

Design of the Multi-sensory Stimulation Space to improve the Neuro-energy

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Abstract. In this study, EEG, HRV, and Vibra image were compared and analyzed in the environmental test room due to the multi-sensory stimulation of sound fluctuation, color temperature, and aroma. The condition of the environmental test room was in temperature 25[°C], relative humidity 50[RH%], air current speed 0.02[m/s] and illuminance 1000[lux] with setting up five different multi-sensory stimulations which are (1)before exposure, (2)Jasmine scent and sound fluctuation a=1.106 music, (3)sound fluctuation a=1.106 music and color temperature RED lighting, (4)Jasmine scent and color temperature RED lighting, (5)Jasmine scent, sound fluctuation a=1.106 music, and color temperature RED lighting. The result of this study, at multi-sensory stimulation of Jasmine scent and sound fluctuation a=1.106 music, relative M α wave, both sides α wave asymmetry index, SEF50, SMR/θ, HRT, and balance were increased, and SDNN, tension/anxiety, stress were decreased. Therefore multi-sensory stimulation of Jasmine scent and sound fluctuation a=1.106 music effects to increase the amenity, concentration, and physical stability.

Keywords: Neuro-energy, Multi-sensory stimulation, EEG, HRV, Vibra image

1 Introduction

Energy includes the new renewable energy, the fossil fuel energy, the physical energy with the use of muscles, and the neuro-energy, which shows psychological energy with the use of perception and sense.[1] The indoor environmental factors adjust physiological rhythm by changing Circadian system in the body, sensitivity and intelligence, thereby changing an occupant's neuro-energy.[2] Grasping the influence of indoor environmental factor upon human body in this way has important significance in improving neuro-energy.[3] However, it is difficult to find the research results on multi-sensory stimulation according to the combination of single-sensory stimulation in the indoor environmental factors. Hence, this study conducted multi-sensory stimulation by applying sound fluctuation a=1.106 sound source, RED(color coordinate 0.6975, 0.3021) lighting and Jasmine scent in the steady temperature and humidity room with the same conditions in temperature 25[°C], relative humidity 50[RH%], illuminance 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.).

2 Method

2.1 Condition of the environmental test room

This study carried out experiment in the steady temperature and humidity room with the structure of $4 \times 5 \times 3$ [m]. Data in the steady temperature and humidity room include temperature $-10 \sim 40$ [$^{\circ}\text{C}$](error range ± 0.5 [$^{\circ}\text{C}$]), humidity $20 \sim 90$ [RH%](error range ± 3 [RH%]) and illuminance $0 \sim 2,000$ [Lux](error range ± 3 [Lux]).

2.2 Condition selection of sense stimulus

This study used the sound source of Bellavia in jazz whose sound fluctuation 'a' index is 1.106. The sound source of Bellavia in jazz is effective for improving the reduction in stress and the relaxation in mind and body.[4] The visual stimulus was used by utilizing RED lighting with low color temperature in $2000 \sim 3000$ [$^{\circ}\text{K}$] like the splendor of the setting sun that induces the psychological stability and the relaxed condition[5]. The jasmine scent, which is helpful for relieving stress and depression, was used as the olfactory stimulation by inducing clear mentality through activating β wave in the brain [6].

2.3 Measurement and analysis of physiologic signal

The subjects in this experiment were selected 15 university students at the ages of 25~28. The subjects' activity level was set to be 1met(metabolic rate: $1\text{met}=58.2 \text{ W/ m}^2$) 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(socks 0.10, pants 0.05, half sleeves 0.25, shorts 0.28).[7]

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. Stress and HRV(Heart Rate Variability, HRV) were gauged by applying SA-6000(Medicore Co. Ltd., Korea), which is the specialized autonomic nervous system balance tester. Vibraimage was used Vibra image7 program available for measuring and analyzing 3 parameters in Tension/Anxiety, Stress and Balance depending on the periodic vibration movement of frequency and amplitude by gauging micro movement in a person's head and neck originating from the micro vibration of a vestibular organ.[8]

