Paper

Effects of House Exterior Lighting on the Evaluation of Lighting Environment on Nighttime Residential Streets

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ABSTRACT

This study examined to know how the function of house exterior lighting, especially gate lighting, entryway lighting and ornament lighting, for the evaluation of lighting environment on the nighttime residential streets. An experiment using a real residential street, where people actually live, was carried out. The results suggested that the evaluation of lighting environment can be improved not only by the amount of light but by the light fittings attached on the gate or at the entryway or on the hedge belonging to private property.

KEYWORDS : lighting environment, residential street, house exterior lighting, landscape

1. Introduction

The purpose of this paper is to examine whether lighting elements of the residence belonging to private property, especially gate lighting or entryway lighting contribute to improve the comfortable nature in lighting environment in public property.

First of all, relevant researches of the lighting on residential streets will be reviewed briefly. Requirements of street lighting have been clarified from on the necessary lighting conditions based on safety when driving a car safely[1], or crime prevention[1)2)3)]. For example, based on the discernment nature of the obstacle on a road, or the state of a road, as for Japan Industrial Standards on lighting for roads (Z9111)[1)] , the standard illuminance of a road surface or the vertical illuminance in the height (1.5m) of a person's face was defined.

Miyamae et al.[3)] examined the lighting conditions with which the visibility about the face of the person located ahead 4 meters using experimental method, and it was shown that about 2 or more lux of the vertical illuminance in the position of the face are required.

As the results of the subjectivity impression evaluation experiment which used computer graphics of residential streets, Shikakura et al.[4)] classified the impression from the street lighting environment in the night into "brightness", "uniformity", and "comfort", and then the "brightness" and the "uniformity" of them showed the correlation with the horizontal illuminance and the vertical illuminance.

Although these researches in the above illustrated invaluable suggestions about the lighting on residential streets, effects of lighting in private property, such as gate lighting or entryway lighting in the residence which will be focussed in this study were not examined.

Concerning to relevant researches about relationships between public property and private property, Newman's study[5)] on the architectural space and the prevention of crime should be mentioned. He suggested the appropriate design enhanced the consciousness of the territory and natural surveillance and it resulted to prevent the crime. His epoch-making suggestions have called a lot of researches[6)7)] et al. on relationships between fear of crime and plan of architectural space which have made sure of it and have proposed objective means. For example, Tomoda[7)] illustrated that opening the residential housing in private property to in public property or semipublic property enhanced the consciousness of the territory. His study showed useful suggestions on the architectural plan and the formation process of the consciousness of the territory. But he did not mention the function of lighting in private property (ex. gate lighting or entryway lighting) and then never examined relationships between the function of lighting in private property and that of lighting in public property (ex. street lighting), which has been studied so far.

In this study, street lighting on public roads, gate lighting and entryway lighting as house external lighting, and ornament lighting on the garden plant were chosen as elements of lighting in nighttime residential streets. Lighting

environment can be classified into lighting environment in public property, which includes street lighting on roads, and one in private property, which includes gate lighting, entryway lighting, lighting out of windows and so on. Of them, though lighting out of windows might be important element, it can be changeable to depend on how to live. The main purpose of this study is to propose the function of lighting environment in private property into the practical lighting design in public property actively, so it was excluded in this study.

2. Impressions of streets in the night

First of all, in order to clarify impressions that individuals had when walking along residential streets alone in the night, open-ended interviews were conducted. The size of subjects was 15 (6 men and 9 women). The range of years was 22-24 years. All subjects were volunteers who consisted of 9 students and 6 workers. The result showed that 87% of subjects felt fear on streets because of little human presence, the narrowness of the streets and the presence of landscape. In addition, it was indicated that feelings of fear was associated with lighting environment as the main factors.

