Effect on the Lighting Condition for Human's Emotion and Task Efficiency Using Electroencephalogram

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Summary: The aim of this research is to clarify the effect on the lighting condition for human's mental factors and task efficiency using electroencephalogram (EEG). It is necessary to raise performances in a limited time due to reduction in working hours. Improvement of indoor environment has attracted attention to do it. In this research, we clarified the relationship between task efficiency and emotion caused by lighting condition using prefrontal cortex EEG. In the experiment, EEG measurements, and task were performed under three conditions with different intensity of illumination and presence or absence of glare. As a result, it was shown that the presence or absence of glare was most closely related to task efficiency, and that the calm score after work increased when there was no glare. These results suggested that by suppressing glare, it is possible to realize a high task efficiency condition in the long term, which can achieve the balance of task efficiency and increase of calm at the same time.

Introduction: It is necessary to raise performances in a limited time due to reduction in working hours. Improvement of indoor environment has attracted attention as a means to do it. Previous researches on the effect of indoor environment are research that defined an environment in which improved task efficiency by comparing task results [1, 2]. These researches defined an environment where task result was best under multiple environments as an environment where task efficiency improved. However, in the defined environment, there is no consideration for reduction in task efficiency due to mental factors such as accumulation of stress and fatigue. Thus, it cannot be asserted that it is an environment with high task efficiency in the long term. Therefore, we evaluated the effect of the indoor environment on humans and aim to discover indoor environments with good task efficiency over the long term. In this research, we focused on lighting condition as indoor environment. To evaluate the effect of the lighting condition on humans, we used prefrontal cortex electroencephalogram (EEG), which are closely related to the arousal effect and emotion induction [3].

Material and Methods: In this experiment, EEG measurements and task were performed under each lighting condition for evaluating the effect of lighting condition on humans quantitatively. There are three lighting conditions with different intensity of illumination and presence or absence of glare shown in Table.1 Intensity of illumination is amount of light received per unit time per unit area. Glare is diligence that causes eye fatigue, discomfort and gaze attention. The experiments were performed for each lighting condition for 6 minutes. The EEG measurements were performed for 30 seconds in the resting closed eye state before and after the task and for 5 minutes during the task (Fig. 1). The procedure was the same in three conditions. EEG measurements were performed using Mind wave mobile. The sampling frequency was 512 Hz. We used the Kraepelin test for the task in this research. The Kraepelin test is a task of performing a simple one-digit addition and entering the last digit of the calculation result. This is done every other minute while changing the row.

Table 1 Experimental condition.

Lighting condition	Intensity of illumination [lx]	glare
A	200	Presence
B	300	Absence
C	400	Absence

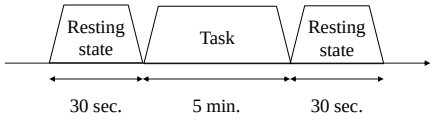

Fig. 1 The procedure of the proposed method (This procedure is a procedure of one lighting condition. EEG measurement was performed for each condition in this procedure)

This section describes the analytical procedure used for comparing the task efficiency and the KANSEI score of each lighting condition. KANSEI score are five types of scores: "likes, interests, concentration, calm, stress" calculated at 0 to 100% every second [4]. 300 samples were obtained during task and 30 samples were obtained before and after task as KANSEI score. KANSEI score was calculated by a unique algorithm of "KANSEI ANALYZER". It performs frequency conversion on the acquired EEG and calculates KANSEI score from the combination of amplitude spectra of each frequency. In this research, three KANSEI scores, "concentration, calm, stress" were used for analysis because they might be related to the mental factor during task. For each subject, three KANSEI scores for 30 sec. before and after task were averaged. A significant difference test was performed

on these averaged scores to verify whether there was significant difference before and after task. The comparison was made for the KANSEI scores before and after the task of each condition. Sample entropy was calculated from three KANSEI score during task for each subject. Sample entropy is a measure of randomness and irregularity of time series data [5]. If sample entropy is large, the data is cluttered, and if sample entropy is small, it means that the data is regular and not cluttered. In this research, sample entropy was used to evaluate the fluctuation of the KANSEI score during task. We compared sample entropy between lighting conditions. We made a comparison on a one-for-one basis, round-robin. We used the number of responses from the Kraepelin test as a task results. Task results were normalized because absolute value of task results included influence of individual potential. By normalization, the task results of each lighting condition were expressed as a ratio to the average (=1). We compared normalized task results between lighting conditions. We made a comparison on a one-for-one basis, round-robin. In this research, two-sample t-test, one of the significant difference tests, was used for comparison.

Results and Discussion: Fig. 2 shows averaged calm scores before and after task under each lighting condition. It was confirmed that the calm score increased significantly after task in the illumination B and C (p<0.05). Illumination B and C were the light with suppressed glare. Moreover, no significant differences were found in other KANSEI scores under all lighting conditions.

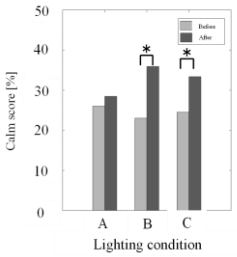

Fig. 2 Calm score before and after task (Significant differences were detected at illumination B and C (p<0.05))

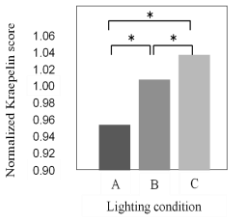

Fig. 3 Normalized Kraepelin score (Significant differences were detected in all combinations (p<0.05))

This section describes sample entropy for each KANSEI score. Sample entropy of the stress score in the illumination B showed a significantly larger score than the illumination A. Evaluation of glare was done in previous research, and discomfort due to glare was declared by questionnaire survey. The calmness is an indicator of calming of the mind. It is considered that when there is no glare, the tendency that the calm score increased is the same trend as the previous research [6]. Illumination B is lighting that gathers light spreading to the right and left direction downward to suppress glare. For this reason, the illuminance on the desk directly under the illumination B was higher than that of the illumination A. Therefore, the eyes tried to adjust to the brightness, which is considered to have affected the stress score during the task.

Fig. 3 shows task results. As a result of performing a significant difference test on the task results of the normalized Kraepelin test, it was confirmed that the task result in the illumination C was significantly the highest. Illumination C is the light with the highest illuminance and suppressed glare. As a reason for improving task efficiency, an arousal effect due to illumination with high illuminance is considered. There are many previous researches showing the awakening effect by illumination with high illuminance [1, 7], and it is said that the same tendency as the content reported in previous researches was confirmed also in this research.

As a result, it was shown that the presence or absence of glare was most closely related to task efficiency, and that the calm score after task increased when there was no glare.

References:

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