

## A study about Multi sensory Stimulation of Fluctuation and Color Temperature Effects on Neuro-energy

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### Abstract

In this study, EEG, HRV and Vibra image are compared and analyzed in the environmental test room for stimulation of sound fluctuation and color temperature. The condition of the environmental test room was in temperature 25[°C], relative humidity 50[RH%], current air speed 0.02[m/s] and illuminance 1000[lux] with different sensory stimulation condition set up which are before exposure, single-sensory stimulation of a=1.106 music, single-sensory stimulation of RED color lighting, and multi-sensory stimulation of fluctuation a=1.106 music and RED color lighting. At multi-sensory stimulation of fluctuation a=1.106 music and RED color lighting, relative Sa wave, relative Mβ wave, SEF50, and SDNN were revitalized, and both sides α wave asymmetry index, HRT, stress index, and fatigue degree were decreased. Also, Vibra image of tension/anxiety and stress were declined. It is found that multi-sensory stimulation of fluctuation a=1.106 music and RED color lighting effects to increase the Neuro-energy like amenity, productivity and concentration.

**Keywords:** EEG, Color temperature, Fluctuation, HRV, Neuro-energy, Multi-sensory stimulation, Vibra image

### Introduction

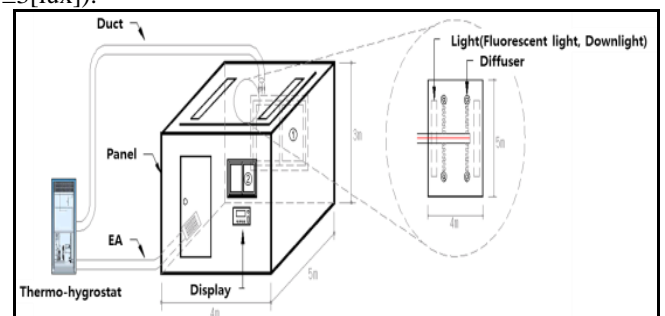
Global warming phenomena are caused by excessive fossil fuel consumption for a long time. Because of this, it should be considered about human body and emergency measure service.[1] However, there is policy according to the Rational Energy Utilization Act to prevent extreme progress of the global warming phenomena. It is not considering about amenity, productivity and work efficiency of human.[2] Hence, this study conducted multi-sensory stimulation by sound fluctuation and color temperature in the steady environmental room with the same conditions in temperature 25[°C], relative humidity 50[RH%], illumination 1,000[lux] and air velocity 0.02[m/sec], which satisfy the comfort zone, by ASHRAE(American Society of Heating, Refrigerating and

Air-Conditioning Engineers, Inc.).[3] This study is to increase the neuro-energy and energy saving.

### Method

#### Condition of the environmental test room

This study carried out experiment in the steady environmental test room with the structure of 4×5×3[m](Fig. 1.). Data in the steady environmental test room include temperature - 10~40[°C](error range ±0.5[°C]), humidity 20~90[RH%](error range ±3[RH%]) and illumination 0~2,000[lux](error range ±3[lux]).



(a) Schematic diagram



(b) Interior Photograph

**Figure 1:** Structure of Environmental Test Room

**Condition selection of stimulus**

In this study, auditory stimulus conditions are selected by sound fluctuation a index(a=1.106 sound source)[4], and visual stimulus conditions are selected by color temperature of 2,000~3,000[°K](RED lighting)[5].

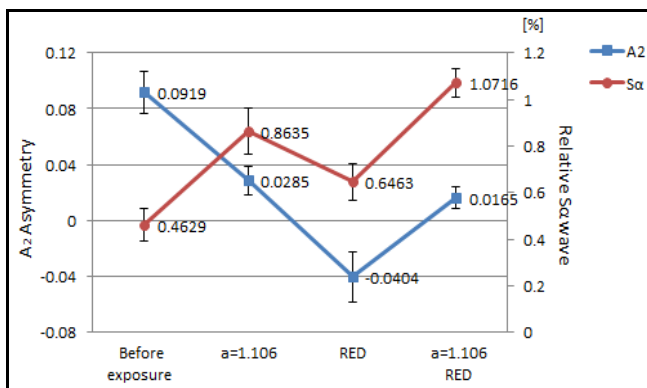
**Measurement and analysis of physiologic signal**