Next, interviews on the base of Sanui's method [8] (one type of repertory grid method) attempted to examine an evaluation network about unease and evaluation items. The size of subjects was 15 (6 men and 9 women). The range of years was 22-24 years. All subjects were volunteers who consisted of 9 students and 6 workers. As results, 113 items causing fear were identified, and 110 items causing easiness were identified. Then, the former items were classified into 13 main groups which are illustrated in Table 1. More than

Table 1 Classification of elements which create feeling of fear

1	Neighborhood	Public place, turn or intersection, absence of residences etc.
2	Human presence	Absence of human presence&pedestrian traffic, visibility of faces etc.
3	Brightness	Dark, direction of light, dark background, strange color etc.
4	Atmosphere	Dense, inactive, lonely etc.
5	Greenery	Many thickets, Green taller than people etc.
6	Territory	Private space, lack of neighborliness etc.
7	Surveillance	Lack of visibility, poor surveyability etc.
8	Crime-prone	Poor public peace, tendency toward crime etc.
9	Experience	Unknown, experienced etc.
10	Spaciousness	Wide view, poor visibility, narrow street etc.
11	Visibility	Poor visibility, able to judge situation etc.
12	Predictability	Inability to find destination, inability to identify current direction etc.
13	Others	Sense that a ghost may appear, little color, a feeling of being lost etc.

Expressed by more than half of the participants

50% of subjects mentioned brightness, neighborhood, a feeling of human presence, spaciousness, the presence of greenery, and surveillance, which closely matched with results of the above mentioned open-ended interviews. It can be likelihood that these elements strongly evoke feelings of fear on residential streets in the night.

3. The relationship between feelings of fear and lighting environment on residential streets in the night

In order to clarify how the indirect effects of lighting elements in the private area, especially the gate lighting or the entryway lighting, on the nighttime residential streets influence on the evaluation of lighting environment, the operated experience was carried out on actual streets. The residential streets in this study are in Tama area in the suburbs of Tokyo and were developed by a private real-estate corporation, which was concerned with a railway company, in 1970's. Variables adopted in the experiment were the illuminance on the road surface (high, medium, and low), a light fitting (10 watt fluorescent lamp covered rectangular opal glass) attached on the gate (existence, nonexistence), light fitting (60 watt incandescent lamp covered hemispherical opal glass) attached at the porch (existence, nonexistence), ornamental lighting fittings set on the hedge (existence, nonexistence) (Table 2). The each illuminance

Table 2 Experiment variable

Street-surface illuminance	gate lighting	entryway lighting	Decorative Lighting
High (about 3.0 lx)	nonexistence	nonexistence	nonexistence
Medium (about 0.6 lx)	existence	existence	existence
Low (about 0.2 lx)			

Note) Street-surface illuminance means average illuminance in the part of the road

level of the road surface was grounded on the following. The high level was grounded on the Japan Industrial Standards on the roads lighting, the medium level was supposed on the general residential roads, and the low level was in the case of no light on the roads. The method of operating the illuminance level on the roads was to attach the filter to the existing luminaire (height: about 4.5 meters, light source: 80 watt mercury lamp) on the roads (Photo 1). The ornamental

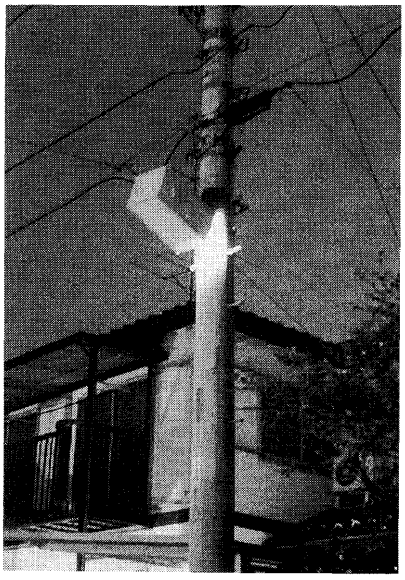

Photo 1 Method of diminishing the street lighting

lighting fittings were the ornament goods for Christmas which consist of 70 midget lamps with blinking function. Subjects stood still at the position where they could came into all view of seven housings operated as experiment variables and then answered (1) question items on the evaluation of the environment ("feelings of fear", "brightness", "feelings of human presence", and "surveillance"), (2) question items of the guess of a resident's personality ("sociability", "the degree of family relationships", "familiarity", "reliability", and "uniqueness") using the seven-grade scale. Question items on the evaluation of the environment were selected on the base of not only Newman's findings and his successors' findings, but also results of our interview survey. Question items of the guess of a resident's personality were based on findings of studies on the perception between one person and the other in Social Psychology[9]. The resident which was selected to evaluate the personality were in house C in Figure 1. The

