

APPROPRIATE RESIDENTIAL LIGHTING ENVIRONMENT WITH VARIOUS LIGHT SOURCES AND VARIOUS INSTALLATIONS

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There is need for change from usually used light sources to more economical ones. Even in Japan, where fluorescent lamps are often used even in residential lighting, we could change halogen lamps of down lights to compact fluorescent lamps, and furthermore we could change them to LED lamps if possible. However we know the change of light sources would bring different lighting effects even with the same installation, and the appropriate lighting installations would vary in different light sources. Therefore we conducted an experiment in a real sized living-dining room to understand them.

In the experimental room, we designed 16 different lighting scenes by use of usual light sources, 15 lighting scenes with compact fluorescent lamps, and 11 different scenes with LED lamps. All lighting scenes are designed to keep their wattage use in similar. A dining table set, a sofa and table set, a PC work corner, and a television set is allocated appropriately in the room. Lighting installations used are ceiling lights, down lights, curtain lights, line lights (attached on the ceiling, the floor or the wall), stand lights for PC work, floor lights, and pendant lights for the dining table. Figure 1 shows the layout of the room and Figure 2 shows the appearance of a lighting scene.

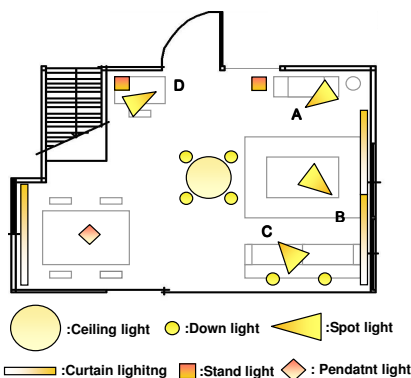


Figure 1 Layout of experiment room

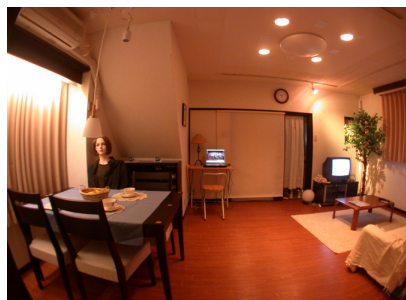


Figure 2 Example of lighting scene

12 young persons and 12 elderly persons participated in the experiment. They were asked to evaluate appropriateness of lighting environment for various assigned situations by use of 5-steps assessment scale (2: quite appropriate, 1: appropriate, 0: neutral, -1: not appropriate, -2: not appropriate at all). First they are asked to enter the room and to evaluate it as first visit of the room (assessment 1). Then they moved to the dining table, sat on the chair, and were asked to assess it in dining situation (assessment 2), and then they read newspaper and assessed it for reading (assessment 3). Next they moved to the center of the room and assessed it for housework (assessment 4). Furthermore they moved to the PC desk and assessed it in PC work situation (assessment 5), and then moved to the sofa and assessed it in 4 situations (assessment 6 to 9: watching television, enjoying family conversation, reading newspaper, and relaxing alone).

Horizontal illuminance distribution of all the lighting scenes was measured, and average illuminance and uniformity were calculated. Furthermore luminance images encompassing

103 degrees wide and 76 degrees high were captured from each eye point of the assessment situation.

Firstly we examined relationship among 9 assessments. As shown in Table 1, except assessment 9 (relaxing alone), the assessments done in the same location indicated strong correlation. Therefore generally to speak the characteristic of the appropriate lighting environment could be common to all except relaxation.

Table 1 Correlation coefficients among assessments

Elderly											Young										
	Ass 1	Ass 4	Ass 6	Ass 7	Ass 9	Ass 8	Ass 2	Ass 3	Ass 5		Ass 1	Ass 4	Ass 6	Ass 7	Ass 9	Ass 8	Ass 2	Ass 3	Ass 5		
Overall	Ass 1	1									Overall	Ass 1	1								
	Ass 4	0.907	1									Ass 4	0.972	1							
living	Ass 6	0.861	0.947	1								Ass 6	0.878	0.871	1						
	Ass 7	0.859	0.963	0.98	1							Ass 7	0.953	0.965	0.927	1					
	Ass 9	0.755	0.828	0.873	0.879	1						Ass 9	0.064	-0.03	0.239	0.04	1				
	Ass 8	0.81	0.918	0.952	0.964	0.924	1					Ass 8	0.887	0.891	0.945	0.942	0.195	1			
Dining	Ass 2	0.649	0.46	0.363	0.359	0.193	0.241	1				Ass 2	0.536	0.512	0.295	0.427	-0.4	0.291	1		
	Ass 3	0.685	0.488	0.406	0.401	0.237	0.286	0.987	1			Ass 3	0.578	0.549	0.344	0.47	-0.36	0.33	0.987	1	
PC	Ass 5	0.043	0.202	0.136	0.121	0.106	0.1	-0.23	-0.26	1		Ass 5	0.427	0.513	0.523	0.478	0.035	0.419	-0.1	-0.09	1

Secondly we examined relation between the assessment and the average illuminance, and found that there is soft correlation but there is possibility of high score under low average illuminance.

