Analyzing and Comparing the Effect on Lightsources and Colours in the Residence and Office Interior

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Abstract

The aim of this study is to propose the predictive index and analyze the effect of lightsources and colour by image types in the residence and office interior.

This study was consisted of four steps, and was carried out as follows.

1) The condition of experiment was set up by optical characteristic of lightsources and colours. 2) The scaled model space was manufactured for the evaluation of the same condition by each space. And, some piece of furniture was manufactured for the representation of each space. 3) The emotivity response of lightsources and colours was measured. 4) Results of the evaluation of lightsources and colours were compared and analyzed by conditions, and the predictive index was proposed by image types

Keywords : residence, office, lightsource, colour, color temperature, hue, value

1. INTRODUCTION

Until now, the interior has been designed to be economical, while a comfort of residents was neglected. Recently, however the active movement toward considering psychological comfort is made out of simple and uniform scheme. Lighting and colour are important factors to produce this pleasantness and they are inseparably related each other.

Therefore, according to their functions, we should to give the resident a comfort, and construct lighting and colour with high function as well. For this purpose we must analyze optical characteristics of lightsource and colour and examine emotivity response to the characteristics.

The aim of this study is to propose the predictive index and analyze the effect of lightsources and colour by image types in

the residence interior and the office interior.

This study is composed of four steps. Figure 1 shows the process of this study.

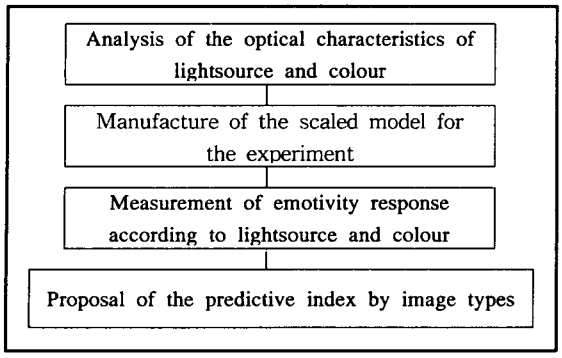


Figure 1. The Process of This Study

In the first step, we set up the condition of experiment by analyzing the optical characteristics of lightsources and colour. In the second step, we manufactured the scaled model for the evaluation of the office and the residential space with the same experimental condition. We also manufactured some furniture to represent each space. In third step, we measured the emotivity response according to lightsources and colour of the wall by placing appropriate the office and the residential furniture in each scaled model. Finally, we analyzed comparatively the results of the evaluation of lightsources and colour by each space, and proposed the predictive index of lightsources and colour by image types.

2. EXPERIMENTAL CONDITION AND METHOD

2.1 Experimental Condition Setting

Variables were set as colour temperature and colour rendering index of lightsource, illuminance and hue and value changed by replacing the wall colour.

2.1.1 Color

Colour used for this study was selected one by one among Munsell 10 hue circle(R, YR, Y, GY, G, BG, B, PB, P and RP). Each value and chroma was respectivelly 9 and 2 used for most interiors according to the results of the study precedent. So we selected total 13 colours to experiment in this study by choosing N9, N8 and N7 out of neutrals.. Table 1 shows the selected colours.

Table 1. Interior Colour

5 R 9/2	5 YR 9/2	5 Y 9/2	5 GY 9/2
5 G 9/2	5 BG 9/2	5 B 9/2	5 PB 9/2
5 P 9/2	5 RP 9/2	N 9	N 8
N 7			

2.1.2 Lightsource

In this study we selected lightsources as the typical sources used for the common interiors of which colour rendering indexes were more than 60. Selected lightsources were 4 types by colour temperature of fluorescent lamp and 4 types by the kinds of lamp type. Table 2 shows lightsources used for this study and their optical characteristics.