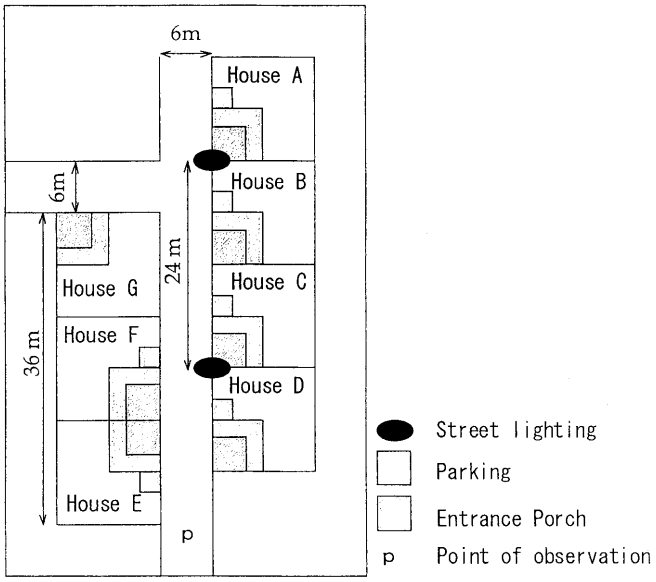

Figure 1 The outline of the street in this study

purpose of guessing personality was to examine if house exterior lighting would indicate some key information for conjecture on the owner focused, irrespective of his or her real personality. (Please note that the coincidence between guessed personality and real personality was not considered in this study.) Photo 2 illustrated the situation of this experience. The size of subjects was 18 (10 men and 8 women). The range of years was 22-28 years. All subjects were volunteers and non-residents on the street focused in this study, who consisted of 12 students and 6 workers.

Results of the evaluation on the environment

Table 3 shows results of question items on the evaluation of the environment ("feelings of fear", "brightness", "feelings of

Photo 2 The residential street in this study

human presence", and "surveillance"). The one-way analysis of variance (ANOVA) was performed to clarify the difference of rated impressions by the following 3 lighting patterns; the pattern of 3 houses (house A, house C, and house F) with gate lighting and entryway lighting among all 7 houses [3/7 on], the pattern of 7 houses with gate lighting and entryway lighting [All on], and the pattern of decorative lighting like Christmas ornamental lighting on the hedge [Decorative Lighting], in comparison with control condition; the pattern of 7 houses without gate lighting and entryway lighting [All off]. [3/7 on] was supposed to be usual setting on the street. Scores in Table 3 are the average of all subjects and the range varies 1 (Negative meaning) to 7 (Positive meaning).

When street-level illuminance was <High>, the significant effects of [All on] were found in "feelings of fear" ($p<0.05$), "brightness" ($p<0.05$) and "feelings of human presence" ($p<0.01$). In the case of [Decorative Lighting] there was significant in "feelings of fear", "brightness" ($p<0.01$) and "feelings of human presence" ($p<0.01$). Concerning to "surveillance", there was no significant among [3/7 on], [All on] and [Decorative Lighting].

When street-level illuminance was <Medium>, the significant effects of [3/7 on] were found in "feelings of fear" ($p<0.01$), "brightness" ($p<0.01$) and "feelings of human presence" ($p<0.05$). In the case of [All on] there was significant in "feelings of fear" ($p<0.05$). In addition, as [Decorative Lighting], there was significant in "feelings of fear" ($p<0.01$), "brightness" ($p<0.01$) and "feelings of human presence" ($p<0.01$). Furthermore, there were no significant effects of [3/7 on], [All on] and [Decorative Lighting] in "surveillance".

