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The evaluation of the emotion by NIRS

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Abstract: We experimented for the purpose of development of the objective evaluation technology of emotions. Persons requiring care will also increase in number with the increase in this population. In the case of the person requiring care who lost the function to convey an intention especially, the objective judgment to a physical and mental pain is required. Specifically, we gave subjects stimulus of a comfortable or an uncomfortable sound and measured concentration of the oxygenated hemoglobin of a frontal lobe part by Near-Infared Spectroscopy. Based on the experimental result, a comfortable state or an uncomfortable state was distinguished concentration of the oxygenated hemoglobin using the bayesian network. As a result, we were able to estimate the subject's psychological condition.

Keywords: objective evaluation, Near-Infared Spectroscopy, bayesian network, emotion.

1 INTRODUCTION

In Japan, low birthrate and longevity are progressing quickly. According to National Institute of Population and Social Security Research, the rate of population aged 65 and over will reach to 35.7% in 2050. Persons requiring care will also increase in number with the increase in this population. In the case of the person requiring care who lost the function to convey an intention especially, the objective judgment to a physical and mental pain is required. In the past, the objective evaluation of the intention by brain waves (the sensitivity-spectrum analyzing method and the sensitivity fractal dimension analyzing method) has been proposed. Moreover, the machine which operates an electronic device using brain waves is developed. The interface which applies cerebral activity to control or support is called Brain Machine Interface. BMI is expected as a machine which supports transfer of a human intention [1][2].

By the way, functional Magnetic Resonance Imaging (fMRI) and Near-Infared Spectroscopy (NIRS) are the methods of measuring cerebral activity. When oxygenated hemoglobin changes to deoxygenated hemoglobin, the method of measuring brain activity indirectly using the increase in a magnetic resonance signal is fMRI [3][4]. Generally restriction by the environment and the conditions of measurement is strong. Moreover, the influence of the motion with the body is strong. On the other hand, NIRS is equipment which measures the amount of change of oxyHb and deoxyHb in blood using near-infrared light. In process of cerebral information processing, the system of the communication of information which nerve activity bears and the system of the energy supply supporting nerve activity are related [5]. If nerve activity takes place, the blood vessel in the circumference will be extended. The mechanism of the adjustment for supplying the arterial blood containing oxygen and glucose occurs [6]. The quantity of a blood flow increases in the tissue of a nearby nerve. The oxidation state (ratio of oxyHb and deoxyHb) of blood changes. Based on assumption that the relation between nerve activity and a blood flow exists, NIRS measures the oxygenated hemoglobin within a brain. In short, this index is not the nerve activity which is actually processing information. However, it is an index of an indirect brain function. Moreover, the measurement by NIRS uses the two characteristics [7]. The 1st is the high permeability of the organism in near-infrared light (700-900 nm). The 2nd is the permeability of the light from which oxyHb and deoxyHb in blood differ. When the head is irradiated with near-infrared light, the ingredient of the light is diffused in cerebral tissue by high permeability. And the cerebral cortex which is in a depth of about 20-30 mm flatly is reached. When light is measured in about 3-cm distance from a glaring point, the optic element which has returned by diffused reflection can be detected [8]. NIRS calculates change of oxyHb and deoxyHb of the cerebral cortex using this detection light. NIRS is inferior to fMRI in the point of visualization of structure and the range of measurement. However, the restriction to a motion of the body is small. Moreover, it can experiment in the more natural state. Therefore, NIRS has high practicality as a means for transmitting an intention.