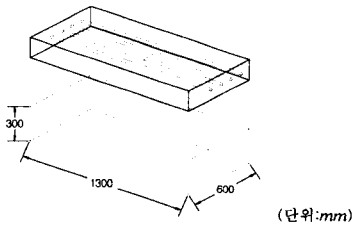
Table 2. Lightsources

Lamp type		Colour rendering index(R_a)	Colour tempera-ture (K)	Luminous flux (lm)
Fluorescent lamp	light bulb	85	2700	3350
	warm white	85	3000	3350
	daylight	85	6000	3250
	cool white	85	4000	3350
Discharge lamp	metal halide	85	2900	8000
	mercury	65	3000	4000
Incandescent lamp	halogen	99	2800	1450
	crypton	99	2750	1500

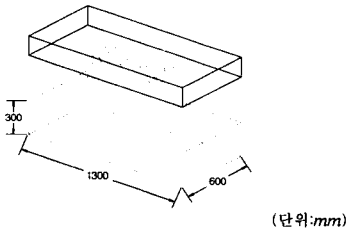
Evaluation objects in this study are total 104 types combined 8 lightsource types and 13 types by the wall colour by each space.

2.2 Scaled Model

Scaled model was manufactured to be at a scale of 1:10, representing 13,000×6,000×3,000mm real interior. Standard illuminant (D65) and lightsources were installed in the ceiling of scaled model. Test lightsources were 4 types of colour temperature and 4 types of lamps selected in the 2.1.2 section. There were 3 interchangeable walls (the front, right, and left wall) in the model, and the walls were made of 1mm iron planes painted with 13 colours. Figure 2 shows the apparatus of the model.



(a) Fluorescent Lamp



(b)Light Bulb Lamp

Figure 2. Apparatus of the Model

In order to simulate real situation the model was furnished and decorated as the office interior and the residence interior as shown in Figure 3. The only difference between two interiors is furniture.

(a) Office Interior

(b) Residence Interior

Figure 3. Interior of Scaled Model

2.3 Experimental Summary

2.3.1 Subjects

Total 30 subjects, 13 males and 17 females participated in this study. They are seniors or graduated school majoring in Architecture who we consider have perceptivity to judge lighting and colour.

2.3.2 Adjectives

Adjectives were based on the existing results[1)2)] of our earlier experiments and they were 12 pair adjecctives needed for the evaluation by optical characteristics of colour and lighting. Table 3 shows adjectives of this study.

Table 3. Adjectives

light	-heavy	active	-inactive
bright	-dark	clear	-dim
clean	-dirty	pleasant	-unpleasant
stable	-instable	comfort	-uncomfort
natural	-artificial	chic	-country
soft	-hard	warm	-cool

2.4 Experimental Methods

Adaptation in this experiment consisted of two parts. Firstly, subjects should wait five minutes to allow their eyes to adapt to the dark room before viewing the condition in

1) 李眞淑 外, 「オフィス照明環境の評價に關する硏究」, 日本東京工業大學院, 博士學位論文, 1989. 3.

2)Lee, Jin-Sook et al., 「The Analysis of the Characteristics and the Extraction of the Evaluation Construct Model in the Office Interior Color」, Journal of Korean Society of Color Studies, No. 7, 1996. 12.

order not to be affected by other lightsources. And then, they viewed the model through the observation window in each condition. Before filling out the response sheets, they should to wait one minute for the second adaptation. In the end of two adaptations, all images were changed across the different experimental conditions and were rated by 30 observers using seven-step semantic differential scales.

3. COMPARING AND ANALYZING EMOTIVITY RESPONSE BETWEEN THE RESIDENCE AND OFFICE INTERIOR

3.1 Analysis Method

The assessment data for the whole study was analyzed using SPSS/PC+. The Mean, the standard deviation, and dispersion for each adjective of each condition were measured by giving the ranks from 1 to 7 point to six semantic differential scales. Also to compare the differences between two interior type factor analysis and multi-regression method were carried out.

3.2 Factor Analysis

Table 4. Factor Analysis Results of the Office Interior

Factor	Adjectives	Factor stressing score			Commu-nality	Factor analysis
		I	II	III		
I	light - heavy	.91172	.25990	-.00205	.89879	Activity
	active - inactive	.89118	.26989	.05295	.86985	
	bright - dark	.88041	.25894	-.05746	.84547	
	clear - dim	.78101	.33875	-.18481	.75906	
	clean - dirty	.73360	.52416	-.08481	.82011	
	pleasant - unpleasant	.68177	.61290	-.00643	.84050	
II	stable - instable	.19500	.88491	.08315	.82800	Stability
	comfort - uncomfort	.36526	.82767	.16597	.84600	
	natural - artificial	.47533	.69338	.02264	.70723	
	chic - country	.59450	.62137	.05171	.74220	
III	warm - cool	-.19849	-.07198	.89207	.84036	Warmth
	soft - hard	.10246	.25633	.87137	.83549	
Eigenvalue		7.16855	1.80225	.86227		
Contribution Rate		59.7	15.0	7.2		
Cumulative Contribution Rate		59.7	74.8	81.9		