3 Result of experiment

3.1 Variation of the amenity due to multi-sensory stimulation

The outcome of measuring asymmetry index and relative $M\alpha$ wave(10~12[Hz]) in EEG according to multi-sensory stimulation is as Fig. 1. The asymmetry index stands at 0.0074 in the multi-sensory stimulation of jasmine scent and fluctuation $a=1.106$ sound source compared to being exposed to multi-sensory stimulation, thereby being the closest to "0." Even relative $M\alpha$ wave stands at 1.9572[%], thereby being activated the most. The result of ANOVA statistical verification on relative $M\alpha$ wave is as Table 1. The value of significance probability(P) stands at 0.016, thereby being able to be known to be statistically significant.

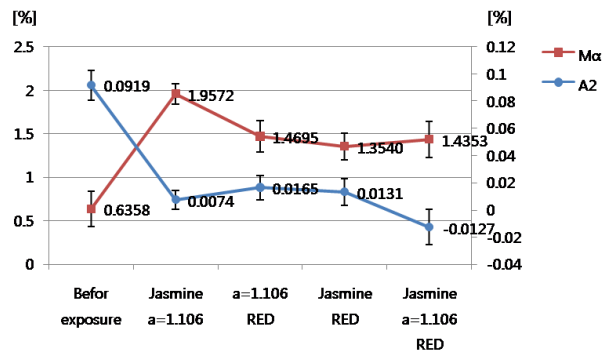


Fig. 1. Variation of A_2 asymmetry and relative $M\alpha$ wave due to multi-sensory stimulation

Table 1. Statistical analysis of relative $M\alpha$ wave

	Sum of Squares	DF	Mean Square	F Value	Pr>F
Relative $M\alpha$	0.281	74	0.016	3.968	0.016**

3.2 Variation of the concentration due to multi-sensory stimulation

The result of measuring SEF50(4~50[Hz]) and SMR/ θ (12-15/4-8[Hz]) in EEG according to multi-sensory stimulation is as Fig. 2. SEF50 was activated the most with 111.2016[%] in the multi-sensory stimulation of jasmine scent and fluctuation $a=1.106$ sound source compared to being exposed to multi-sensory stimulation. SMR/ θ was also activated the most with 6.4910[%]. The result of ANOVA statistical verification on SEF50 and SMR/ θ is as Table 2. The value of significance probability(P) stands at 0.062 and 0.021, respectively, thereby being able to be known to be statistically significant.

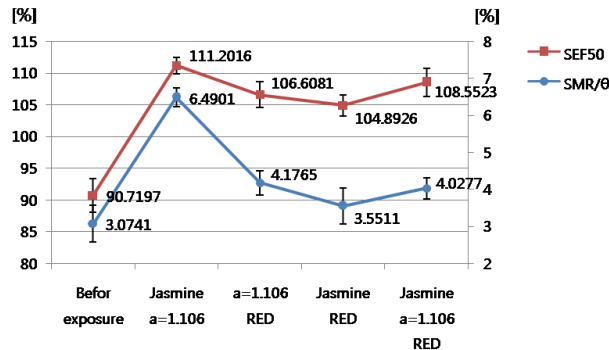


Fig.2. Variation of SEF50 and SMR/θ wave due to multi-sensory stimulation

Table 2. Statistical analysis of SEF50 and SMR/ θ

	Sum of Squares	DF	Mean Square	F Value	Pr>F
SEF50	1347.803	74	86.128	4.301	0.062**
SMR/θ	7.262	74	0.431	5.977	0.021*

3.3 Variation of the physical stability due to multi-sensory stimulation

The outcome of measuring Mean Heart rate, HRT, and Standard Deviation of all the normal RR intervals, SDNN according to multi-sensory stimulation is as Fig. 3. HRT lowers the most with 59.6[bpm] in the multi-sensory stimulation of jasmine scent and fluctuation a=1.106 sound source compared to being exposed to multi-sensory stimulation. SDNN stands at 56.9[ms] as well, thereby being able to be known to rise the most.

