A Study on the Effect of Blue Light Illumination upon Smoking Behavior

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Abstract

Recently much attention has been paid to blue light illuminations in the streets. In the present study, the effect of blue light illumination on smoking behavior was examined by an ecological method. In the experiment, the number of the cigarette butt left in the smoking spots in the campus of Kanagawa University under white light illumination and blue light illumination was counted twice everyday for 2 months from October to December, 2010. Four smoking spots were chosen for each of white and blue light illuminations. The results indicated that smoking behavior was not much affected by blue light illumination. It was suggested that the effect of light illumination takes longer time to appear, resulting in an ambiguous effect in the present study.

KEYWORDS: blue light illumination, lighting, smoking, relaxation

INTRODUCTION

Recently much attention has been paid to blue light illuminations applied to the streets in Glasgow, a city in Scotland. Although those blue light illuminations were applied, changed from orange light ones, in 2000 originally to improve the landscape of the shopping streets of the city (Fukuda, 2008; Kanashiro, 2008; Kubo, 2008; Sudani, 2008), almost 10,000 crime numbers decreased there in a year as the byproduct.

Blue light illuminations were attempted in Nara City in Japan as soon as in 2005 for the way of crime prevention. As the effect of it was obvious, the blue light illuminations have spread in at

least 17 prefectures in Japan including Aomori, Fukushima, Gunma, Kanagawa, Shizuoka, Aichi, Hiroshima, and Okinawa. The blue color was set as a symbol of safety by Aomori prefectural police and Fujinomiya City, Shizuoka Prefecture. Blue light illuminations are thus considered to be useful for crime prevention and the identification of its activity as well (Fig. 1).

More recently blue light illuminations were attempted at the railway crossings , e.g. Hanwa Line, Osaka in JR West, 2006 and the platforms of the stations, e.g. Gumyoji Station ,Yokohama in Keikyu Railways, 2008, with the purpose of suicide prevention.

The East Japan Railway set up the blue light LED at the edge of the platform in all 29 stations of Yamanote Circle Line in 2009 (Fig. 2). No other railway company in Japan adopted those blue lighting for all stations throughout the line. JR East says if it is useful, they are planning to adopt blue light illuminations in other lines.

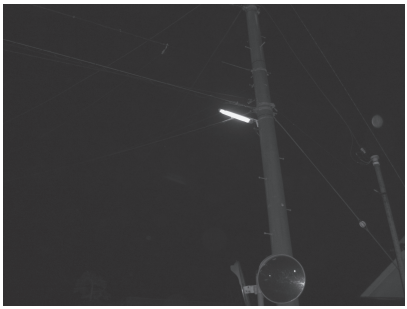

Fig. 1 A blue light street illumination in the author's hometown (Fujinomiya City, Shizuoka)

Fig. 2 Lighting by blue light LED at Gotanda Station in Yamanote Line

Thus blue light illuminations appear to give feeling of relaxation to people under it. If so, it is predicted that people's smoking behavior should decrease under blue light illuminations.

In the present study, the subjects (e.g. smokers) were bathed in blue light illumination for a short time just as when it is used for the suicide prevention. The objective of the present

study was to see how the number of cigarette butts would change under blue light illumination. The predicted results were the decrease in the number of cigarette butts with the assumption that blue light illumination would bring emotional relaxation.

METHOD

Apparatus, stimulus and illumination

The specifications of the light sources are shown in Table 1. The average illuminance in the horizontal plane was measured with MINOLTA T-10 on each ashtray which was about 100cm high in average from the ground. The illuminance was measured at between 19:00 and 21:30.

