

## **A RELATIONSHIP BETWEEN THE PROCESS OF LIGHT CHANGING AND THE HUMAN EMOTION VARIATION.**

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### **ABSTRACT**

There are many researches to make plan of suitable lighting condition for comfortable life scene. It is necessary to change light plan for every life scene to apply it to actual life. If light changes in color, light and shade, etc, occurs without the consideration of human emotion, sufficient effects of next scene with planned light design, will not be able to be obtained. In this paper, a relationship between the process of light changing and the human emotion variation is investigated and described. On the experiments 6 types of light stimuli such as Light and shade, Color taste, Focus, Angle, Height and Darkness are provided. The subjects operate the light stimuli by themselves and then reply their state of mind with Multiple Mood Scale (MMS). All subjects are Japanese and aged 20 to 29 years old. Subjects are totally 20, 13 males and 7 females. The data are analyzed with the multiple comparisons of Tukey's HSD test, principal component analysis and cluster analysis, as the results of the analysis, we conclude : 1) Color change can bring friendly and pleasurable emotion easily. 2) Focus, Height and Angles are relatively difficult to characterize from the emotional evaluation. 3) However, [Angle and Darkness] and [Light and Shade and Focus] can be the factors affect to change the emotion of Peace of Mind.

**Keywords:** *Human Emotion, Process, lighting*

## **1. BACKGROUND**

There are many researches to make plan of suitable lighting condition for comfortable life scene. (1-5)

Oishi and other said "When light reached at brain, physiologically control and it is perceived on comparison of experience, memory and learning. This perception effects to emotion and behavior"(6) Considering mental process is important in research of lighting. Therefore, for example, the planed space provides more comfortable condition if the light plan having suitable mental process is used. Under recent living environment, a room is used as multi use. It is important the plan of lighting must be changed depending on the purpose of room use. The process of light changing without considering the light plan gives a feeling of wrongness. Under the condition of a feeling wrongness, process of light changing to have suitable light plan dose not always give comfortable condition. To design lighting equipments, it is most important to consider the problem of light changing process. We investigate the utility for design lighting equipments by analyzing the process of light change to solve this problem.

## **2. SUBJECT OF RESEARCH**

After experience of light change process, it is considered that many variations are occurred when we treat life scene. By accepting the lighting plan that give preparation condition of mental and human emotion, the more suitable lighting space to is expected. An example of the previous description is stage lighting. In the field, there is no definition to evaluate lighting effects. Stage lighting is designed by the experience and feeling of designer. On the life scene, there is small number of study to confirm the same effect as stage lighting. So, We research human emotion when lighting conditions such as location, and the light and shade etc are changed.

## **3. EXPERIMENT**

### **3.1. Outline**

The experiment is designed as follows:

- a: In the environment of non defined life scene.
- b: Making experiment the process of light change.
- c: Evaluating the condition of human emotion change on the Multiple Mood Scale.
- d: Analyzing the relationship between variation of light changing and human emotion change.

### **3.2. Method**

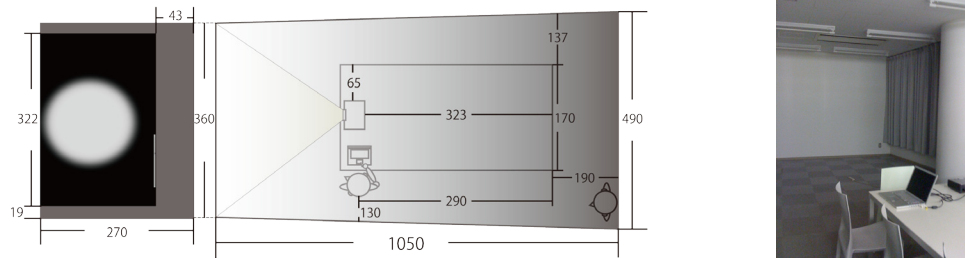
#### **3.2.1. Environment**

a: We prepare a large room to avoid influence of room to subject and having large white wall to show subject clear stimulation light.

b: Too reduce physical load, Subject sit on the chair comfortably to keep easy operation of light.

