

How Lighting Conditions Affect on Interior Atmosphere? : The Difference among Generations of People

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ABSTRACT

In residential houses or buildings, luminous conditions should be comfortable for residents of all generations. In particular, the living room lighting design is complicated where various generations get together for various activities. Lighting for elderly people seems to have been studied mainly in terms of the visibility (e.g. Inoue et al. 1998¹⁾). In offices, drawing rooms or factories, visibility is obviously the most important factor. Although visibility is an essential factor in living rooms as well, it is not necessarily the only important factor.

Actually, illuminance level in the home of elderly people is usually quite similar to that in the home of younger people. Iwata et al.²⁾ show that elderly people do not prefer a high illuminance level, which appeared to be required from the previous studies¹⁾. Still elderly people need quite a high minimum illuminance level. In other words, the range of preferred illuminance level for elderly people is narrower than for younger people. Iwata et al.²⁾ also showed that young people prefer a higher illuminance level than elderly people.

This paper explores the difference among generations in evaluating interior lighting environment, and provides some knowledge for interior lighting design, which can accommodate all generations.

In accordance with the previous studies^{3) 4)}, types of luminaires, arrangements of luminaires, and the color temperature of light sources were examined as the factors related to preference of luminous environment in the interiors. Ten Computer Graphic pictures of living rooms, which had the same dimensions (W7150 mm x H2400 mm x D7600 mm) but different luminous environments were evaluated. Pictures were presented on a screen with a slide projector in a shaded dark room. The sizes of pictures were 1310 mm x 870 mm. The distance between the screen and the observing point was 3000 mm.

A Semantic Differential technique with 13 subjective scales with 5 steps was used for the evaluation. Participants were chosen from 3 age groups: young people (20 to 25 years old students), middle age people (40 to 57 years old), and elderly people (65 to 70 years old).

Factor analysis (Principal factor method with Varimax rotation) was applied to examine the difference in the evaluation construct among the 3 age groups. Similar three factors are extracted from the data of 3 age groups, which are named "Comfort", "Homeliness (Directedness)", and "Cleanliness" respectively. The cumulative contribution of the 3 factors is about 70%. According to the variances from 3 age groups, the personal equation is the largest in elderly group.

A difference among generations in evaluating interior lighting environment emerged. For example, elderly people in Japan tend to feel comfortable and directed in the room lit by general ceiling lighting with local light. They also tend to feel comfortable in the room lit with a single diffused pendant light.

These tendencies could not be explained solely by visibility. It seems that personal experience is closely related to the evaluation and preference of luminous environment. As brightness and easiness are strongly related in elderly people, visibility and atmosphere could be related. These results support the theory of three factors contributing to visual comfort in the environment⁵⁾. Further studies based on the theory should be appropriate to obtain better knowledge for interior lighting design, which can accommodate all generations.

Keywords : age group, subjective evaluation, luminaire arrangement, color temperature, preference of atmosphere, interior lighting, Semantic Differential Technique

1. INTRODUCTION

In residential houses or buildings, luminous conditions should be comfortable for residents of all generations. In particular, the living room lighting design is complicated where various generations get together for various activities. Lighting for elderly people seems to have been studied mainly in terms of the visibility (e.g. Inoue et al. 1998¹⁾) or glare (e.g. Mochizuki et al. 1997⁶⁾). In offices, drawing rooms or factories, visibility is obviously the most important factor. Although visibility is an essential factor in living rooms as well, it is not necessarily the only important factor.

Actually, illuminance level in the home of elderly people is usually quite similar to that in the home of younger people. Iwata et al.²⁾ show that elderly people do not prefer a high illuminance level, which appeared to be required from the previous studies¹⁾. Still elderly people need quite a high minimum illuminance level. In other words, the range of preferred illuminance level for elderly people is narrower than for younger people. Iwata et al.²⁾ also showed that young people prefer a higher illuminance level than elderly people.

This paper explores the difference among generations in evaluating interior lighting environment, and provides some knowledge for interior lighting design, which can accommodate all generations.

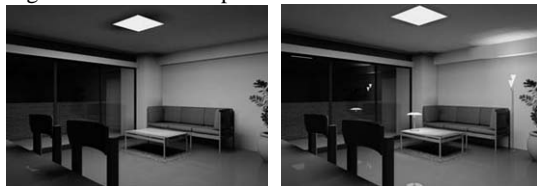
2. METHODS

2.1 Experimental Conditions

In accordance with the previous studies^{3) 4)}, types of luminaires, arrangements of luminaires, and color of light sources were examined as the

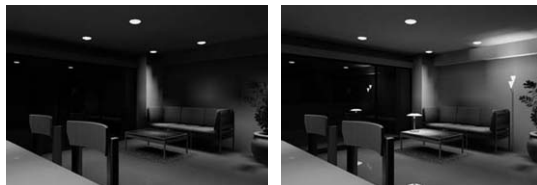


Fig.1 Picture of the experiment room



Nos.1-2

Nos.3-4



Nos.5-6

Nos.7-8



Nos.9-10

Fig.2 Samples of CG pictures

factors related to preference of luminous environment in the interiors.