Table 1 The specifications of the light sources

condition	smoking spots		the light sources	color appearance	electricity consumption electricity	total luminous flux	average illumination
				(color temperature:K)	W	lm	lx
The blue light illumination	Bldg. 1	before	HITACHI FLR40SW/M-B	White (4,200K)	40	3,000	34.28
		after	Panasonic FLR40S・EB/M	Blue	40	1,100	11.95
	Bldg. 24	before	HITACHI FHT24EX-L-B	Highlumic Incandescent (3,000K)	24	1,800	20.17
		after	Panasonic FDL27EB	Blue	27	440	9.80
	East gate	before	HITACHI FHT24EX-L-B	Highlumic Incandescent (3,000K)	24	1,800	131.50
		after	Panasonic FDL27EB	Blue	27	440	60.85
	West gate	before	HITACHI FHT24EX-L-B	Highlumic Incandescent (3,000K)	24	1,800	127.73
		after	Panasonic FDL27EB	Blue	27	440	83.55
The white light illumination	Bldg. 4		HITACHI HRF250X	(4,100K)	250	9,500	3.50
	Bldg. 5		HITACHI HRF250X	(4,100K)	250	9,500	3.24
	Bldg. 8		HITACHI FLR40SW/M-B	White (4,200K)	40	3,000	69.14
	Bldg. 11	under roof	HITACHI FLR40SW/M-B	White (4,200K)	40	3,000	3.14
		side of Bldg. 25 (outdoor light)	Panasonic FL20SS・ENW/18X	Natural	18	1,470	
		outdoor light (cage pattern)	HITACHI HF400X	(4,100K)	400	22,000	

(note) The value : from the catalog of each company.
The average illuminance : taken the illuminance measured at between 19:00 and 21:30
(The location of measurement was about 100cm high in average from the ground).
The light sources : the product number, the name of articles or the form.

The luminance was measured with MINOLTA CS-100 (Table 2).

Table 2 The chromaticity coordinates of the lights and the luminance on the ashtrays in the smoking spots (see the text for detail)

date	spot	luminance (cd/m²)	×	y
2010/9/29	Bldg. 1	8.73	0.366	0.408
	Bldg. 24	6.52	0.327	0.388
	East gate	27.00	0.431	0.437
	West gate	35.50	0.391	0.428
	Bldg. 4	6.29	0.318	0.381
	Bldg. 5	4.50	0.353	0.427
	Bldg. 8	19.00	0.361	0.407
	Bldg. 11	17.60	0.249	0.282

date	spot	luminance (cd/m²)	×	y
2010/10/17	Bldg. 1	2690	0.153	0.098
	Bldg. 24	8860	0.158	0.133
	East gate	10800	0.159	0.136
	West gate	9840	0.159	0.136
	Bldg. 4	2590	0.361	0.458
	Bldg. 5	2010	0.374	0.455
	Bldg. 8	21.7	0.357	0.403
	Bldg. 11	31400	0.352	0.465

The same date as Table 2 was plotted in Figure 3.

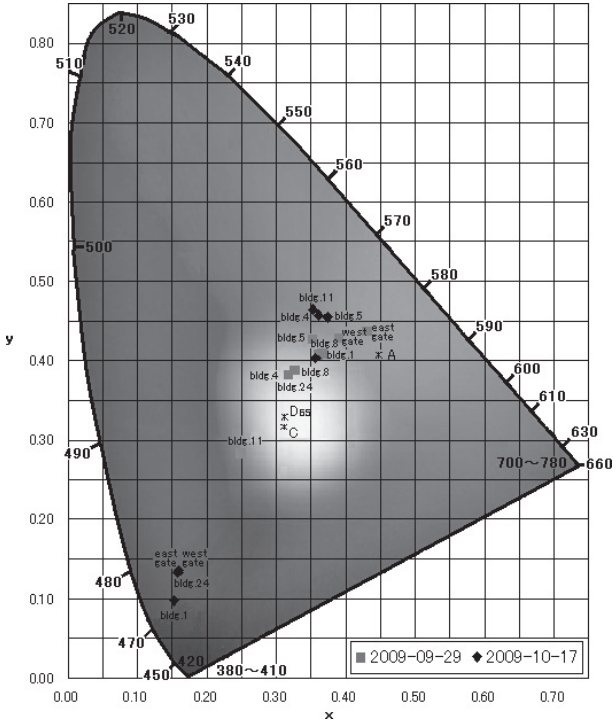

Fig. 3 The chromaticity coordinates of illuminating lights. (The coloration of this diagram was done by the author herself.)

Smoking spots

In total 8 smoking spots in the university campus were chosen as indicated in Figure 4.

For blue light illuminations, they were the spots at Building 1, East Gate, West Gate, and Building 24, and for white light illuminations, the spots at Building 4, Building 5, Building 8, and Building 11.

