

# The effects of color stimulus on autonomic nervous system activity and subjective arousal state

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## ABSTRACT

**Aim:** This research examines the hypothesis that colors adopted for the home environment impact autonomic nervous system activity and subjective arousal.

### Methods

**Subjects:** Seventeen healthy adult women consented to participate in this research project.

**Experimental requirement:** A room at our school, built to simulate a model standard home. We changed only the color of the tablecloth. For the colors used in the experiment, we used chromatic colors from the Munsell hue circle. We selected red, yellow and blue with high chroma. For the achromatic colors, we selected black and white.

**Measurement item:** 1) Autonomic nervous system activity evaluation index: The evaluation was HF and LF/HF. 2) Subjective awareness: We collected data using the Japanese UWIST Mood Adjective Checklist (JUMACL). Outcomes are Tense Arousal (TA) and Energetic Arousal (EA). Before and after subjects looked at each color, we collected the data. And after five experiments with each subject, we asked each which of the five colors had the highest degree of impact on her consciousness.

### Results

**Autonomic nervous system activity evaluation index:** 1) HF: HF value decrease was significantly in black. 2) LF/HF: The proportional increase was significant in black and white, and activation of sympathetic nervous system activity was found. Yellow also showed a marginal significance.

**Subjective arousal (JUMACL):** A pre- and post-trial comparison of TA scores showed that post-trial scores were significantly lower for blue and white. The post-trial EA scores were significantly lower for all colors except red.

**Conclusions:** Significant activation of autonomic nervous system activity was found in an object that was commonly used in daily life, a tablecloth in black, yellow, or white. At the same time, colors except red have a tension reducing effect. We believe that color stimulation can be used to adjust physical and mental activity in daily nursing.

**Keywords:** *autonomic nervous system activity, the Japanese UWIST Mood Adjective Checklist (JUMACL), color stimulation*

## 1. Introduction

This research examines the hypothesis that colors adopted for the home environment impact autonomic nervous system activity and subjective consciousness.

A color has a deep connection with everyday life. Personality traits have been shown to influence color preference [1]. Also, it is shown that bright colors are related to positive feelings, and dark colors are related to negative feelings [2]. In the global research, it

Because the color preference was connected with national traits, we paid our attention to the researches in

was shown that color preference included national traits [3].

There are many researches about the influence that a color gives to the psychology or Physiology of the human. However, they are conducted by non-daily setting. For example, in the lighted living room and the unlighted laboratory, it is estimated the reactions are different. Depending on the brightness of the room, that the impression is different even with the same color are well known.

Japan. In previous research, an entire room was standardized in one color [4] [5], on the screen of a

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personal computer (PC) [6]. Thus, little research has addressed color in the home environment. And, there is little research on nursing using a color effect, too.

This research investigates the influence of different colors, using five distinct tablecloth colors presented in an environment similar to that of a standard home. Also, we want to mention the application in the nursing.

## 2. Methods

### Subjects

Seventeen healthy adult women from 18 to 30 years of age (average age  $21.4 \pm 1.1$  years old) consented to participate in this research project.

### Experimental requirement

#### Subjects

Healthy subjects with normal color sense and normal autonomic nervous function.

#### Experiment environment

A room at our school, built to simulate a model standard home (Fig.1).



Fig.1 experiment environment

### Color stimulus

We used a small table (light brown, 7.5YR6/8). We changed only the color of the tablecloth (85\*150\*30cm). For the colors used in the experiment, we used chromatic colors from the Munsell hue circle. We selected red, yellow and blue with high chroma. For the achromatic colors, we selected black and white. We used color tablecloths that were marketed products. The Munsell values were red (5R4/14), yellow (5Y8/13), blue (5PB4/14), black (N1.25), and white (N9) (Fig.2). The colorimetry was selected using visual judgment based upon the colors in the Munsell system devised by the Japan Color Research Institute Foundation and instrumental judgment using the colorimetry of the ColorMunki Design (X-Rite, Incorporated). All subjects participated in five color experiments on the same day, and the tablecloth order was randomly determined for each subject.

### Measurement item and measurement equipment

#### Autonomic nervous system activity evaluation index

We used Heart Rhythm Scanner (HRS, Fig.3) (Biocom, San Diego, California). The evaluation index was LF/HF at RR interval.

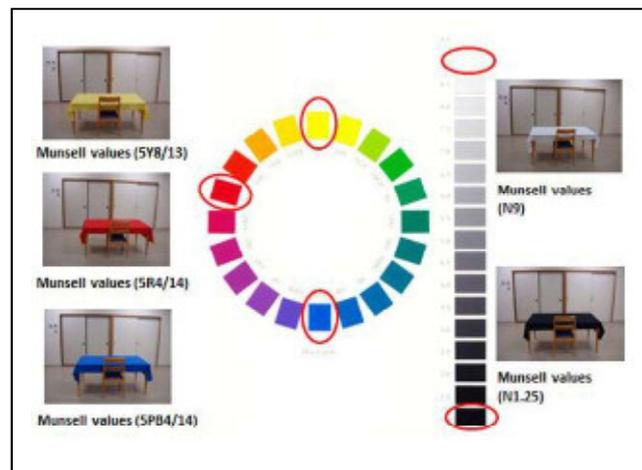


Fig.2 Munsell hue circle and five tablecloths



Fig.3 Heart Rhythm Scanner (HRS)

### Subjective arousal

We collected data using the Japanese UWIST Mood Adjective Checklist (JUMACL) [7]. JUMACL is a Japanese version of the mood checklist was developed by a group of Cambridge University [8]. This tool consisted of 20 items pertaining to the subject's emotion. Outcomes are Tense Arousal (TA) and Energetic Arousal (EA). Each score is measured by four-point scale. These scores evaluated according to a test guide (table 1). Before and after subjects looked at each color, we collected the data.