We experimented for the purpose of development of the objective evaluation technology of emotions. There are

some researches on the emotions using NIRS. For example, there is research on change of a cerebral blood flow when a vision stimulus and a sense-of-smell stimulus are given. But, there are still few examples. Moreover, there is almost no example studied about objective evaluation of a comfortable sound or an uncomfortable sound. A sound stimulus is one of the important stimuli which evoke the emotions of those dependent on care. A sound stimulus is one of the important stimuli which evoke the emotions of a person requiring care [9]. Therefore, we set up the sound stimulus as a candidate for evaluation. Specifically, we gave subjects stimulus of a comfortable or an uncomfortable sound and measured concentration change (⊿oxyHb) of the oxygenated hemoglobin of a frontal lobe part by NIRS. Be based on the measured data, we evaluated quantitatively the difference in brain activity. By developing the technology of objective evaluation, it may be applicable to evaluation of the brain activity under various environments. It is shown that the result of an experiment has relation nature between the psychological amount by a comfortable or an uncomfortable sound and ⊿oxyHb in a part of frontal lobe. Based on the experimental result, a comfortable state or an uncomfortable state was distinguished ⊿oxyHb using the bayesian network (BN). As a result, we were able to distinguish the subject's psychological condition.

2 EXPERIMENT METHOD

2.1 Experimental environment

It experimented within electromagnetism shield room. Room temperature was 22.0±1.0 [℃]. Illumination was about 200 [lx]. The interior of a room was calm. Fig.1 showed the counting system. The shimadzu FOIRE-3000 was installed next to the subject and we measured ⊿oxyHb. Fig.2 shows the position of the measured channel and measurement. The position of measurement serves as the middle point of the position of irradiation, and the position of detection. First of all, the channel 9 of the holder for measurement was united with Fpz. In the next step, the subject was equipped with the holder using the fixed belt. The interval of the probe for irradiation and the probe for detection was set to about 30 [mm].The number of the measured channels was 32. Sampling time was 175 [ms].

2.2 Experimental conditions

The number of subjects was 5 (21-25 age, healthy subjects). We experimented after the subject rose and 4 hours or more had passed. The subject's previous day sleeping hours were about 8 hours. 2 hours before beginning an experiment, ingestion of a meal, smoking and a caffeine was forbidden. Excessive movement on the day was forbidden. This experiment was conducted by ethical consideration based on Declaration of Helsinki (1964). The subject's human rights were considered in the experiment. We fully explained and got consent by signature. Fig. 3 shows a measurement schedule. The subject which hears sound was performed in Task. The subject was made to hear white noise within a rest time. The comfortable sound used the album (music gentle to autonomic nerves). The uncomfortable sound used scratch sound. It is clear that these tasks give a subject comfortable or uncomfortable emotions in a preliminary experiment. Time to hear these tasks was set to 60 [sec]. Moreover, Visual Analogue Scale questionnaire was written 20 seconds after the start of rest time.