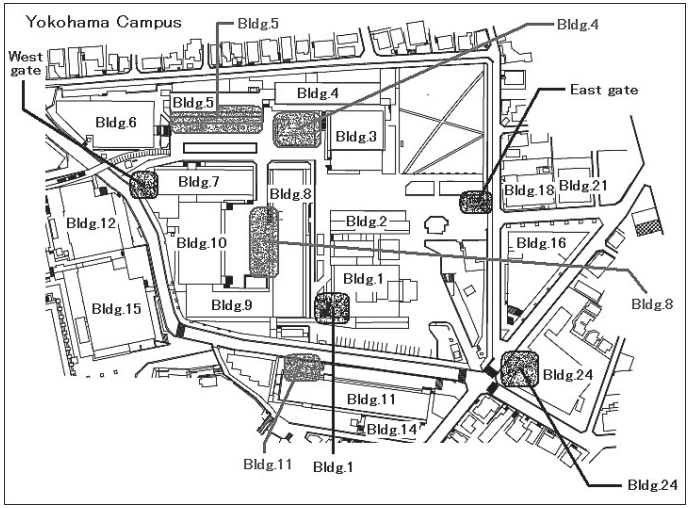

Fig. 4 Smoking spots in the university campus (2009–10–05)

All of 4 smoking spots with blue light illumination were under the roof, while the other 4 spots with white light illumination were without roof. The number of ashtrays, the distance between the ashtray and the light source and the number of light sources were different for each smoking spots.

Experimental period

The study was carried out everyday between the 5th of Oct. in 2009 and the 13th of Nov. in 2009 except for Saturday and Sunday. After, that period from the 17th of Nov. to the 10th of Dec. in 2009, it was made on Tuesday and Thursday.

Participants

Kanagawa university students and staffs participated in the present study. Almost all of them were students. All the participants were smoking by definition. They were not familiar with the objective of the study.

Procedure

Blue light illuminations were turned on at 4 smoking spots among 8 ones in the campus (Fig. 4).

The number of cigarette butts left in the ashtrays under each of blue light illuminations and white light illuminations was collected and counted everyday except Saturday and Sunday during the period.

Data (cigarette butts) were collected twice a day, first at around 17:00 for cigarette butts left between 9:00 and 17:00 and second at around 21:00 for those left between 17:00 and 21:00. Those data were analyzed separately in order to make sure whether there is any difference for different collecting times.

Only their weight was taken as data for cigarette butts collected between 9:00 and 17:00, and both their weight and number were taken as data for those collected between 17:00 and 21:00.

Such procedure as this was adopted in order to check the variation of the data which might occur by illuminance, not color, at each spot, and the weather of the day or any other unexpected factors.

The collection of the cigarette butts asked the cleaner of the university maintenance for Building 4, Building 5, Building 8, Building 11, East gate and West gate at 17:00. Building 1 and Building 24 were done by the author herself. And, all of 8 spots were collected as 21:00 by the author herself.

RESULTS

Table 3 shows the net weight and the number of cigarette butts left at the ashtrays between 17:00 and 21:00.

Kitchen scale UH-3201 of the A&D Co. was used for the weighing. In fact the number of the filter of the cigarette butts was counted for date.

Some dates were not obtained due to the typhoon #18 and the university festival when few students were there.

The weather in Tables 3, were judged by the author herself. In the first half of the period, it was described with either of

Table 3 The change in the weight and the number of cigarette butts in each smoking spots during the period (time: 17:00～21:00)