Additionally, after five experiments with each subject, we asked each which of the five colors had the highest degree of impact on her consciousness. Each subject answered in writing.

Table 1 test guide of JUMACL scores

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	male	female
<b>TA</b>		
slightly low	10-13	10-12
normal	13-23	12-22
slightly high	23-29	22-27
high	29-40	27-40
<b>EA</b>		
low	10	10-11
slightly low	10-17	11-17
normal	17-31	17-31
slightly high	31-37	31-37
high	37-40	37-40

### Experimental procedure

After collecting the basic data while each was wearing the measuring equipment, each subject took a resting position (five minutes). Then we started the experiment. The procedure for each experiment was to have each subject rest with her eyes open (two minutes), rest with her eyes closed (two minutes), look at Color 1 (two minutes), and look at Color 2 (two minutes, Color2 is the same color as Color1), for a total of eight minutes (Fig.4). Each experimental procedure was the same, with a 5-minute break between each of the five color experiments.

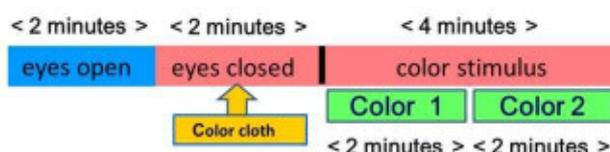


Fig.4 Experimental procedure

### Analytical method

For the autonomic nervous system activity evaluation, we compared (a) resting with eyes open and color stimulation and (b) resting with eyes closed and color stimulation, for each of the five colors. We performed multiple comparison using the Wilcoxon signed rank test with its significant standard corrected using Bonferroni correction ( $p < 0.025$ ).

We marked the JUMACL score according to a test guide. In the experiment before and after, we compared scores using the Wilcoxon signed-rank test.

For the subjective investigation we simply totaled the number of subjects, using the binomial test as 20% at a probability which could occur accidentally.

All data processing was done using PASW Statistics 18.0J for Windows ( $p < 0.05$ ).

### Ethical considerations

This research was conducted with the approval of the ethics committee of Meiji University of Integrative

Medicine. Each subject was given proper oral and documented informed consent.

Table 2-1 Comparison of resting with eyes open and color stimulation

	RR interval	wilcoxon test	LF/HF	wilcoxon test
<b>black</b>				
rest	882.5±31.7	—	1.3±0.3	—
color stimulation 1	859.7±31.9	0.017	2.0±0.5	0.102
color stimulation 2	862.4±29.8	0.065	1.6±0.2	0.332
<b>white</b>				
rest	872.7±30.7	—	2.0±0.6	—
color stimulation 1	876.1±30.0	0.449	1.7±0.4	0.962
color stimulation 2	859.7±26.0	0.758	2.8±0.8	0.435
<b>red</b>				
rest	875.9±27.5	—	1.6±0.4	—
color stimulation 1	879.9±29.8	0.868	2.0±0.4	0.118
color stimulation 2	863.2±29.0	0.407	1.8±0.3	0.603
<b>yellow</b>				
rest	872.2±26.4	—	1.1±0.2	—
color stimulation 1	865.8±26.0	0.156	1.4±0.3	0.177
color stimulation 2	865.5±24.2	0.478	1.2±0.2	0.246
<b>blue</b>				
rest	876.4±29.4	—	1.3±0.3	—
color stimulation 1	862.2±26.3	0.148	1.2±0.3	0.906
color stimulation 2	870.9±29.6	0.538	1.8±0.3	0.068

Table 2-2 Comparison of resting with eyes closed and color stimulation

	RR interval	wilcoxon test	LF/HF	wilcoxon test
<b>Black</b>				
rest	606.6±35.0	—	1.2±0.3	—
color stimulation 1	859.7±31.9	0.001	2.0±0.5	0.006
color stimulation 2	862.4±29.8	0.002	1.6±0.2	0.076
<b>White</b>				
rest	901.1±34.1	—	0.8±0.1	—
color stimulation 1	876.1±30.0	0.025	1.7±0.4	0.003
color stimulation 2	859.7±26.0	0.170	2.8±0.8	0.002
<b>Red</b>				
rest	900.6±33.4	—	1.8±0.7	—
color stimulation 1	879.9±29.8	0.170	2.0±0.4	0.309
color stimulation 2	863.2±29.0	0.093	1.8±0.3	0.407
<b>Yellow</b>				
rest	884.2±26.5	—	0.8±0.1	—
color stimulation 1	865.8±26.0	0.003	1.4±0.3	0.084
color stimulation 2	865.5±24.2	0.035	1.2±0.2	0.044
<b>Blue</b>				
rest	891.7±28.4	—	1.2±0.2	—
color stimulation 1	862.2±26.3	0.068	1.2±0.3	0.687
color stimulation 2	870.9±29.6	0.028	1.8±0.3	0.102

Values in the tables are averages and standard errors ( $n=17$ , averages  $\pm$  SE). P-values are indicated in the test results (Results of the Wilcoxon signed-rank sum test).  $p < 0.025$  is assumed to be significant (Bonferroni correction).

