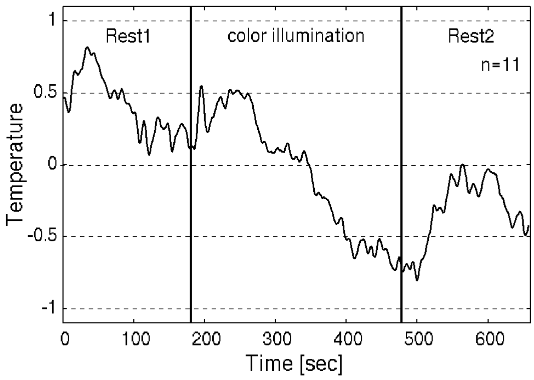

Fig.5. NST in yellow illumination

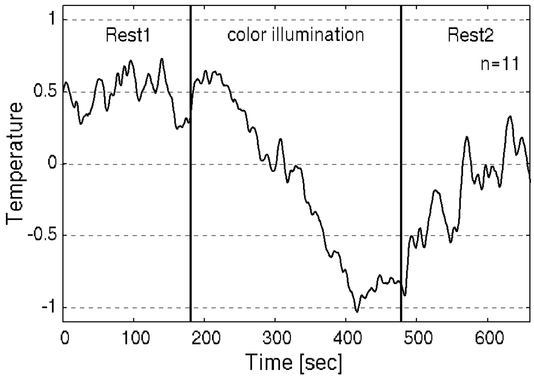

Fig.6. NST in red illumination

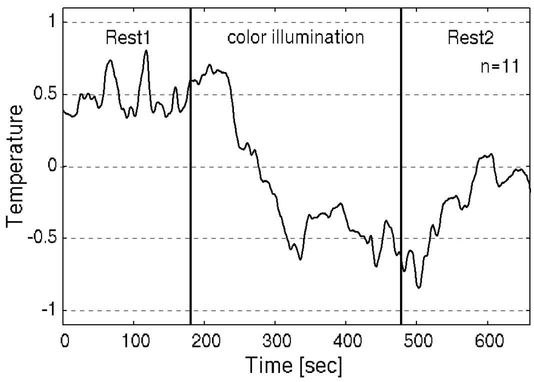

Fig.7. NST in blue illumination

Table.2. Results of Ptime, ΔTmax, ΔTdmax

Colors	Yellow	Red	Blue
Ptime (s) (SD)	104.2(84.0)	76.1(62.8)	82.5(103.4)
ΔTmax (SD)	1.8(1.1)	2.4(0.8)	2.0(1.1)
ΔTdmax (SD)	1.2(0.5)	1.5(0.7)	1.1(0.3)

VAS value and NSTs (Ptime, ΔTmax, ΔTdmax). There were intermediate and strong correlations (four VAS values for yellow, eleven VAS values for red and six VAS values for blue). As a result, red is most influential color physiologically and psychologically. Particularly, high correlation coefficient 0.82 was observed between “Unpleasant-Pleasant” and ΔTmax for red. From this viewpoint, the NST decreases when red illumination is felt unpleasant.

Table.3. VAS vs NST(Ptime, ΔTmax and ΔTdmax)

Colors	Yellow			Red			Blue		
VAS	Ptime	ΔTmax	ΔTdmax	Ptime	ΔTmax	ΔTdmax	Ptime	ΔTmax	ΔTdmax
Unpleasant-Pleasant	0.26	**-0.50**	0.25	0.14	**0.82**	**0.52**	-0.29	**-0.44**	-0.16
Distracted-Concentrate	-0.02	-0.35	-0.33	**-0.66**	-0.02	-0.16	0.15	**-0.41**	-0.23
Unhappy-Happy	0.34	-0.18	0.38	**-0.41**	0.32	-0.06	-0.03	**-0.48**	-0.39
Fatigue- Vigor	0.25	**-0.72**	-0.24	**-0.68**	**-0.54**	**-0.51**	**-0.44**	-0.32	0.01
Cold-Hot	0.27	-0.33	0.25	-0.07	**-0.59**	0.03	**-0.49**	0.00	0.38
Dark-Light	0.34	**-0.76**	-0.17	0.04	-0.11	**0.48**	-0.35	0.01	-0.07
Sleepy-Awake	0.21	**-0.74**	-0.19	**-0.70**	0.00	**-0.50**	**0.41**	-0.14	-0.23

However, there were correlations between "Unpleasant-Pleasant" and ΔTmax in yellow and blue illuminations. On the contrary, positive correlations were shown in red. This result cannot be explained by the conventional hypothesis that NST decreases with unpleasant feeling.

This result can be explained as follows: NST decreases "fast" down with unpleasant feeling. Red is the most influential physiologically and psychologically at three colors and there was a negative intermediate correlation between "Unpleasant-Pleasant" and ΔTdmax of red.

In previous studies, the stimulations by tasks or loads to subjects were calculation problem [4,5], metal scratch noise [7] and driving task[8]. The reaction of NST for these stimulations decreased fast immediately after starting the stimulation. However, NST decreased after Ptime in this experiment. In comparison between the results of previous studies and this experiment, the color illumination might be less influential to human conditions physiologically and mentally than the stimulations previously used.

III. CONCLUTION

In this study, we investigated the color influences physiologically by use of nasal skin temperature measured by infrared thermography under yellow, red and blue illuminations. As a result, it was suggested that the mental and physical conditions are affected by the colors difference. Significant temperature change was observed under red illumination.

It is necessary to examine color influences mental and physiological with more subjects, more the VAS items and more color illuminations.

In order to clarify the relationship between NST and human mental/physiological conditions, further studies are required. It is expected to develop a novel system by infrared thermography to measure human mental/physiological conditions.

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