date	weather	Bldg.1		Bldg.24		East gate		West gate		subtotal		Bldg.4		Bldg.5		Bldg.8		Bldg.11		subtotal		sum total	
		g	n.	g	n.	g	n.	g	n.	g	n.	g	n.	g	n.	g	n.	g	n.	g	n.	g	n.
10/5(mon)	rain	–	36	–	50	–	76	–	1	–	163	–	20	–	91	–	58	–	7	–	176	–	339
10/6(tue)	rain	–	27	–	55	–	95	–	84	–	261	–	20	–	121	–	61	–	9	–	211	–	472
10/7(wed)	rain	26	43	123	53	278	123	1	2	428	221	70	35	64	70	276	122	11	8	421	235	849	456
10/8(thu)	typhoon	Data is excluded due to the typhoon.																					
10/9(fri)	fine	33	20	55	55	106	46	16	34	210	155	80	40	29	72	146	78	7	25	262	215	472	370
10/12(mon)	fine	21	7	111	40	168	60	35	71	335	178	113	48	45	82	251	122	11	14	420	266	755	444
10/13(tue)	fine	49	25	138	65	126	51	28	62	341	203	101	48	32	78	125	70	12	23	270	219	611	422
10/14(wed)	fine → rain	34	36	135	60	157	62	20	40	346	198	114	54	68	113	235	124	3	7	420	298	766	496
10/15(thu)	fine	37	35	65	76	199	79	34	71	335	261	107	62	56	115	188	93	5	11	356	281	691	542
10/16(fri)	fine	46	35	138	57	200	73	36	76	420	241	109	49	43	95	43	78	16	18	211	240	631	481
10/19(mon)	fine	8	17	47	38	219	93	32	64	306	212	213	99	41	98	407	161	14	25	675	383	981	595
10/20(tue)	fine (gale)	24	13	87	60	187	85	23	51	321	209	158	78	49	99	171	73	10	24	388	274	709	483
10/21(wed)	fine	37	35	103	42	237	100	17	34	394	211	179	80	65	143	220	110	20	18	484	351	878	562
10/22(thu)	fine	44	26	116	77	237	98	20	40	417	241	111	62	68	133	591	262	3	8	773	465	1190	706
10/23(fri)	fine	24	26	153	63	166	75	20	44	363	208	96	46	44	86	156	62	11	28	307	222	670	430
10/26(mon)	rain → typhoon	53	27	112	51	154	64	22	41	341	183	63	25	154	78	241	103	4	2	462	208	803	391
10/27(tue)	fine	15	23	38	80	174	83	24	56	251	242	92	58	42	99	166	68	11	12	311	237	562	479
10/28(wed)	fine	47	26	107	53	189	87	28	59	371	225	157	90	126	102	379	156	9	16	671	364	1042	589
10/29(thu)	fine	27	40	135	66	190	74	30	64	382	244	120	63	51	87	320	133	3	8	494	291	876	535
10/30(fri)	fine	Data is excluded due to the university festival.																					
11/2(mon)	fine (gale)	44	17	98	39	140	64	54	63	339	183	110	55	65	94	271	117	5	10	451	276	790	459
11/3(tue)	fine	36	18	124	57	65	29	21	48	246	152	91	46	35	75	137	61	7	15	270	197	516	349
11/4(wed)	fine	44	26	127	55	144	69	27	55	342	205	89	57	41	84	246	140	6	14	382	305	724	510
11/5(thu)	fine	90	42	133	53	109	74	26	54	358	223	45	60	26	60	264	117	12	7	347	244	705	467
11/6(fri)	fine	25	24	133	48	61	77	32	40	251	189	27	61	57	100	178	76	14	29	276	266	527	455
11/9(mon)	cloudy	50	19	160	60	66	70	37	77	313	226	26	59	67	116	303	128	13	24	409	327	722	553
11/10(tue)	rain	54	23	182	71	54	67	31	68	321	229	38	52	59	90	242	94	7	8	346	244	667	473
11/11(wed)	rain	84	37	113	50	39	67	38	71	274	225	147	63	136	58	210	88	23	12	516	221	790	446
11/12(thu)	rain → cloudy	50	25	111	42	91	74	29	63	281	204	27	41	72	92	263	116	4	3	366	252	647	456
11/13(fri)	cloudy → rain	50	16	100	41	91	56	25	42	266	155	25	19	42	48	136	57	38	18	241	142	507	297
11/17(tue)	rain	39	25	156	68	42	52	29	50	266	195	31	13	79	34	46	15	20	9	176	71	442	266
11/19(thu)	cloudy	80	33	195	72	127	59	25	51	427	215	67	39	79	79	158	69	10	5	314	192	741	407
11/24(tue)	cloudy	58	34	122	52	140	65	27	55	347	206	36	46	33	78	176	76	4	11	249	211	596	417
11/26(thu)	fine	66	26	92	60	140	68	17	37	315	191	50	73	76	122	212	94	13	19	351	308	666	499
12/1(tue)	fine	21	10	77	30	146	94	51	65	295	199	14	37	37	66	158	72	9	19	218	194	513	393
12/3(thu)	rain	76	28	118	48	145	67	21	36	360	179	18	10	45	18	92	43	17	8	172	79	532	258
12/8(tue)	fine → rain	63	24	153	72	211	89	39	74	466	259	151	79	68	108	156	82	10	21	385	290	851	549
12/10(thu)	fine	85	37	180	84	154	67	46	97	465	285	34	47	48	100	227	112	3	8	312	267	777	552
average		45	27	119	57	146	73	28	54	338	210	86	51	60	88	217	97	11	14	374	251	712	461