- c: PC display is located beside the subject and operate trackpad with single hand.
- d: The PC operation has designed to avoid by subject's dominance of hand, because of no changing of sitting position.

The environment of experiment considering above mentioned condition is shown in Fig. 1.



**Figure 1:** The environment of laboratory inside

- a: The table is set on the right side of the room center.
- b: The PC and projector are set left side on the table.
- c: A subject sits in front of the PC.
- d: A subject can look the process of light changing on the left side wall.

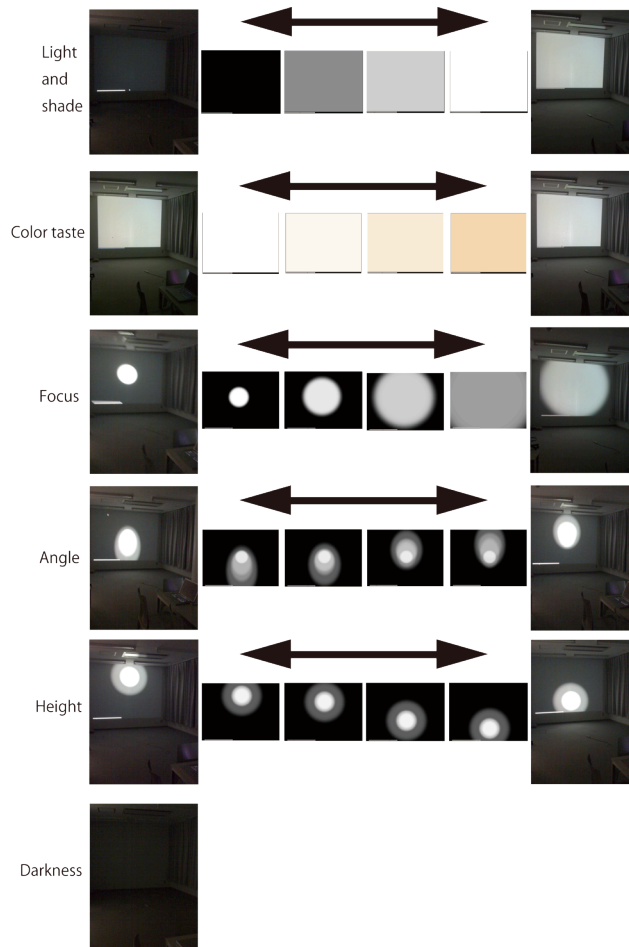
### 3.2.2. Stimuli of task

To realize natural light condition with artificial way, stage lighting method is accepted.

The factors of light stimulation is that:

- a. Light and shade
- b. Color taste
- c. Focus
- d. Angle
- e. Height
- f. Darkness

Fig. 2 Shows the patterns of six conditions.



**Figure 2:** Six lighting stimulation task.

The stimulation patterns are made by PC and the light is projected on the wall. During light is projected, PC display always turned off.

### 3.2.3. Process

All experiments are done after sunset. Every subject spends about 30 minute for this experiment.

The process of experiment is as follows:

1. Subject takes a seat after entrance.
2. The subject receives the explanation of experiment about survey and treatment of the instrument.
3. After subject understand the expression completely, the room light is turned off then experiments start.
4. The subject can manipulate the instrument freely with out limitation of time. The subject notify researcher when every experiment is finished. Then the room light turned on.
5. Subject answers on questionnaire about their emotion.

3,4,5 are repeated six times. Every subject has different order of tasks from others, to avoid order effect of tasks to the result of experiment.

### 3.2.4. Subjects

All subjects are have Japanese and aged 20 to 29 years old. Subjects are totally 20 13 males and 7 females.