When street-level illuminance was <Low>, the significant effects of [All on] were found in "feelings of fear" ($p<0.01$), "feelings of human presence" ($p<0.01$) and "brightness" ($p<0.05$). In the case of [Decorative Lighting] there was significant in "feelings of fear" ($p<0.01$), "brightness" ($p<0.01$)

Table 3 Results of the guess of a resident's personality

	All off	3/7 on	All on	Decorative Lighting
<Street-surface illuminance High>				
Feelings of easiness	3.89	4.17	2.94*	1.78**
Brightness	4.06	3.67	2.94*	1.39**
Feelings of human presence	4.11	3.56	2.61**	2.28**
Surveillance	2.33	2.5	2.67	2.78
<Street-surface illuminance Medium>				
Feelings of easiness	4.61	2.83**	3.67*	1.89**
Brightness	4.56	3.33**	3.94	2.89**
Feelings of human presence	4.61	3.67*	4.33	2.67**
Surveillance	3.5	3.11	3.44	2.83
<Street-surface illuminance Low>				
Feelings of easiness	5.28	5.44	4.11**	3.33**
Brightness	5.5	5.17	4.61*	4.11**
Feelings of human presence	6.39	6.56	5.06**	4.72**
Surveillance	4.11	4.17	3.72	3.5

Note) **p<.01,*p<.05
Scores vary 1 (positive) to 7 (negative).
"All on" means the pattern of 7 houses without gate and entryway lighting.
"3/7 on" means the pattern of 3 houses with gate and entryway lighting among all 7 houses.
"All on" means the pattern of 7 houses with gate and entryway lighting.
Street-surface illuminance <High> is about 3.0lx.
Street-surface illuminance <Medium> is about 0.6lx.
Street-surface illuminance <Low> is about 0.2lx.
"Decorative lighting" means decorative lighting like Christmas ornamental lighting on the hedge.

Table 4 Results of the evaluation on environment

	All off	3/7 on	All on	Decorative Lighting
<Street-surface illuminance High>				
Sociability	4.50	3.28**	3.72*	2.11**
Degree of family relationships	3.89	3.28	3.50	2.61**
Familiarity	4.44	3.17**	3.72	2.61**
Reliability	3.94	3.33	3.61	3.00**
Uniqueness	3.89	4.17	3.78	2.67**
<Street-surface illuminance Medium>				
Sociability	4.33	2.78**	4.00	2.17**
Degree of family relationships	4.11	3.00**	4.00	1.94**
Familiarity	4.50	3.28**	4.28	2.28**
Reliability	4.11	3.17**	4.00	2.67**
Uniqueness	4.39	3.56*	4.22	2.61**
<Street-surface illuminance Low>				
Sociability	4.28	4.28	4.11	2.83**
Degree of family relationships	4.28	3.94	3.67	2.83**
Familiarity	4.83	4.39	4.06	2.78**
Reliability	4.11	4.06	4.33	3.39*
Uniqueness	4.22	4.56	4.39	3.44

Note) **p<.01,*p<.05
Scores vary 1 (positive) to 7 (negative).
"All on" means the pattern of 7 houses without gate and entryway lighting.
"3/7 on" means the pattern of 3 houses with gate and entryway lighting among all 7 houses.
"All on" means the pattern of 7 houses with gate and entryway lighting.
Street-surface illuminance <High> is about 3.0lx.
Street-surface illuminance <Medium> is about 0.6lx.
Street-surface illuminance <Low> is about 0.2lx.
"Decorative lighting" means decorative lighting like Christmas ornamental lighting on the hedge.

and "feelings of human presence" ($p<0.01$). Concerning to "surveillance", there was no significant among [3/7 on], [All on] and [Decorative Lighting] like as in the case of <High> street-level illuminance and <Medium> street-level illuminance.

Summarizing the above-mentioned results, in the case of street-level <High> and <Low>, it was shown that using lighting methods of [All on] and [Decorative Lighting] decreased "feelings of fear" and increased "feelings of human presence", while effects of [3/7 on] was no significant.

In the other hand, when street-level illuminance was <Medium>, it resulted that the lighting methods of [3/7 on] and [Decorative Lighting] increase "feelings of fear", and decreased "brightness" and "feelings of human presence", while effects of [All on] was no significant except improving "feelings of fear". Similarly, in the case of street-level illuminance <Medium>, there was no significant except the above mentioned relationships.

Results of the guess of a resident's personality

Table 4 shows results of question items of the guess of a resident's personality ("sociability", "the degree of family relationships", "familiarity", "reliability", and "uniqueness").