n : number of cigarette butts (g, n)
g : weight of cigarette butts

"Fine" or "Rain". In the latter half, it was described with "Fine", "Cloudy" or "Rain" (The data corrected from the Japan Meteorological Agency HP).

Figure 5 shows the number of cigarette butts in 4 spots during the period of between 17:00 and 21:00.

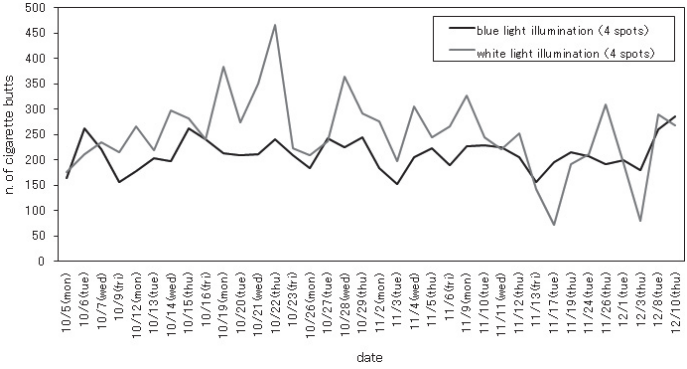

Fig. 5 The change in the number of cigarette butts (time: 17:00～21:00)

As shown in the number of cigarette butts under white light illuminations were longer than that under blue light illumination.

Figure 6 shows relative the number of cigarette butts at 4 blue lighting spots (B) the number of cigarette butts in 8 spots (B+W).

The vertical dotted line in the figure indicates 50% of B/(B+W) which was obtained, by chance, on the very first day of blue light illuminations.

After blue light illuminations were set up, the ratio was kept always at 50% or lower. There seen two abrupt increase on Nov. 17th and Dec. 3rd, which was maybe due to serious by bad weathers.

The relation between the weight and the number of cigarette butts was shown in Figure 7 for blue light illuminations.

The weight and the number of cigarette butts changed clearly in a parallel way.

The average weight of one cigarette butt was calculated for

$$\frac{\text{Number of cigarette butts under blue light illumination (B)}}{\text{Number of cigarette butts under white light illumination (W)} + \text{Number of cigarette butts under blue light illumination (B)}}$$

Table 4 The relative number of cigarette butts under each light illumination and average air temperature

date	weather	average air temperature	B / W+B	W / W+B
unit		℃	%	%
10/5(mon)	rain	19.1	48	52
10/6(tue)	rain	17.2	55	45
10/7(wed)	rain	16.9	48	52
10/9(fri)	fine	20.0	42	58
10/12(mon)	fine	18.2	40	60
10/13(tue)	fine	19.2	48	52
10/14(wed)	fine → rain	17.9	40	60
10/15(thu)	fine	17.6	48	52
10/16(fri)	fine	17.9	50	50
10/19(mon)	fine	19.4	36	64
10/20(tue)	fine (gale)	21.7	43	57
10/21(wed)	fine	18.7	38	62
10/22(thu)	fine	18.4	34	66
10/23(fri)	fine	18.0	48	52
10/26(mon)	rain → typhoon	14.2	47	53
10/27(tue)	fine	19.0	51	49
10/28(wed)	fine	17.4	38	62
10/29(thu)	fine	16.4	46	54
11/2(mon)	fine (gale)	13.3	40	60
11/3(tue)	fine	10.6	44	56
11/4(wed)	fine	12.1	40	60
11/5(thu)	fine	13.7	48	52
11/6(fri)	fine	15.2	42	58
11/9(mon)	cloudy	17.1	41	59
11/10(tue)	rain	17.7	48	52
11/11(wed)	rain	16.7	50	50
11/12(thu)	rain → cloudy	13.0	45	55
11/13(fri)	cloudy → rain	10.7	52	48
11/17(tue)	rain	9.8	73	27
11/19(thu)	cloudy	7.6	53	47
11/24(tue)	cloudy	11.7	49	51
11/26(thu)	fine	14.2	38	62
12/1(tue)	fine	11.4	51	49
12/3(thu)	rain	10.0	69	31
12/8(tue)	fine → rain	9.9	47	53
12/10(thu)	fine	11.1	52	48

