Measurement of the difference of the cerebral blood flow while viewing image contents by using different displays

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Abstract— **In the development of displays, the development and diffusion have been progressing to realize higher definition and higher realism, and opportunities to view various digital contents through display are increased in everyday life. Even in the same image viewing, depending on the type of display monitor, differences in color, resolution, etc. may occur which difference may affect user's preferences. Therefore, for discussing the diference between them, using NIRS, subjective evaluation experiments using two kinds of displays LCD and OLED were conducted, and obtained the data of cerebral blood flow at that time. Then, we compare the difference for cerebral blood flow while viewing the LCD and OLED.**

Keywords—QoE; NIRS; Oxy-Hb

I. INTRODUCTION

In recent years, in the development of displays, development and diffusion have been advanced to realize higher definition and higher realistic sensation, and opportunities to view digital contents on various types of displays such as 4K television and smart phones have increased. The three features of QoE are "direct perception", "mutual relationship of networks", and "usage situation". "Direct perception" corresponds to color information, motion, and impression. "Network interrelationship" corresponds to responsiveness and comfort. "Usage status" corresponds to product operability, accessibility, reliability [1].

Furthermore, three factors, "Context", "System" and "User", which affect QoE, can be cited. "System" conforms to the quality of contents, media and network. "Context" corresponds to physical, temporal, and task. "User" is related to social status, growth, constitution, and mental structure. Along with examination of taste in viewing image contents, we are focusing on the evaluation of "direct perception" mainly as a constituent element. When viewing digital contents through a display, differences in color, resolution, and the like may occur in digital contents displayed due to differences in displays such as liquid crystal and organic EL. It is thought that a difference also occurs in the sensitivity evaluation which the user feels by the difference.

In the previous research, it evaluate the sensibility evaluation for the displayed space using multiple displays [2]. However, it is unclear how the difference by the display influences the preference of the viewer to observe. In this study, we conducted a subjective evaluation experiment of images displayed using two kinds of displays, and at the same time we conducted a measurement experiment of cerebral blood flow using NIRS, and how the difference in display influences user's preference will be examined.

A. NIRS

NIRS is a method for noninvasively measuring brain activity by measuring changes in cerebral blood flow using near infrared light which changes according to the state of bonding with oxygen. The NIRS measuring apparatus used in this experiment is OEG-SpO2 by Spectratech [3]. As shown in Fig. 1, there are 6 light transmitting probes and 6 light receiving probes, and it is possible to measure all 16 channels. During the experiment, NIRS was attached to the amount of the subject, and the Hb (hemoglobin) concentration change in the frontal lobe was measured at sampling intervals 0.0812 seconds.

B. Oxy-Hb

Along with brain activity, 3 values that can be obtained from NIRS are Oxy-Hb, Deoxy-Hb (deoxygenated hemoglobin), and Total-Hb (total hemoglobin). If it is unconditionally accepted that blood flow appreciate occurs as an indicator of brain activity, it is assumed that the idea that Oxy-Hb's behavior is very complicated when measuring with light is general common [4]. In addition, since Total-Hb is merely the sum of Oxy-Hb and Deoxy-Hb, we measured and analyzed the change of Oxy-Hb(ΔOxy-Hb) in the experiment. Changes in Oxy-Hb within 3 seconds after nerve activity, and the fluctuation of Oxy-Hb after twice the time reflects cerebral circulation reaction. In this experiment, analysis is carried out with these considerations taken into account.

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I. EXPERIMENT METHOD

In this experiment, subjects of 5 boys with normal eyesight were subjected to a biometric information experiment to measure ΔOxy-Hb when viewing image contents using NIRS, subjective evaluation experiments in questionnaire at the same time. In the experiment, 30 images were selected from the Nencki Affective Picture System (NAPS) as images content that viewers are likely to be affected by preferences. In these images, psychological factors are classified by NAPS, and images of "happiness" are defined as "favorite" images in this experiment. Images of "disgust", "sadness", "fear", "anger" are defined as "dislike" images.

A. Flow of expeiment

For the experiment, we use two types of displays: OLED E 6 P 55 type (3840 × 2160 pixels) and Regza Z 700 X 55 type (3840 × 2160 pixels). Subjects are asked to view the same evaluation image separately for OLED type 55 and Regza 55 type, and the data of the cerebral blood flow at the viewing time is measured by NIRS and compared. Subjects were instructed not to perform strong blinks or head movements as much as possible before the experiment, and experiments were conducted in the darkroom in order to focus on viewing the image contents. Subjects prepared multiple patterns to display in consideration of causality in the presentation order, and randomly showed images. A single experimental time is about 20 minutes, presenting 30 images in 15 divided images in 2 times. After presenting 15 images, take the time of the brain's break once, and present the remaining 15 sheets again. The images used in the experiments are shown in Figures 1 to 4 below. In the experiment, after presenting the evaluation image for 15 seconds, present a gray image for resting the brain for 5 seconds. Next, present the questionnaire response screen for subjective evaluation for 5 seconds, finally present the gray image for 15 seconds and present the next evaluation image again. In the subjective evaluation, the subjects are asked to evaluate the likes and dislikes of each image in five stages of 2 to 3 for each image.

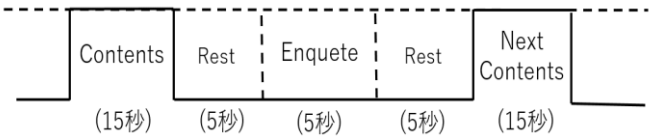

Fig. 1. Display pattern.