Table 5. Factor Analysis Results of the Residence Interior

Factor	Adjectives	Factor stressing score			Commu-nality	Factor analysis
		I	II	III		
I	light - heavy	.914	.215	-.001	.882	Activity
	active - inactive	.897	.209	.009	.857	
	bright - dark	.867	.208	-.194	.833	
	clear - dim	.733	.382	-.324	.788	
	clean - dirty	.652	.574	-.228	.806	
II	stable - instable	.104	.854	.221	.789	Stability
	comfort - uncomfort	.187	.818	.341	.820	
	pleasant - unpleasant	.483	.743	.122	.800	
	natural - artificial	.413	.721	.175	.722	
	chic - country	.535	.672	-.001	.738	
III	warm - cool	-.170	.114	.910	.870	Warmth
	soft - hard	-.004	.383	.825	.829	
Eigenvalue		4.123	3.691	1.921		
Contribution Rate		34.358	30.757	16.010		
Cumulative Contribution Rate		34.358	65.115	81.125		

To understand how lightsources and the wall colour have an influence on an interior image, factor analysis for each adjective was used. The results for each inteior, the office interior and the residence interior, is shown respectively in Table 4 and Table 5.

As a result, three factors were extracted.

Factor 1 composed of 「light」, 「active」, 「bright」, 「clear」, and 「clean」 can be named as 「Activity」 axis, related to activity factor to be used mostly for the evaluation of visual phenomenon.

Factor 2 composed of 「stable」, 「comfor t」, and 「natural」 can be named as 「Stablity」 axis, related to evaluation factor to be used for the evaluation of human psychological stability.

Finally, factor 3, potency factor composed of 「warm」 and 「soft」, can be named as 「Warmth」 axis.

The structures of these factors correspond with those extracted from the existing study.

3.3 Analyzing the Tendency of the Evaluation by Each Space

The multi-regression was carried out in order to analyze quantitatively emotivity response affected by each variable. Variable as objects of analysis are 3 categories, that is, lightsource, hue and value of the wall ; 8 lightsources are the daylight fluorescent lamp, the cool white lamp, the warm white lamp, lightbulb-colour lamp, the metalhalide lamp, the mercury lamp, the crypton lamp and hallogen lamp ; colours of the wall are 11, from R to RP 10 colours and 1 neutrals ; and value is 3 steps, 7, 8, and 9.

As the result of multi-regression analysis, variables had similar influence on the image both residence and office interior. The multi-correlation coefficient out of most adjectives was relatively high that it was 0.8 or greater.

Considering adjectives concentrated on the partial correlation coefficient correlated highly with the interior image, as shown in Table 6 and Table 7, we could find that lightsources had the greatest influence on the both interior space. In the 「warm」 and 「soft」 adjectives, so did hue of the wall as well as lightsource. But in the adjectives related to 「Activity」 value had relatively great influence on the residence interior rather than the office interior.

Table 6. The Multi-regression Results of the Office Interior -Multi · partial Correlation Coefficient

Adjectives	Multi-correlation Coefficient (R)	Partial correlation coefficient(Range)		
		Lightsources	Wall Colour	
			Hue	Value
Natural	0.9031	**0.899 (2.112)**	0.381 (0.608)	0.335 (0.501)
Bright	0.9399	**0.935 (2.944)**	0.395 (0.685)	0.549 (0.835)
Light	0.9357	**0.927 (2.571)**	0.427 (0.629)	0.610 (0.937)
Active	0.9343	**0.925 (2.503)**	0.383 (0.588)	0.625 (0.970)
Pleasant	0.9284	**0.924 (2.436)**	0.399 (0.586)	0.504 (0.774)
Comfort	0.8896	**0.885 (1.606)**	0.312 (0.424)	0.390 (0.536)
Warm	0.8910	**0.822 (1.811)**	0.797 (1.770)	0.089 (0.168)
Soft	0.7433	**0.587 (0.786)**	0.566 (0.762)	0.352 (0.412)
Chic	0.9203	**0.916 (1.991)**	0.377 (0.405)	0.484 (0.630)
Clean	0.9265	**0.922 (2.580)**	0.397 (0.605)	0.514 (0.806)
Stable	0.8767	**0.871 (1.293)**	0.379 (0.445)	0.278 (0.287)
Clear	0.9262	**0.920 (2.770)**	0.418 (0.758)	0.548 (0.893)