The subjects in this experiment were 8 selected university students at the ages of 20~28. The subjects' activity level was set to be 1met(metabolic rate: 1met=58.2 W/m<sup>2</sup>) as the active mass when taking rest by being seated on a chair in the comfortable thermal condition. The clothing-weight state was unified with about 0.7clo.[6] The measurement of brain wave was utilized PolyG-I(Laxtha Inc.), which is the specialized bio-signal measuring equipment. To analyze quantitative brain wave, the measurement was made for 5 minutes per 1 time based on the analytical unit. The measurement of HRV(Heart Rate Variability, HRV) was utilized SA-6000(Medicore Co. Ltd., Korea), which is autonomic nervous measuring equipment. The measurement of vibra image was utilized Vibra image 7 program(Vibra system Inc.), which is measured and analyzed three parameters of tension & anxiety, stress, and balance by webcam[7].

**Result of experiment**

**Variation of the amenity in EEG due to the multi-sensory stimulation of sound fluctuation and color temperature.**

The outcome of measuring A<sub>2</sub> asymmetry and relative Sα in EEG according to the stimulation of sound fluctuation and color temperature is as Fig. 2. The A<sub>2</sub> asymmetry index stands at 0.0165 in the multi-sensory stimulation of fluctuation a=1.106 sound source and Red lighting compared to being exposed to before exposure and single-sensory stimulation, thereby being the closest to "0". Even relative Sα stands at 1.0716[%], thereby being activated the most. In addition, the result of ANOVA statistical verification on relative Sα wave is as Table 1. The value of significance probability(P) stands at 0.009\*\*, thereby being able to be known to be statistically significant.



**Figure 2:** Variation of A<sub>2</sub> asymmetry and relative Sα due to the multi-sensory stimulation of sound fluctuation and color temperature

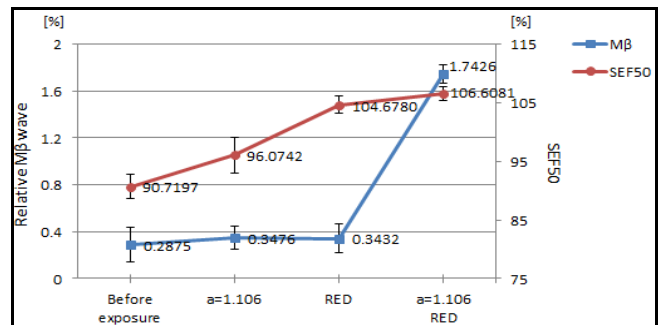
**Table 1:** Statistical Analysis of Relative Sα wave

	Relative Sα wave
Sum of suares	0.158
DF	31
Mean Suare	0.015
F Value	5.879
Pr > F	0.009**

\*\* P < 0.05

**Variation of the concentration in EEG due to the multi-sensory stimulation of sound fluctuation and color temperature.**

The outcome of measuring relative Mβ(15~20[Hz]) and SEF50(4~50[Hz]) in EEG according to the multi-sensory stimulation of sound fluctuation and color temperature as shown in Fig. 3. Relative Mβ was activated the most with 1.7426 [%] in the multi-sensory stimulation of fluctuation a=1.106 sound source and Red lighting compared to being exposed to before exposure and single-sensory stimulation. SEF50 was also activated the most with 106.6081[%]. In addition, The result of ANOVA statistical verification on relative Mβ and SMR/θ is as Table 2. The value of significance probability(P) stands at 0.074\* and 0.007\*\*, respectively, thereby being able to be known to be statistically significant.



**Figure 3:** Variation of relative Mβ and relative SEF50 due to the multi-sensory stimulation of sound fluctuation and color temperature

**Table 2:** Statistical Analysis of Relative Mβ wave and SEF50

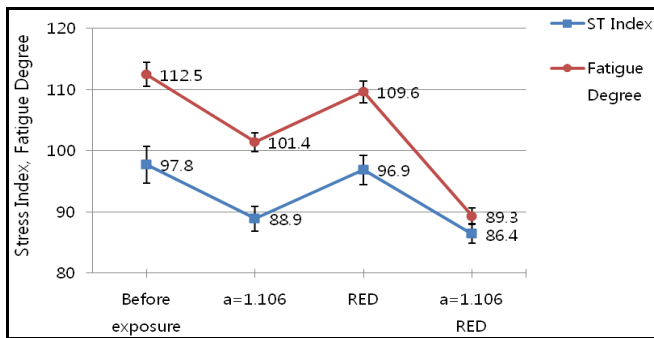
	Relative Mβ wave	SEF50
Sum of suares	0.043	6.848
DF	31	31
Mean Suare	0.003	0.767
F Value	3.242	8.294
Pr > F	0.074*	0.007**