The one-way analysis of variance (ANOVA) was performed to clarify the difference of evaluation by the following 3 lighting patterns; [3/7 on], [All on], and [Decorative Lighting], in comparison with [All off] as same as evaluation on the environment before. Similarly, scores in Table 4 are the average of all subjects and the range varies 1 (Negative meaning) to 7 (Positive meaning).

When street-level illuminance was <High>, the significant effects of [3/7 on] were found in "sociability" ($p<0.01$) and "familiarity" ($p<0.01$). The significant effects of [All on] were found in "sociability" ($p<0.05$). Then, in the case of [Decorative Lighting], there were significant differences in all the items: "sociability" ($p<0.01$), "the degree of family relationships" ($p<0.01$), "familiarity" ($p<0.01$), "reliability" ($p<0.01$), and "uniqueness" ($p<0.01$).

When street-level illuminance was < Medium >, the significant effects of [3/7 on] were found in "sociability" ($p<0.01$), "the degree of family relationships" ($p<0.01$), "familiarity" ($p<0.01$), "reliability" ($p<0.01$), and "uniqueness" ($p<0.05$). In the same way as <High> of street-level illuminance, in the case of [Decorative Lighting], there were significant differences in all the items: "sociability" ($p<0.01$),

"the degree of family relationships" ($p<0.01$), "familiarity" ($p<0.01$), "reliability" ($p<0.01$), and "uniqueness" ($p<0.01$).

When street-level illuminance was < Low >, the significant effects of [Decorative Lighting] were found in "sociability" ($p<0.01$), "the degree of family relationships" ($p<0.01$), "familiarity" ($p<0.01$) and "reliability" ($p<0.05$). In the case of [3/7 on] and [All on], there were no significant differences in all the items.

As the results, irrespective of street-level illuminance, it showed that using [Decorative Lighting] made effects for people to guess that the residence had positive personality. In addition, it was illustrated that in the conditions of <High> and < Medium> of street-level illuminance, the lighting method of [3/7 on] made people guess the residence as having positive personality.

4. Discussion

In this session, on the base of the results which were mentioned above, first, the matters which are connected with the results directly will be examined. Next, the problems to be solved in the future will be mentioned. Finally, the perspective will be discussed to apply the findings in this study to practical lighting designs.

First, the results of the evaluation on environment will be considered. It resulted that using lighting methods of [All on] and [Decorative Lighting] decreased "feelings of fear", and increased "feelings of human presence" and "feelings of human presence" in cases of <High> and <Low> of street-level illuminance. Then, in the case of < Medium > of street-level illuminance, it was shown that lighting methods of [3/7 on] and [Decorative Lighting] increase "feelings of fear", and decreased "brightness" and "feelings of human presence".

The first consideration is taken into reasons why the number of gate lighting and entryway lighting made effects on the evaluations differently between <High> or <Low>, and <Medium> of street-level illuminance. When illuminance level is higher, that is, more bright on the streets, the higher illuminance seems to increase the evaluation of environment more positively. If the number of gate lighting and entryway lighting increases slightly like in the case of [3/7 on], it does not effect the evaluation strongly. Once all of gate lighting and entryway lighting are lit like in the case of [All on], the effects may influence on the evaluation significantly. In addition, when illuminance level is lower, that is, less bright on the streets, the lower illuminance seems to decrease the evaluation of environment more negatively. Similarly, if the number of gate lighting and entryway lighting increases slightly like in the case of [3/7 on], it does not effect the evaluation strongly. Once all of gate lighting and entryway lighting are lit like in the case of [All on], the effects may influence on the evaluation significantly. In the other hand, when illuminance level is medium, it does not have so strong effects on the evaluation of the environment. In such a case, if the number of gate lighting and entryway lighting increases slightly like in the case of [3/7 on], it makes effects the evaluation significantly. It means that illuminance level on streets should be also considered in order to maximize the effects of gate lighting and entryway lighting.