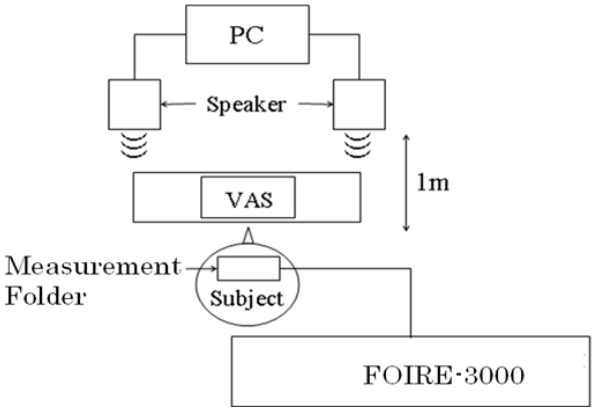

Fig.1. Measurement System

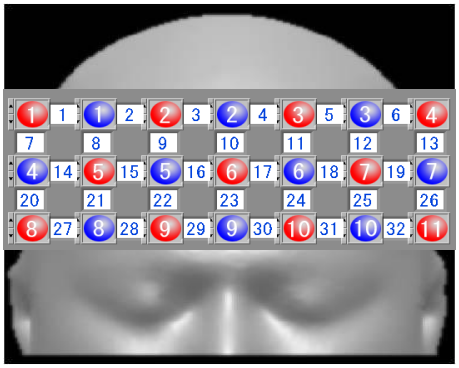

Fig.2. Measurement position

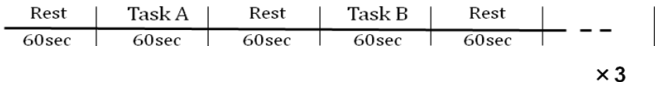

Fig.3. Measurement Schedule

3 EVALUATION METHOD

3.1 Psychological index

The Visual Analogue Scale questionnaire was used for the psychological index [10]. Fig.3 shows an example about how to write a Visual Analog Scale questionnaire. Visual Analog Scale is a tool used to help a person rate the intensity of certain sensations and feelings. The rate (0% - 100%) of the length from a left end to a check position was measured to the length of a line segment. This experiment estimated uncomfortable (0%) - comfortable (100%).

3.2 Physiological index

⊿oxyHb in a frontal lobe part was measured. Baseline compensation was performed in order to extract only a changed part to a stimulus (Fig.4). Task for 3 times was added and averaged. The following is the method of compensation. ⊿oxyHb of the channel measured at the TASK time T and the REST time R is made into the following.

$$h(t),(-R<t<T+R) \qquad (1)$$

Compensation data is hC(t). The data at the time of a Task start is h(0).

$$h_C(t)=h(t)-h(0) \qquad (2)$$

Moreover, the average amount of change of oxygenated hemoglobin concentration is defined as ⊿oxyHbave. It is considered as a physiological index.

$$\Delta oxyHb-abe=\frac{1}{T}\sum_{t=0}^{T}h_C(t) \qquad (3)$$

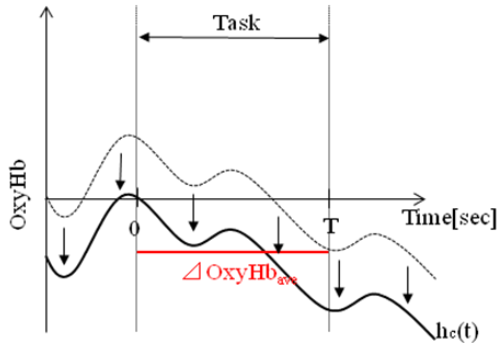

Fig.4. Baseline compensation

4 EVALUATION METHOD

When a comfortable stimulus was given, ⊿oxyHb decreased in a part of measured part (Fig.5). On the other hand, when an uncomfortable stimulus was given, ⊿oxyHb decreased slightly (Fig.6). However, the parts which reacted to each stimulus differed. Comfortable and uncomfortable emotions are related to a limbic system. It is closely related to especially an amygdaloid body. Control and rise of frontal lobe activity are affected. In short, reduction of ⊿oxyHb is considered that rise of activity of a limbic system has influenced. Under the influence through which blood flowed into the nearby part, it is thought that reduction of ⊿oxyHb occurred in a part of frontal lobe part. Based on the result of Fig.5 and Fig.6, the difference in ⊿oxyHb in two stimuli was evaluated. T test was performed for every Channel using ⊿oxyHbave. As a result, there was a significant difference in Channel 2 and Channel 28 (Fig.7). Fig.8 is a time change of ⊿oxyHb in Channel 2. ⊿oxyHb at the time of giving a comfortable stimulus showed the tendency higher than ⊿oxyHb at the time of giving an uncomfortable stimulus. The relation between ⊿oxyHbave of channel and VAS was considered. Fig.9 is a relation of ⊿oxyHbave and VAS in Channel 2. In the case of Channel 2, the correlation coefficient of VAS and ⊿oxyHbave was 0.55. In the case of Channel 28, it was 0.66. Both of channels were positive correlation. It inquired in the similar way also to other subjects. Channels which were a significant difference and positive correlation were examined. It was a result as shown in Table 1. These results show a possibility that NIRS can estimate emotions objective.