Ten Computer Graphic color pictures of living rooms, which had the same dimensions (W7150 mm x H2400 mm x D7600 mm) but different luminous environments were evaluated. Pictures were presented on a screen with a liquid crystal projector in a shaded dark room. The sizes of pictures were 1310 mm x 870 mm. The distance between the screen and the observing point was 3000 mm. The appearance of the experiment room and examples of the pictures are shown in Figures 1 and 2 respectively. Conditions of luminous environments are shown in Table 1. Ceiling lights and Japanese style pendant lights are very popular for living rooms in Japan. Stands and downlighters are relatively unpopular, but preferred by designers.

2.2 Evaluation Methods

A Semantic Differential technique with 13 subjective scales with 5 steps was used for the evaluation. The language used in the evaluation is Japanese. Subjective variables translated into English are shown in Table 2.

The schedule of the experiment was as follows. First, instructions were given to the participant, and all 10 pictures were presented for 1 second each in order that participants familiarize themselves with the procedure and object environments. Then, the first picture was

Table 1 Lighting conditions

No.	Type of luminaires	Color Temperature
1	A ceiling light	2800K
2		6500K
3	A ceiling light with stands	2800K
4		6500K
5	Four recessed downlights	2800K
6		6500K
7	Four recessed downlights with stands	2800K
8		6500K
9	A Japanese style pendant light	2800K
10		6500K

Table 2 List of subjective variables

variables	
homely	- not homely
interesting	- uninteresting
fresh	- not fresh
exceptional	- ordinary
quiet	- annoying
warm	- cool
directed	- not directed
bright	- dark
mild	- rugged
feel clean	- not feel clean
comfortable	- uncomfortable
easy	- uneasy
like	- dislike

presented and evaluated. When the participant finishes the evaluation for the picture, the next picture was presented. These methods are almost the same as the previous study³⁾.

2.3 Participants

Participants were chosen from 3 age groups. Young people: 20 to 25 years old students, 6 females and 9 males. Middle age people: 40 to 57 years old, 2 females and 13 males. Elderly people: 65 to 70 years old, 7 females and 8 males.

3. RESULTS AND DISCUSSION

3.1 Factor analysis

Factor analysis (Principal factor method with Varimax rotation) was applied to examine the difference in the evaluation construct among the 3 age groups. Three factors are extracted from the data of young people, which are named “Comfort”, “Directedness”, and “Cleanliness” respectively. The cumulative contribution of the 3 factors is 68% (Table 3).

From the data of the middle age group, 3 factors are extracted as well, which are “Comfort”, “Cleanliness”, and “Directedness”. The cumulative contribution of the 3 factors is 68% (Table 4).

From the data of the elderly group, 2 factors are extracted, which are “Comfort”, “Directedness” and “Cleanliness”. The cumulative contribution of the 3 factors is 74% (Table 5).

While the 3 factors of young people and middle age people show relatively high contributions (Table 3 and 4), only the first factor of elderly people shows a high contribution (Tables 5).

In all age groups, Comfort and Warmness are included in the first factor, the positions of these two are different according to the age group. While Comfort is the primary value for young and middle age people, Warmness is the primary value for elderly people.

Whereas Directed - undirected and ordinary - exceptional are included in the same factor of young people and middle age people, they are included in different factors for elderly people.

In young and middle age people, Brightness, Freshness, and Feeling of cleanliness are strongly related to each other. While only in elderly people, Cleanliness is related to ordinary feeling. Also in young and middle age people, brightness is hardly related to Comfort, while in elderly people, brightness is essential to Comfort. It seems that as the age becomes older, brightness becomes more related to Comfort.

3.2 Factor scores and lighting conditions

Though subjective scales, which are included in the same named factor are not always the same, the same named factor generally represents the

Table 3 Factor loadings of young people

Variables	Factor 1	Factor 2	Factor 3
comfortable – uncomfortable	0.899	0.015	0.121
easy – uneasy	0.868	0.083	-0.092
quiet – annoying	0.810	0.024	0.037
like - dislike	0.779	-0.249	0.269
mild – rugged	0.777	0.239	0.288
warm – cool	0.650	0.182	0.387
directed – not directed	0.153	-0.818	-0.049
homely – not homely	0.313	0.707	0.290
exceptional – ordinary	-0.380	-0.699	-0.267
interesting – uninteresting	0.374	-0.613	0.388
bright – dark	0.268	0.036	0.735
feel clean – not feel clean	-0.049	0.054	0.725
fresh – not fresh	0.160	0.292	0.709
Eigen value	5.116	2.319	1.433
cumulative contribution (%)	39.356	57.149	68.220