Then we examined luminance images under hypothesis that area size of a certain range of values could explain the characteristic of commonly accepted lighting environment. Logarithmic luminance images were first examined. We assigned the values to make the range from 0.25 (1.8 cd/m²) to 3 (1000 cd/m²) with 0.25 interval, calculated area sizes (%) of every combination of the values, and examined the correlation coefficients between the area sizes and the assessments. Table 2 shows the result, sorted by correlation to elderly assessment the first key and young assessment the second key. Because of our adaptation to the scene the minimum values of the high correlation ranges varies in different scene.

Table 2 Luminance range and coefficients for assessment

Luminance range		For dining		Luminance range		For converstaion		Luminance range		For housework	
min	max	Young	Elderly	min	max	Young	Elderly	min	max	Young	Elderly
0.75	1.50	0.93	0.97	0.25	1.25	0.91	0.92	0.50	1.00	0.87	0.92
0.50	3.00	0.95	0.96	0.25	1.50	0.91	0.92	0.50	1.25	0.86	0.91
0.75	1.75	0.92	0.96	0.25	1.75	0.91	0.92	0.25	1.25	0.93	0.91
0.50	2.75	0.95	0.96	0.25	2.00	0.91	0.92	0.25	1.50	0.93	0.91

The same procedure was applied to the brightness image converted from luminance image based on Nakamura's method. The value assigned were 4 NB to 10.5 NB with 0.5 interval. Table 3 shows the result sorted similarly. We can say the minimum values were quite near each other. Therefore the highest correlation range to the 7 assessments, other than relaxing alone and PC work, was examined and finally we found the area range from 5 to 8.5 NB showed highest correlation coefficient as 0.919 for the young and 0.924 for the elderly.

Table 3 Brightness range and coefficients for assessment

NB range		For dining		NB range		For converstaion		NB range		For housework	
min	max	Young	Elderly	min	max	Young	Elderly	min	max	Young	Elderly
5.50	10.50	0.96	0.97	5.50	7.50	0.88	0.92	5.50	6.00	0.91	0.94
5.50	10.00	0.96	0.97	5.00	7.50	0.91	0.92	5.50	6.50	0.87	0.93
5.50	9.00	0.96	0.97	5.50	8.00	0.88	0.92	5.00	7.50	0.94	0.92
5.50	8.50	0.96	0.97	5.00	8.00	0.90	0.92	5.00	8.00	0.93	0.92
5.50	9.50	0.96	0.97	5.50	8.50	0.88	0.92	5.00	8.50	0.93	0.92

Consequently we obtained the function to predict the assessment from the area size of brightness image by use of regression analysis. Figure 3 shows the result. The figure shows 82% and 81% of the assessment variation can be explained by the area size of brightness range of 5 to 8.5 for the elderly and the young respectively.

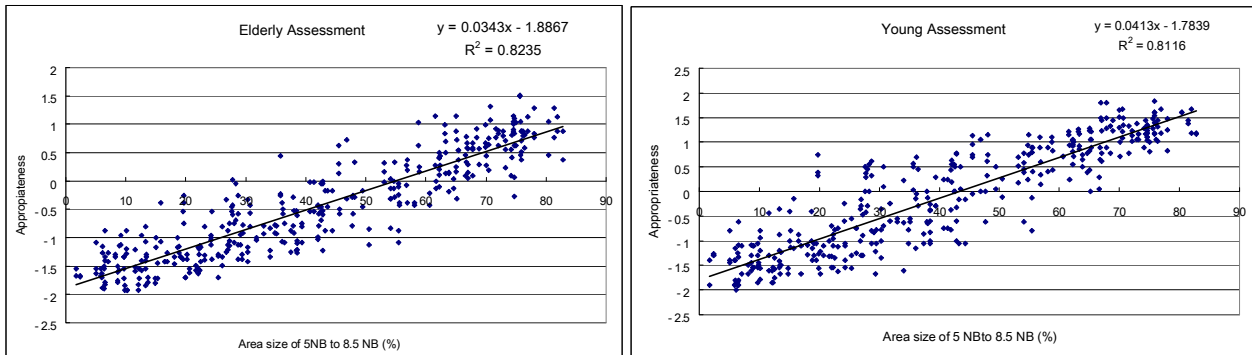


Figure 3 Prediction function of appropriate assessment