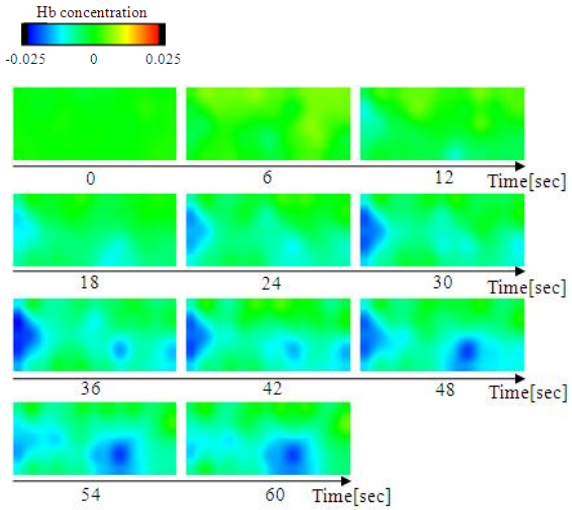

Fig.5. Topographical observation
(When a subject hears a comfortable sound)

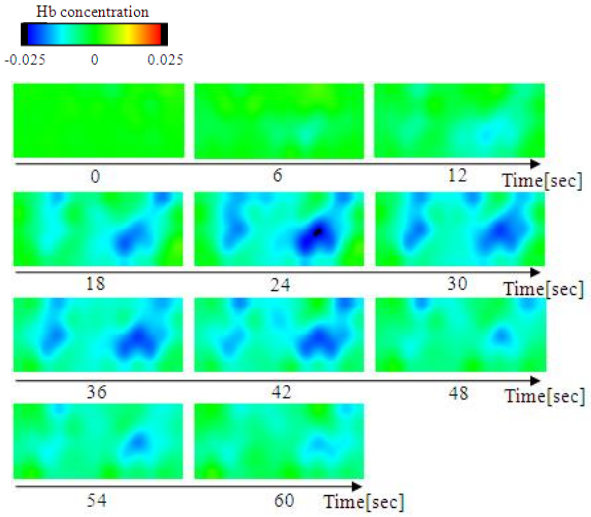

Fig.6. Topographical observation
(When a subject hears an uncomfortable sound)

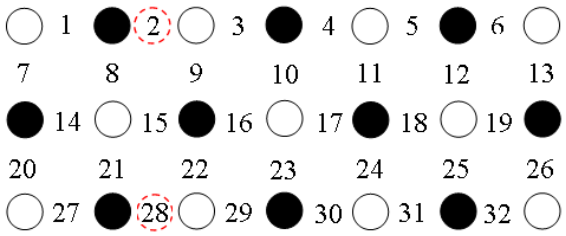

Fig.7. Channels with a significant difference

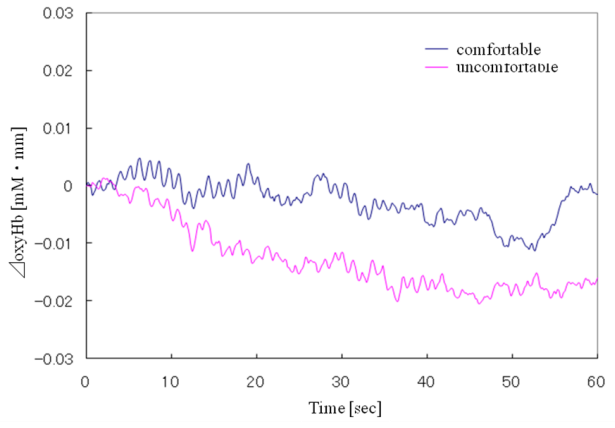

Fig.8. Time series graph of ⊿oxyHb (channel 2)