Table 4. factor loadings of middle age people

Variables	Factor 1	Factor 2	Factor 3
comfortable – uncomfortable	0.885	-0.026	0.075
like - dislike	0.827	0.182	-0.208
mild – rugged	0.820	0.019	0.280
easy – uneasy	0.808	-0.156	-0.111
quiet – annoying	0.740	-0.200	0.030
interesting – uninteresting	0.655	0.365	-0.262
warm – cool	0.614	0.309	0.326
homely – not homely	0.512	0.370	0.464
feel clean – not feel clean	-0.010	0.877	-0.013
fresh – not fresh	0.043	0.830	0.087
bright – dark	-0.028	0.815	0.251
exceptional – ordinary	-0.149	-0.325	-0.769
directed – not directed	0.281	0.079	-0.700
Eigen value	4.726	2.773	1.393
cumulative contribution (%)	36.355	57.687	68.402

Table 5. factor loadings of elderly people

Variables	Factor 1	Factor 2	Factor 3
warm – cool	0.826	0.163	0.253
quiet – annoying	0.788	0.364	0.058
bright – dark	0.746	0.054	0.469
comfortable – uncomfortable	0.737	0.264	0.421
fresh – not fresh	0.672	0.051	0.460
homely – not homely	0.667	0.217	0.329
mild – rugged	0.650	0.314	0.400
interesting – uninteresting	0.650	0.197	0.477
like - dislike	0.596	0.335	0.571
directed – not directed	0.182	0.914	0.174
feel clean – not feel clean	0.146	0.244	0.846
easy – uneasy	0.441	0.230	0.694
exceptional – ordinary	-0.547	0.079	-0.628
Eigen value	8.006	0.870	0.778
cumulative contribution (%)	61.582	68.275	74.261

same value. As Ishibashi et al.⁷⁾ show that the comparison among factors is valid, factors from different age groups are compared and the relation between the 10 conditions and factor

scores are explored.

As the variances of variables are different among the age group, distributions of factor scores from each participant were investigated. Generally speaking, personal equations of the elderly group are the largest, while those of the middle age group are the smallest.

In all age group, the color temperature that is felt comfort and directed is 2800K. Personal equations except young people seem to be large in evaluating 6500K conditions. The distribution of light that is felt comfort or directed is vary among age groups.

General findings about evaluation of lighting conditions are as follows.

- A ceiling light with stands are generally felt comfortable throughout all age groups.
- For young people, non-uniform distribution of light produced by downlighters gives directed comfortable atmosphere. Uniform diffused distribution of light produced by a pendant also gives comfortable atmosphere but not felt directed.
- For middle age people, non-uniform distribution of light produced by downlighters gives directed comfortable atmosphere.
- For elderly people, luminous conditions from a ceiling light with stands are felt comfortable and directed. They also feel comfortable in luminous conditions from a pendant.

3.3 Discussions

A difference among generations in evaluating interior lighting environment emerged. These tendencies could not be explained solely by visibility. It seems that personal experience is closely related to the evaluation and preference of luminous environment. Kelly's personal construct theory⁸⁾ might be useful in evaluating luminous environment.

As brightness and comfort are related only in elderly people, visibility and atmosphere could be related. These results support the theory of three factors contributing to visual comfort in the environment⁵⁾. This theory was proposed by the author et al.⁵⁾ in order to construct a comprehensive explanation for visual comfort. Some of this kind of theory is well known. In his classic paper, Waldram explores the mechanism of interior lighting and in a flow chart defines three aspects of interior lighting: Adaptation, Revealing of Form and Texture, and Emphasis⁹⁾. In this diagram he considers three detail luminance patterns: texture pattern, shadow pattern and modelling pattern. Cuttle has subsequently extended the modelling concept and introduces a term "preferred appearance" related to the flow of light¹⁰⁾.

However, the factors contributing to visual comfort in the environment are thought to be more extensive.

The first factor is the physiological and psychological condition of the visual system. This not only includes adaptation state but also visual stress, visual fatigue, concentration or mood, etc. which are correlated with the other two factors below.

The second factor is the visibility for object discrimination related to the nature of the visual task, safety issues and security issues (feeling secure).

The third factor is the meaning of the environment. The meaning of the environment means not only the understanding of the environment but also environmental conditions favorable for survival and well-being as well as some kind of effect of "lifting the spirits"¹¹⁾. The meaning of the environment from the visual information presented can be categorized into two groups: (i) the lighting condition and (ii) the feature of the surroundings, such as their shapes, spatial arrangements and other attributes.

Further studies based on the theory should be appropriate to obtain better knowledge for interior lighting design, which can accommodate all generations.

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