Table 7. The multi-regression Results of the Residence Interior -Multi · partial Correlation Coefficient

Adjectives	Multi-correlation Coefficient (R)	Partial correlation coefficient(Range)		
		Lightsource	Wall Colour	
			Hue	Value
Natural	0.9252	**0.913 (1.408)**	0.602 (0.676)	0.532 (0.525)
Bright	0.9842	**0.963 (2.765)**	0.399 (0.297)	0.805 (0.925)
Light	0.9794	**0.977 (2.297)**	0.419 (0.323)	0.763 (0.804)
Acitive	0.9766	**0.974 (2.161)**	0.498 (0.357)	0.721 (0.729)
Pleasant	0.9360	**0.925 (1.570)**	0.460 (0.383)	0.683 (0.750)
Comfort	0.8665	**0.817 (0.977)**	0.590 (0.545)	0.510 (0.508)
Warm	0.9664	**0.953 (2.276)**	0.900 (1.534)	0.145 (0.175)
Soft	0.9359	**0.904 (1.552)**	0.830 (1.141)	0.270 (0.242)
Chic	0.9547	**0.950 (1.664)**	0.626 (0.644)	0.586 (0.525)
Clean	0.9828	**0.982 (2.262)**	0.600 (0.488)	0.702 (0.567)
Stable	0.8242	**0.741 (0.646)**	0.633 (0.541)	0.403 (0.346)
Clear	0.9842	**0.984 (2.820)**	0.444 (0.325)	0.622 (0.563)

The Influence level of variables for each image type was represented as standardization category score, which indicated how much each category affected on corresponding image type.

Table 8. The Effect of 「Light」 Image

The office Interior (R=0.9327)								The Residence Interior (R=0.9794)							
Division / Factor	Categories	Freq	Cat.score	Partia cor.	Rane	Rang weig	Cat.score Distribution -1.0 0 1.0	Division / Factor	Categories	Fre	Cat.score	Partia cor	Range	Rang weig	Cat.score Dis ribution -1.0 0 1.0
Light source	Lightbulb	13	-0.627	0.927	2.571	47.2	X11	Light source	Lightbulb	13	-0.616	0.977	2.271	66.8	X11
	Warm white	13	-0.005				X12		Warm white	13	0.026				X12
	Daylight	13	0.694				X13		Daylight	13	0.381				X13
	Cool white	13	0.469				X14		Cool white	13	0.528				X14
	Metal halide	13	0.897				X15		Metal halide	13	[illegible]				X15
	Mercury	13	1.000				X16		Mercury	13	0.963				X16
	Crypton	13	-1.491				X17		Crypton	13	-0.995				X17
	Halogen	13	-1.017				X18		Halogen	13	-1.280				X18
Colour / Hue	R	8	-0.250	0.427	0.629	21.7	X21	Colour / Hue	R	8	-0.037	0.419	0.323	9.51	X21
	YR	8	-0.358				X22		YR	8	-0.032				X22
	Y	8	0.034				X23		Y	8	0.213				X23
	GY	8	0.082				X24		GY	8	-0.045				X24
	G	8	0.217				X25		G	8	0.092				X25
	BG	8	0.212				X26		BG	8	-0.110				X26
	B	8	0.271				X27		B	8	0.073				X27
	PB	8	-0.078				X28		PB	8	0.030				X28
	P	8	0.053				X29		P	8	-0.022				X29
	RP	8	-0.020				X210		RP	8	0.055				X210
	N	24	-0.054				X211		N	24	-0.072				X211
Value	9	88	0.115	0.610	0.937	31.1	X31	Value	9	88	0.082	0.763	0.804	23.6	X31
	8	8	-0.439				X32		8	8	-0.184				X32
	7	8	-0.822				X33		7	8	-0.722				X33