The lighting method of [Decorative Lighting] revealed to have strong effects on the evaluation of the environment except for "surveillance". As the reasons, [Decorative Lighting] consists of a lot of bright midget lamps, which can be easy to make effects of sparkle [10]. In addition, its blinking function might enhance the attention toward it. However, more quantitative analyses (the number of lumps, the existence of blinking function or not, and the position in the porch et al.) should be considered in the future. Moreover, in recent Japan, decorative lighting has been set up in not only the commercial facilities but also the individual residence in the season of the Christmas and then it has invited the people except for inhabitants with a purpose of seeing it in some of the residential areas which many residences where decorative lighting is installed. As the results, noise by the non- inhabitant and a problem such as dispersion of the trash have been apparent. It must be examined as for the side of the minus of decorative lighting as well.

Concerning the question item of "surveillance", there were no significant differences in all of the illuminance level on streets. The following interpretations come to mind. The first one is that increasing the number of housings with lit gate lighting or lit entryway lighting has the effect of increasing "feelings of human presence" but not has the power of improving the quality of "surveillance". The second one is that the term of "surveillance" can be ambiguous for the subjects to understand. That is, the subjects can understand it as different nuance, when it is defined as the environmental efficiency for the subjects to observe something, or as the degree of feelings that the other people observe the subjects. Moreover, the term of "surveillance" in itself is unfamiliar in daily life and difficult for the subjects to understand. Thus, The ambiguousness of interpretations on the term could lead to be confusion. It cannot be judged within this study whether which reason is right or not, and the further examination should be carried out.

Next, results of the guess of resident's personality will be examined. Irrespective of street-level illuminance, it showed that using [Decorative Lighting] made effects for people to guess that the resident had positive personality. In addition to the same reasons as the evaluation of environment, [Decorative Lighting] is the private lighting as an amusement without uses or purposes, which made the subjects evaluate the resident as possessing positive personality. It suggests that in the case of the medium number of gate lighting or entryway lighting as like [3/7 on], it has significant effects on the guess of the personality, while effects of them have less effects in the case of [All on]. As the results, the relationship between the number of gate lighting

or entryway lighting, and the guess of the personality seems be not positive correlation simply but the optimal number of the number of gate lighting or entryway lighting might exist to maximize the evaluation. Furthermore, turning on gate lighting or entryway lighting can make the same effects as putting garden plants and their personal belongings in the front of the porch leads to present the resident's personality[11)12)]. However, it was not sure whether the personality guessed by subjects in this study was the same as the real personality of the owner or not. In this time, we could not consider it because of time limitation. The further study on coincidence between guessed personality and real personality should be carried out to support the findings in this study.

In conclusion, it was shown that the research hypothesis, that light in the private area such as gate lighting, entryway lighting and decorative lighting influenced the evaluation of environment in the public area and the guess of inhabitant's personality, was supported. Then, the results in this study indicated that not only enhancing the illuminance level by increasing the number of street lighting or improving street lighting, but also considering the other aspects except "brightness": turning on gate lighting or entryway lighting in the private area, would make effects on improving the environment in residential streets. In addition, the illuminance level on streets should be considered to make use of the effects of the gate lighting and entryway lighting.

It is not clear to be able to generalize the findings, because this study is based on the investigation in 1 residential area in the suburbs of Tokyo. We will conduct the additional studies using the other residential streets which have different history, the different forms, different lighting setting, and distinct surroundings in the near future. Furthermore, though the light out of windows was excluded in this study as mentioned in Introduction, there are many academic interests to examine the effects of the light out of windows, in order to in-deeply understand the influence of the light in the private area on the evaluation of light environment in the public area.

Finally, the perspective will be discussed to apply the findings in this study to practical lighting designs. Though the gate lighting and entryway lighting have the strong point to be installed easily into small street space where it is difficult to build ordinal street light, the gate lighting and entryway lighting in themselves are controlled by an inhabitant independently and installing them and how to manage them are entrusted to the judgment of the inhabitant who is the possession of them. According to our interview survey with inhabitants who offered their housings after this experiment, more than 80% of them answered that the purpose of gate lighting and entryway lighting was turned on for their family and turned off just after all of their family came home. In order to include gate lighting and entryway lighting in private property for the practical lighting plan on streets, the agreement about the risk against the burden of the cost to the management and the control and the accident and so on, should be formed between the administration of public property and the inhabitant. Furthermore, inhabitant's privacy might be violated by providing gate lighting and entryway lighting in private property for the public welfare. The research on between public welfare and the individual right in the consideration of social dilemma should be carried out in the future.

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