## 4. EVALUATION AND ANALYZATION

### 4.1. Method of measurement

We tries to evaluate the relationship between the result of six tasks and emotional evaluation of stimulation. Traditionally, Ekman's evaluation method is widely used to evaluate human emotion. In his evaluation, anger, fear, disgust, joy, sadness and surprise are used as scale of human emotion. However the scale is not suitable for designing light plans because only the joy is represents as good human emotion. So that, Multiple Mood Scale: MMS (Masaharu Terasaki, Youichi Kishimoto, and Manato koga 1992) (7) which, has rich evaluation for good human emotion, is accepted. The MMS scale consists of Emotion Categories (EC) such as · Depressive and Anxiety · Hostility · Boredom · Active pleasure · Non active pleasure · Affinity · Concentration · Astonishment. Each category has 10 items (totally 80 items). The word item used in this case means question to the subject. On the experiments subjects answer by grades (1: subject has no feeling, 2: little feeling, 3: not so clear feeling, 4: clear feeling) for every item. The order of items is different for each subject.

Each grade number has taken as a evaluation value for further analysis. We made sum of subject's scores on each scales to the result score of scales.

### 4.2. Results

It is said that there is not large difference of subjects on mean value and distribution taken by the sum of subject's scores on each emotion categories. The mean value and 95% confidence interval are calculated by eight ECs for every lighting stimulation. Human emotion result of evaluation on EC x lighting stimulation are classified by the level of average and 95 confidential intervals as follows.

- 1: strong feeling: average and lower 95% confidential level > 25
- 2: middle feeling: average > 25 but lower 95% confidential level < 25
- 3: weak feeling: average < 25 but higher 95% confidential level > 25
- 4: no significant feeling: average and higher confidential level < 25

The result of classification is shown table 1.

**Table 1:** The result of experiment.

|        | EC                     | Light stimulation | Mean value | Upper 95% confidence | Lower 95% confidence |
|--------|------------------------|-------------------|------------|----------------------|----------------------|
| Strong | Non active pleasure    | Color taste       | 28.85      | 32.2                 | 25.49                |
|        | EC                     | Light stimulation | Mean value | Upper 95% confidence | Lower 95% confidence |
| Middle | Depressive and Anxiety | Darkness          | 25.3       | 28.18                | 22.41                |
|        | Affinity               | Color taste       | 25.4       | 28.07                | 23.32                |
|        | Active pleasure        | Color taste       | 25         | 28.07                | 23.32                |
|        | EC                     | Light stimulation | Mean value | Upper 95% confidence | Lower 95% confidence |
| Weak   | Depressive and Anxiety | Angle             | 22.8       | 26.25                | 19.34                |
|        |                        | Angle             | 21.8       | 25.12                | 18.47                |
|        | Non active pleasure    | Height            | 21.85      | 25.26                | 18.4                 |
|        |                        | Darkness          | 21.45      | 25.19                | 17.7                 |

### 4.3. Analysis

#### 4.3.1. Feeling difference by lighting stimulation.

Multiple comparisons of Tukey's HSD test is applied for ECs on each lighting stimulations. The result on table 2 indicates the HSD Threshold Matrix that showing if a difference exceeds the least significant difference (HSD) for all comparisons of ECs.

**Table 2:** Averages and groups with significant difference analyzed by Tukey's HSD test.

Same Roman character means these items are not regarded as significant difference.