\*P < 0.1, \*\* P < 0.05

**Variation of the physical stability due to the multi-sensory stimulation of sound fluctuation and color temperature.**

The outcome of measuring stress index and fatigue degree in HRV according to the multi-sensory stimulation of sound fluctuation and color temperature is as Fig. 4. Stress index was decreased the most with 86.4 in the multi-sensory

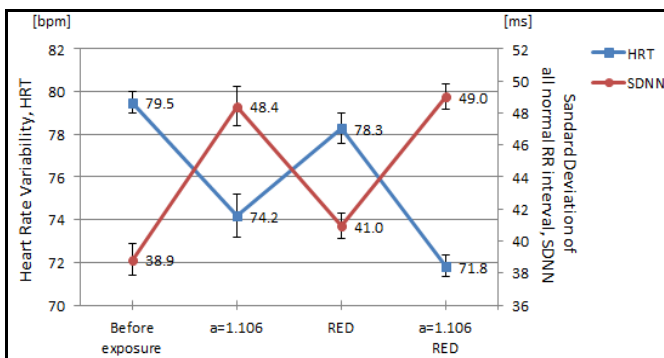
stimulation of fluctuation  $a=1.106$  sound source and Red lighting compared to being exposed to before exposure and single-sensory stimulation. Fatigue degree was also decreased the most with 89.3.



**Figure 4:** Variation of stress index and fatigue degree due to the multi-sensory stimulation of sound fluctuation and color temperature

**Variation of the physical stability due to the multi-sensory stimulation of sound fluctuation and color temperature.**

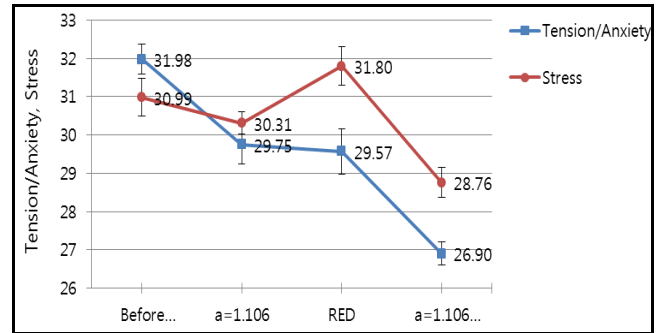
The outcome of measuring HRT(Mean Heart rate) and SDNN(Standard Deviation of all the normal RR intervals) in HRV according to the multi-sensory stimulation of sound fluctuation and color temperature is as Fig. 5. HRT was decreased the most with 71.8[bpm] in the multi-sensory stimulation of fluctuation  $a=1.106$  sound source and Red lighting compared to being exposed to before exposure and single-sensory stimulation. SDNN was also increased the most with 49.0[ms].



**Figure 5:** Variation of HRT and SDNN due to the multi-sensory stimulation of sound fluctuation and color temperature

**Variation of the vibra image due to the multi-sensory stimulation of sound fluctuation and color temperature.**

The outcome of measuring tension & anxiety and stress in vibra image according to the multi-sensory stimulation of sound fluctuation and color temperature is shown in is as Fig. 6. Tension & anxiety was decreased the most with 26.90 in the multi-sensory stimulation of fluctuation  $a=1.106$  sound source and Red lighting compared to being exposed to before exposure and single-sensory stimulation. Stress was also decreased the most with 28.76.



**Figure 6:** Variation of stress tension & anxiety and stress due to the multi-sensory stimulation of sound fluctuation and color temperature

**Conclusion**

As a result of the experiment, the multi-sensory stimulation of fluctuation  $a=1.106$  sound source and Red lighting is effected to increase physical and psychological stability and concentration, to decrease stress and fatigue degree. Also, the neuro-energy was increased about 24.88[%] in the multi-sensory stimulation. It knows that the multi-sensory stimulation is effective on growing the neuro-energy. However, given being performed a research and a consideration by using more various multi-sensory stimulation conditions hereafter in light of what the stimulus condition in auditory and vision sense is one thing each, the optimal multi-sensory stimulation condition is judged to be possibly found in consideration of an occupant's mental state along with the objective of space.

**Acknowledge**

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