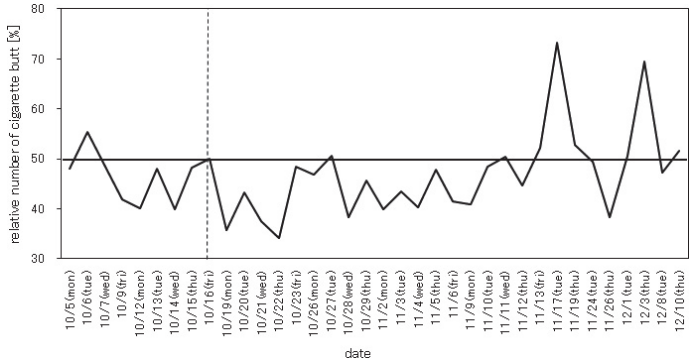

Fig. 6 The change in the relative number of cigarette butts under blue light illumination (time: 17:00～21:00)

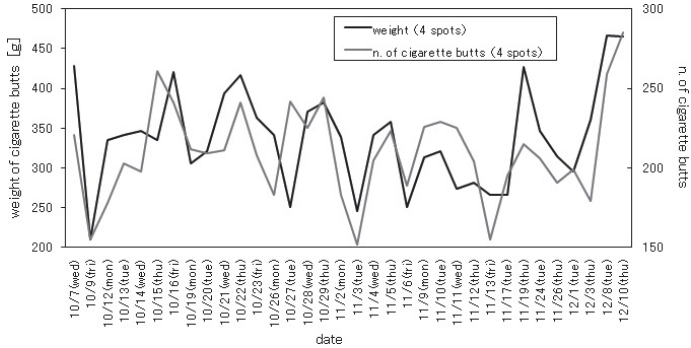

Fig. 7 The weight and the number of cigarette butts under blue light illumination (time: 17:00～21:00)

date at the West Gate.

As shown in Figure 8, the weight of one cigarette butt was almost constant.

Figure 9 shows the number of cigarette butts at 8 spots and average air temperature.

The number of cigarette butts and average air temperature went in a parallel between 17:00 and 21:00 except for the periods between Oct. 5th and Oct. 20th.

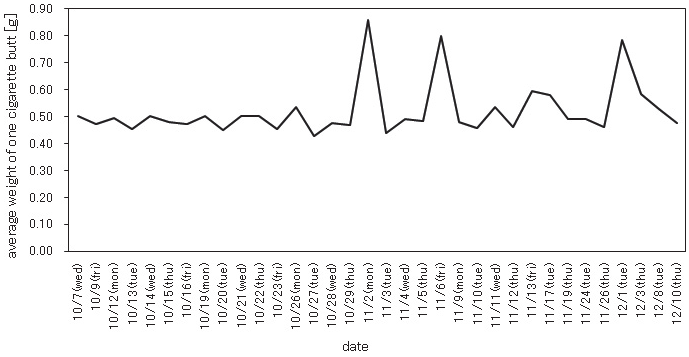

Fig. 8 Average weight of one cigarette butt at the west gate (time: 17:00～21:00)