Fig. 2. Images (Happiness).

Fig. 3. Images (Disgust).

II. ANALYSIS METHOD

A. Band pass filter

Band pass filter processing was carried out to cut noise due to the device and body motion in the data of the signal value to be output and to obtain smooth data. By cutting high frequency components, we aim to reduce data information and observe the increase and decrease of ΔOxy-Hb. For the purpose of leaving only the component of ΔOxy-Hb, by correcting the value of 0.001 Hz to zero, uniformity of change can be easily observed.

B. Baseline correction

It is considered that baseline correction based on measured values at rest is necessary. The value of ΔOxy-Hb distributed as spectral frequency has a slope called the baseline in the spectrum. Here, baseline correction processing by quadratic curve interpolation is performed, and by correcting the value of ΔOxy-Hb at the start of viewing of the next image to zero, uniformity of change can be easily observed.

C. Z-score

Since the signal values that can be measured from the NIRS brain function measurement device are the relative change amount from the start time, it is difficult to compare between subjects or calculate statistics. Therefore, the signal value is Z-scoreized so that the average is 0 and the standard deviation is 1 for each channel.

D. T-test

When there is a one-to-one correspondence between the two data of OLED and LCD obtained from the experiment results, it is investigated whether one of the two population to which each data belongs is larger than the other.

III. RESULTS

Fig. 4 and Fig. 5 shows ΔOxy-Hb when the brain was stimulated by viewing happiness images and disgust images between OLED and LCD. The horizontal axis was the presentation time, and the vertical axis was the value of ΔOxy-Hb. One of 5 subjects showed a significant difference in the subjective evaluation value of OLED and LCD, but the other four subjects did not show a significant difference in subjective evaluation value by display difference. Subjects with significant differences in subjective evaluation values also showed significant differences in cerebral blood flow data.

One of 4 subjects who did not show a significant difference in the subjective evaluation value showed a significant difference due to the difference in display even in the cerebral blood flow data but the other 3 subjects did not show a significant difference in the cerebral blood flow data (Fig. 6).

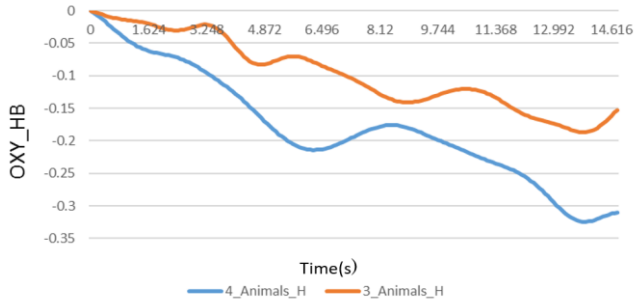

Fig. 4. ΔOxy-Hb when viewing happiness images and disgust images using OLED.

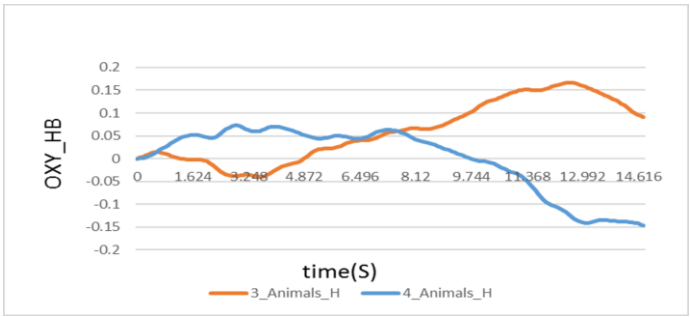

Fig. 5. ΔOxy-Hb when viewing happiness images and disgust images using LCD.

IV. Consideration

In the subjective evaluation, 4 out of 5 subjects did not show a significant difference. Furthermore, 3 out of 5 subjects did not show a significant difference in ΔOxy-Hb fluctuation. Thus, it is thought that the subjective evaluation and the change of the cerebral blood flow were influenced by the difference of the display. Equally, we considered that subjects who found a significant difference in subjective assessment and cerebral blood flow data could not differentiate display differences both psychological evaluation and latent reactions. In the relationship between subjective evaluation and ΔOxy-Hb, a common significance trend was seen among 4 subjects among 5 subjects, but 1 subject did not have a significant tendency common to subjective evaluation and ΔOxy-Hb response. As a cause, the subjects psychologically read the difference of the display and evaluated, but it seems that the latent reaction could not read the difference.

subject	Subjective evaluation value	oxy_Hb
A	acceptable	acceptable
B	not acceptable	not acceptable
C	not acceptable	not acceptable
D	not acceptable	not acceptable
E	not acceptable	acceptable
	Significance level 5% or less	

Fig. 6. Result of significance.

V. Conclusion

In this study, subjective evaluation experiment and measurement of cerebral blood flow were carried out using two kinds of display LCD and OLED, and it was verified whether the difference of the display influences user's preference. As a result of this experiment, among the 5 subjects, 4 subjects recognized the difference in the display from the subjective evaluation score, and 3 subjects recognized from ΔOxy-Hb. However, we confirmed that subjects who could not distinguish the display difference from subjective evaluation and ΔOxy-Hb data. Also, even if a subject recognized the difference in display psychologically, it seems that they were unable to distinguish the differences by latent reaction.

Acknowledgment

This work was supported by Grants-in-Aid for Scientific Research (No.17K00154) funded by Japan Ministry of Education, Culture, Sports, Science and Technology.

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