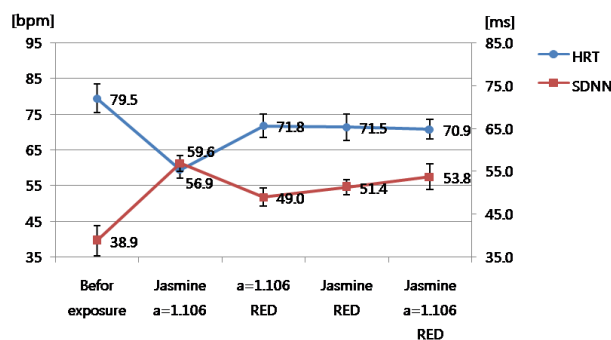


Fig. 3. Variation of HRT and SDNN due to multi-sensory stimulation

3.4 Variation of the Vibra image due to multi-sensory stimulation

The result of measuring 4 Vibraimages in Tension/Anxiety, Stress and Balance according to multi-sensory stimulation is as Fig. 4. Tension/Anxiety and Stress reduce the most with 30.5 and 29.37, respectively, in the multi-sensory stimulation of jasmine scent and fluctuation $a=1.106$ sound source compared to being exposed to multi-sensory stimulation. Even balance can be known to rise the most with 72.

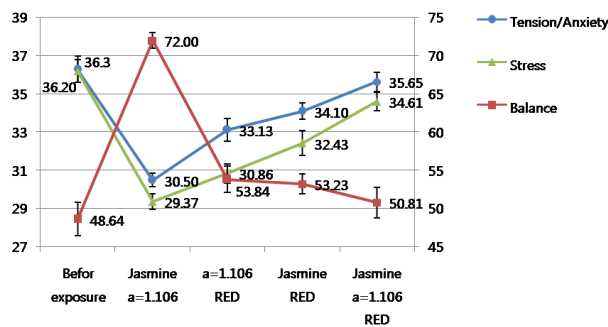


Fig. 4. Variation of Tension/Anxiety, Stress, and Balance due to multi-sensory stimulation

3.5 Analysis of the Neuro-energy due to multi-sensory stimulation

The outcome of comparing neuro-energy between before being exposed to multi-sensory stimulation and when being exposed to multi-sensory stimulation is as Fig. 5. Relative Ma wave and SEF50 were up by 3.05% and 28.69%, respectively, when being exposed to the multi-sensory stimulation of jasmine scent and fluctuation $a=1.106$ sound source. Stress index was down by 23.59%. SDNN can be known to be up by 58.5%.

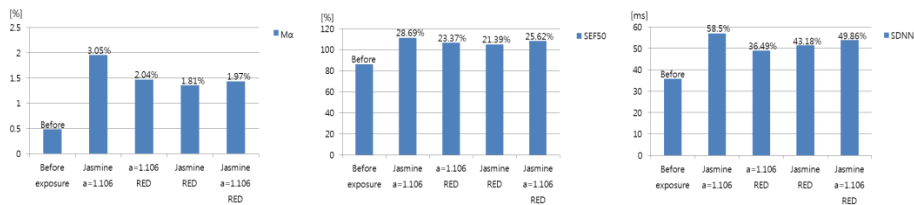


Fig. 5. Variation of Neuro-energy due to multi-sensory stimulation

4 Conclusion

As a result of the experiment, sensitivity, mind & body rest, and concentration rose the most in the multi-sensory stimulation of jasmine scent and fluctuation $a=1.106$

sound source. The body and the heart showed stably physical condition. Also, averagely 22.26% of neuro-energy could be known to grow when being exposed to multi-sensory stimulation compared to before being exposed to multi-sensory stimulation. 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, vision, and olfactory 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. Accordingly, in case of needing to inevitably maintain the indoor temperature at 28 °C in summer and 18 °C in winter according to the Energy Utilization Act, the multi-sensory stimulation space design is expected to be likely to be a plan available for reducing new renewable energy and fossil fuel energy and enhancing neuro-energy.

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