| Emotional Categories   | Light and Shade |       | Color taste |       | Focus |       | Angle |       | Height |       | Darkness |       |
|------------------------|-----------------|-------|-------------|-------|-------|-------|-------|-------|--------|-------|----------|-------|
|                        |                 | Ave.  |             | Ave.  |       | Ave.  |       | Ave.  |        | Ave.  |          | Ave.  |
| Concentration          | A               | 20.6  | A           | 28.85 | A     | 21.7  | A     | 22.8  | A      | 21.85 | A        | 25.3  |
| Non active pleasure    | A               | 19.45 | A           | 25.7  | A B   | 20.95 | A     | 21.8  | A B    | 20.1  | A B      | 21.55 |
| Depressive and Anxiety | A               | 19.15 | A           | 25    | A B   | 19.95 | A B   | 21.65 | A B    | 19.75 | A B      | 21.45 |
| Active pleasure        | A               | 19.1  | B           | 19.25 | A B   | 19.85 | A B   | 21.05 | A B    | 18.95 | A B C    | 20.25 |
| Astonishment           | A               | 18.6  | B           | 19.25 | A B   | 19    | A B C | 17.85 | A B    | 18.95 | A B C    | 19.8  |
| Boredom                | A               | 18.35 | B C         | 16.35 | A B   | 18.55 | A B C | 17.35 | A B    | 18.1  | B C D    | 16.3  |
| Affinity               | A               | 15.7  | B C         | 15.25 | A B   | 16.6  | B C   | 16    | A B    | 16.85 | C D      | 14.75 |
| Hostility              | A               | 15.5  | C           | 11.9  | B     | 15.4  | C     | 14.55 | B      | 14.15 | D        | 13.75 |

From the result of multiple comparison, we found following characteristics among ECs.

1) In case of color taste, Non-Active Pleasure, Affinity and Active Pleasure have higher in average and significantly different to other ECs. These ECs are even higher in the average value of sum of MMS evaluation. Also, Hostility is not clearly difficult to be felt by this stimulus.

2) In case of Focus, there are little difference of the feeling level among ECs. Only the Concentration and Affinity have significant difference affected by this stimuli.

3) In case of Angle, Active Pleasure and Hostility are significantly inactive to this stimuli. All the rest are not significant in difference.

4) In case of Height, there are little difference of the feeling level among ECs. Only the Hostility and Non-Active Pleaser have significant difference affected by this stimuli.

5) In case of Darkness, Affinity, Hostility and Active Pleasure are clearly inactive by this stimuli. Depressive and Anxiety, Concentration, Non-active Pleasure, Boredom and Astonishment can not be differentiate each other but significantly active to this stimuli.

To summarize above, Color taste can be said to affect subjects in Non-Active Pleasure, Affinity and Active Pleasure but can not in Hostility. Focus and Height will not give different feeling among ECs clearly. Angle and Darkness will affect to specific ECs, such as Active Pleasure, Hostility and Affinity, Hostility, Active Pleasure respectively but inactive direction of feeling.

This means the color taste can arose human emotion clearly than other stimuli.

#### 4.4. Tendency of light variation

From the result of multiple comparison, there we found some difference between the characteristics of light stimuli. To make sure the characteristics of light stimuli, we applied principal component analysis (PCA) with the sum of MMS evaluation value as factors and lighting stimuli as samples.

The results of PCA are shown in table 3.

**Table 3:** The results of principal component analysis.

| Component                           | 1        | 2        |
|-------------------------------------|----------|----------|
| Eigenvalue                          | 5.4259   | 1.7906   |
| Variance proportion                 | 67.824   | 2.383    |
| Accumulation of variance proportion | 67.824   | 90.207   |
| Depressive and Anxiety              | 0.33199  | 0.4438   |
| Hostility                           | 0.38039  | -0.32173 |
| Boredom                             | 0.07321  | 0.70295  |
| Active pleasure                     | -0.38353 | -0.30925 |
| Non active pleasure                 | -0.38504 | 0.21258  |
| Affinity                            | -0.40849 | 0.13936  |
| Concentration                       | 0.35493  | 0.06379  |
| Astonishment                        | 0.38928  | -0.26265 |