Table 9. The Effect of 「Stable」 Image

The office Interior (R=0.8767)								The Residence Interior (R=0.8242)							
Division / Factor	Categori es	Fre	Cat.score	Partia cor.	Range	Rang weig	Cat.score Distribution -1.0 0 1.0	Division / Factor	Categori es	Fre	Cat.socre	Partia cor.	Range	Rang weig	Cat.score Distribut on -1.0 0 1.0
Light source	Light bulb	13	-0.290	0.871	1.293	57.0	X11	Light source	Light bulb	13	-0.050	0.741	0.646	42	X11
	Warm white	13	0.004				X12		Warm white	13	0.094				X12
	Daylight	13	0.159				X13		Daylight	13	-0.324				X13
	Cool white	13	0.454				X14		Cool white	13	[illegible]				X14
	Metal halide	13	[illegible]				X15		Metal halide	13	0.305				X15
	Mercur y	13	0.495				X16		Mercur y	13	0.092				X16
	Crypto n	13	-0.768				X17		Crypto n	13	-0.168				X17
	Haloge n	13	-0.579				X18		Haloge n	13	-0.271				X18
Colour / Hue	R	8	-0.244	0.379	0.445	24.8	X21	Colour / Hue	R	8	0.036	0.633	0.541	35	X21
	YR	8	-0.048				X22		YR	8	0.210				X22
	Y	8	-0.077				X23		Y	8	[illegible]				X23
	GY	8	-0.110				X24		GY	8	-0.143				X24
	G	8	-0.169				X25		G	8	-0.288				X25
	BG	8	0.099				X26		BG	8	-0.237				X26
	B	8	0.010				X27		B	8	-0.191				X27
	PB	8	0.040				X28		PB	8	0.176				X28
	P	8	-0.031				X29		P	8	0.092				X29
	RP	8	-0.074				X210		RP	8	0.177				X210
	N	24	[illegible]				X211		N	24	-0.029				X211
Value	9	88	[illegible]	0.278	0.267	18.2	X31	Value	9	88	[illegible]	0.40	0.346	23	X31
	8	8	-0.246				X32		8	8	0.019				X32
	7	8	-0.211				X33		7	8	-0.319				X33

In the axis I named as 「Activity」, when we compared the office interior with the residence interior, in view of colour temperature of lightsource, the daylight fluorescent lamp at 6,000K was highly assessed in the office interior, on the other hand, in the residence interior high assessment was given to the cool white fluorescent lamp. In view of colour, in the office interior the cool colour of B and BG was highly rated while in the residence interior the warm colour including hue of the Y was highly rated. In view of value, both of interior space showed the high assessment at value 9.

In the axis II named as 「Stability」, there was the greatest differences between the office and residence interior. Results analyzed by the categories in the 「Stable」 image are as follow.

The analysis by colour temperature of lightsource showed that the daylight fluorescent lamp with high colour temperature was highly rated in the office space, but in the residence living room, the cool white lamp and the warm white fluorescent lamp were highly rated. In view of colour, in the office interior neutrals or the cool colour was given high assessment but in the residence interior the warm colour was given high assessment. In both of the interiors, value was highly rated at 9.

Finally, in the axis III of 「Warmth」, there was no difference between two interior spaces. Analyis by each category showed that two interior spaces were highly rated at the incandescent lamps the lightbulb-colour fluorescent lamp, the warm white fluorescent lamp in the lightsources, warm colour and value 8, 9.

4. CONCLUSION

In this study, we manufactured the scaled model for the evaluation of the same experimental condition and analyzed assessment by each interior space.

The results of this study are as follow : experimental condition and analyzed assessment by each interior space.

The results of this study are as follow :

1)When the lightsource of three variables, lightsource, hue and value, had the greatest influence on image assessment in the interior space, then hue and value came in order.

2)In case of lightsource, the office interior received high assessment on the daylight fluorescent lamp but the residence interior received high assessment on the warm white fluorescent lamp and the cool white fluorescent lamp.

3)In case of colour, N and the cool colour were highly rated in the office interior but in the residence interior the warm colour was highly rated.

4)In case of value, there is no difference in the evaluation between two interior spaces and most adjectives showed the high evaluation at value 9.

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