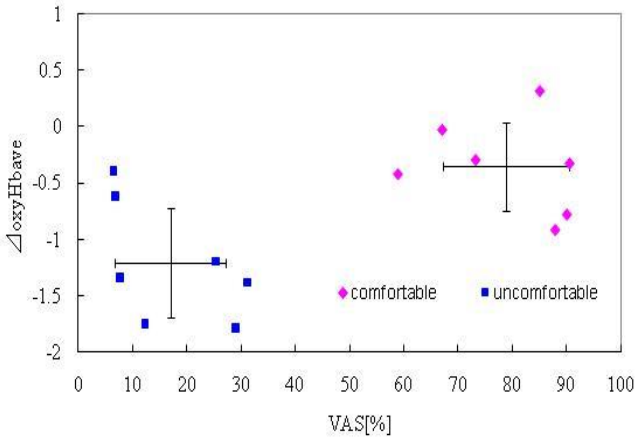

Fig.9. Relation between ⊿oxyHb-ave and VAS (channel 2)

Table.1. Channels with a significant difference
(All subjects)

	Channel				
Subject A	2	28			
Subject B	3				
Subject C	2	6	9		
Subject D	2	4	9	15	18

5 ESTIMATION MODEL

Based on the experimental result, we built the estimation model of emotions using BN. A figure is the estimation model of emotions. Visual Analog Scale performed t official approval by each channel. The data used for the construction was data of the channel which had a significant difference in ⊿oxyHb. A physiological quantity used the average value (⊿oxyHb-ave) of ⊿oxyHb of task. A psychological quantity classified the value of Visual Analog Scale into three states. Three states were "uncomfortable (0-33%)", "normal (34-66%)", and "comfortable (67-100%)." The frequency of each state was computed from reference data. Graph structure and the conditional probability in each state were calculated. BN was built using the data. The following is a formula of graph structure. The following is a formula of graph structure. The amount-of-information standard AIC was used for the judgment of the dependency between nodes. The number of times of trial was performed 10 times per person. The amount of seven trials was the reference data

for model construction. The amount of three trials was the data for evaluation for presumption.

6 RESULT AND CONSIDERATION

Bayesian estimation was performed from the built model to the data for evaluation. The presumed result was compared with actually measured VAS and the presumed rate was calculated from the number of coincidence. Fig.10 is presumed accuracy. The presumed rate became 67% on the average as a result of the experiment. This result shows a possibility that emotions can be presumed by BN.

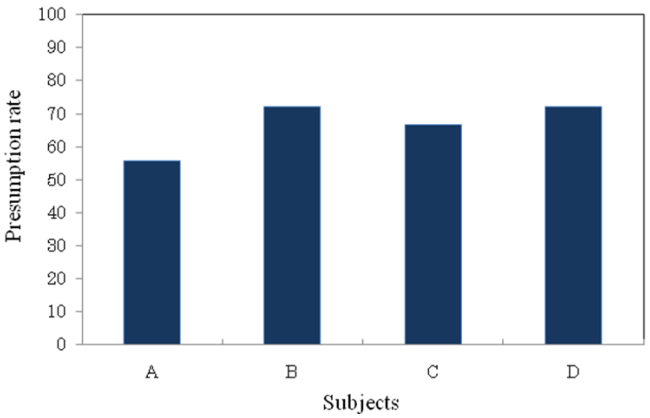

Fig.10. Estimation rate

7 CONCLUSION

We proposed the technique of objective evaluation of the emotions by NIRS. If this research develops, we may be able to develop the system by which a care worker can understand the emotions of a person requiring care easily. Specifically, we gave subjects stimulus of a comfortable or an uncomfortable sound and ⊿oxyHb of a frontal lobe part by NIRS. Be based on the measured data, we evaluated objectively the difference in brain activity. It is shown that the result of an experiment has relation nature between the psychological amount by a comfortable or an uncomfortable sound and ⊿oxyHb in a part of frontal lobe. Based on the experimental result, a comfortable state or an uncomfortable state was distinguished ⊿oxyHb using BN. The presumed rate became 67% on the average as a result of the experiment. This result shows a possibility that emotions can be presumed by BN. As a result, we were able to estimate the subject's psychological condition by BN.

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