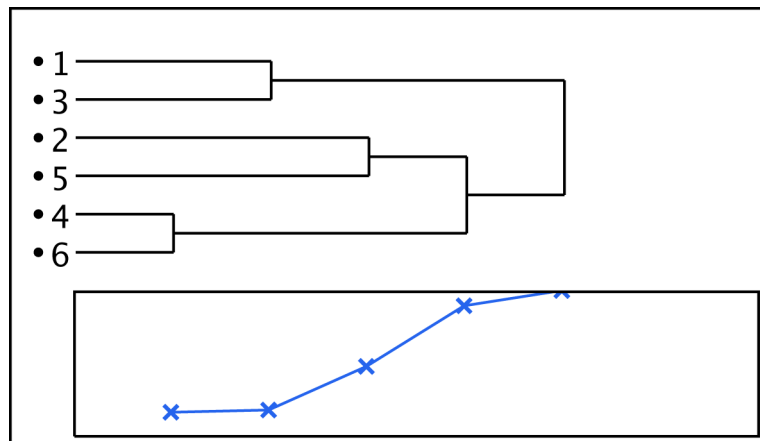
Up to the second principal component, the eigenvalue was greater than 1. So we accepted up to the second Principal component for consideration. Then the accumulation of variance proportion exceeded one. On the factors, In the first principal component, there are greater factor loading with Depressive and Anxiety, Hostility, Astonishment and Concentration and negative factor loading with Active Pleasure, Non-active Pleasure and Affinity. This means the Active and Non-active Pleasure and Affinity are similar ECs opposed to the ECs of Depressive and Anxiety, Hostility, Astonishment and Concentration. This is understandable that pleasurable emotion are opposite to those un-pleasurable emotion. So, the first principal component can be regarded as Friendliness axis toward the lighting stimuli with friendly in minus direction. In the second principal component, Boredom showed bigger factor loading than other ECs, followed by Depressing and Anxiety. Although the proportion of variation is 22%, Boredom is a unique characteristic among these ECs. Considering the balance of eigenvectors, the second principal component can be regarded as the peace of mind while experiencing the light changing stimuli. With the analysis, we obtained principal component according to the six lighting task (table 4).

**Table 4:** First and second Principal components for lighting stimuli

|                  | first principal components | Second principal components |
|------------------|----------------------------|-----------------------------|
| Light and Shade: | 0.55876032                 | -1.6753164                  |
| Color taste:     | -4.2881419                 | 0.0385866                   |
| Focus:           | 1.73996603                 | -1.4452016                  |
| Angle:           | 0.94990105                 | 1.56671137                  |
| Height:          | -0.8871996                 | 0.28126298                  |
| Darkness:        | 1.92671407                 | 1.23395713                  |

From the first principal components, we can understand the stimuli of Color taste related to the emotion of Friendly very well. This result can support our former result of analysis of multiple comparison that the Non-Active Pleasure, Affinity and Active Pleasure have higher average score and significantly different to other ECs. From the second principal component, we can understand Light and Shade and Focus give greater opposing effect to Peace Of Mind while Angle affect to increase the feeling of Peace Of Mind. In other word, the effect of Light and Shade and Angle will give vitalize feeling to human.

Based on this result of PCA analysis, we tried to classify the stimulus we tested using cluster analysis with the principal components. We used word method and euclid distance for this analysis. The result of hierarchical dendrogram is shown on Figure 3.



**Figure 3:** Dendrogram by cluster analysis with the principal components.

Concerning on the distance between clusters, it can be optimal to regard the similar group of stimuli as: [Light and Shade and Focus], [Color taste and Height] and [Angle and Darkness]. Referring the principal component plot in Figure 4, we can understand the Color contributes Friendliness very much and [Angle and Darkness] contributes Peace Of Mind while [Light and Shade and Focus] affect negative to the Peace Of Mind.



## 5. CONCLUSIONS

Throughout the experiment and analysis, it is concluded as follows.

- 1) Color change can bring friendly and pleasurable emotion easily.
- 2) Focus, Height and Angles are relatively difficult to characterize from the emotional evaluation.
- 3) However, [Angle and Darkness] and [Light and Shade and Focus] can be the factors affect to change the emotion of Peace of Mind.

## 6. PLAN OF FURTHER RESEARCH

Although there we found certain relationship between emotional evaluation and changes of lighting as stimuli, we have to proceed to more detailed to changing patterns of lighting. Also, we have to recognize there can be more subtle changes of emotion that even human can not notice by themselves. We may add physiological and behavioral measurement to detect these sub-conscious emotional reaction: Kansei process.

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