## 3. Results

### Autonomic nervous system activity evaluation index

Statistical results are presented in Table 2.

#### RR interval

Comparing resting with eyes open and color stimulation, the RR interval was significantly short only with black.

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Comparing resting with eyes closed and color stimulation, the interval was significantly short in black and yellow. A significant shortening tendency was found with white and blue. No significant difference was found between each color.

### LF/HF

When comparing resting with eyes open and color stimulation, no significant difference was found in any of the colors. Comparing resting with eyes closed and color stimulation, the proportional increase was significant in black and white, and activation of sympathetic nervous system activity was found. Yellow also showed a significant tendency to activate the sympathetic nervous system. No significant difference was found between colors.

### Subjective arousal

#### JUMACL

Statistical results are presented in Table 3. A pre- and post-trial comparison of TA scores showed that post-trial scores were significantly low for blue and white. The post-trial EA scores were significantly lower for all colors except red.

Both TA scores and EA scores decreased, but were the normal rank by the test guide.

Table 3 Comparison pre- and post-trial of JUMACL scores

	pre-trial	post-trial	Wilcoxon test
<b>Black</b>			
TA		15.1±1.1	0.086
EA		25.4±1.7	0.001
<b>White</b>			
TA		14.9±0.9	0.040
EA		26.4±1.7	0.038
<b>Red</b>	TA		
	17.8±1.2		
EA		16.1±1.1	0.108
	EA		
	30.7±1.0	28.6±1.5	0.139
<b>Yellow</b>			
TA		16.4±1.2	0.342
EA		28.3±1.3	0.027
<b>Blue</b>			
TA		14.9±0.9	0.013
EA		25.6±1.8	0.005

Values in the tables are averages and standard errors (n=17, averages ±SE). TA: tense arousal, EA: energetic arousal.

### Subjective investigation

Yellow had the highest impact on the consciousness for nine of the 17 subjects (52.9%). This ratio was significantly higher than an accidental probability of 20% (p = 0.001).

Examining the other eight subject responses, blue had

the highest impact for three of the subjects and red for another three subjects, while white had the highest impact for two.

## 4. Discussion

It was shown that the autonomic nervous system and emotion were activated by the color tablecloths except the red one.

In the findings, black was the strong color of the impression. According to the Lüscher Color Test, red and yellow is the color of strong awakening and excitement. And it is stated that the black is low awakening color [9]. It is thought that this is caused by the fact that they looked at a large size color into a field of view. Effects of field sizes are well known [10] [11]. In addition, it may be one caused by the fact that a large size plain black color is little seen in daily life.

In the subjective arousal, because JUMACL scores decreased, it was thought that mental tensions were relieved. And both TA and EA scores were in normal ranks, we thought that it was not decreased in the level of awakening.

There were many subjects who answered that yellow was the most strong color in the subjectivity investigation. It was different from the result of the heart rate variability.

The results showed that black was a high-impact color because heart rate variability data provided a significant difference in comparison with eyes open, but in the subjective investigation yellow had the highest degree of consciousness. For this reason, it is possible that yellow seemed vivid because it had the highest color value in the chromatic scale used for this research, and thus accorded with consciousness.

We believe that color stimulation can use to adjust physical and mental activity in daily nursing. For example, we may let the patients activate using a tablecloth before meal or recreation. It is thought that it performs the method at home, because not only nurses but also patient's family may be able to do. In the elderly people, it is might be possible that the number of pneumonia patients decrease and stimulate the dementia patients.

In conclusion, this research provides new information that the color impacts the autonomic nervous system activity and subjective consciousness in environments such as the home.

### Limitation of the study

Several research limitations should be mentioned. In this research, we were not able to clarify it at activated continuation time of the autonomic nervous system activity by the color stimulation, because experiment time was short. Moreover, further researches are needed to per-

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form in patients as the subjects were healthy adults. Especially, the research for a home care patient and elderly people would be required. We are going to carry out our continued research in the future in the clinical setting.

In addition, we do not confirm the cerebral activity. Further research at this point is on the way to clarify. Our findings would be supported more if we could confirm cerebral activity.

### 5. Conclusion

Significant activation of autonomic nervous system activity was found in an object that was commonly used in daily life, a tablecloth in black, yellow, or white. The results also showed that subjective consciousness varies according to color and that yellow had the highest conscious awareness for most subjects. We believe that color stimulation can increase autonomic nervous system activity prior to eating and engaging in recreation.

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