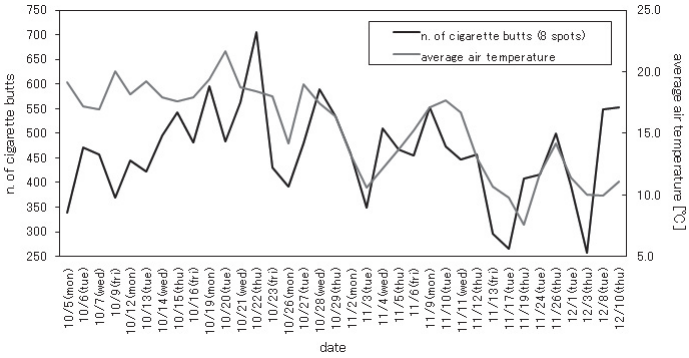

Fig. 9 Number of cigarette butts and average air temperature at 8 smoking spots (time: 17:00～21:00)

DISCUSSION

The hypothesis in the present study was not proved, in which it was assumed that the smoking behavior should be affected from psychological effect by a blue light illumination. There seems to be several reasons for it.

First, the time in which the participants spent for smoking in the blue light illumination was too short. For the electroencephalogram, the blood pressure, and the heart rate to

be evoked, the subject should be under the light as long as one hour (Shimagami, 1992; Kubo & Inoue, 2008). For the amylase of the salivary enzyme to respond, it must take 15 minutes (Mizuno et al., 2002).

In this study, the participants must have spent perhaps for at longest 5 minutes under blue light illumination for smoking, causing no or very week physiological or psychological effect.

Second, the lighting environment was different for the white light illumination and the blue light illumination. The lighting environments for each color illumination were difficult to control. Furthermore, since the smoking spots were in the outside of the buildings, such natural factors as weather and air temperature were not constant. The weather and the air temperature must somehow affect the behavior of the smokers (Fig. 9). The seasonal effect should also be included in this factor.

Third, some participants began to know the objective of this study, preventing them from smoking under blue light illuminations.

Fourth, blue light illumination does not have relaxation effect. Some studies suggest that blue light illumination was not effective for relaxation (Sato, cited in Oishi, 1999; Kubo & Inoue, 2008).

Lastly it might be that it is difficult for smokers to change their mind with the light illumination of whatever colors, because they came to the smoking spots after deciding their minds to smoke.

Further study, including methodological examination, should be necessary.

CONCLUSION

The smoking behavior was not affected under the blue light illumination, showing no or little relaxation effect as long as it was investigated form September to December. Some reasons for it

were briefly argued.

ACKNOWLEDGMENTS

The author expresses her deep gratitude to Mr. Hayashi Koji, a chief of facilities division of Kanagawa University for information of the illumination and the construction of the light systems.

She also greatly appreciates Mr. Yagi Shigeji a chief manager of the maintenance and his cleaners for collecting cigarette butts.

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青色照明が喫煙行動に及ぼす影響について

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キーワード；青色照明、照明、喫煙行動、リラックス効果

最近、青色照明についての関心が高まっている。2000 年にイギリス北部の都市グラスゴーで、景観改善を目的に照明の色をオレンジ色から青色に変えたところ、偶然にも犯罪発生件数が年間約 1 万件減少するという現象が起きた。日本では 2005 年に奈良市が青色照明を導入し、犯罪が現象したという報告がなされている。また、つい最近では踏切やプラットホームに設置され、自殺防止にも役立てられている。このような試みが報告されている背景には青色照明のリラックス効果が挙げられる。

本研究では、青色照明のリラックス効果について、エコロジカルな方法を用いて検討した。照明を短時間しか浴びない状況として、喫煙行動を取り上げ、青色照明のリラックス効果を用いて喫煙行動を抑制できるかどうかを検討した。神奈川大学構内の喫煙所 8 箇所の照明をそれぞれ、青色照明 4 箇所、白色照明 4 箇所に設置し直し、10 月から 12 月の 2 カ月間に渡り、毎日、喫煙所の灰皿内の吸殻の本数を計測した。もし、青色照明のリラックス効果が喫煙行動を抑制するならば、照明を変更してから徐々に吸殻の本数が減少していくことが予想される。

結果においては、青色照明による吸殻の本数の減少は見られなかった。したがって本研究においては青色照明下の喫煙行動に及ぼすリラックス効果は検証されなかった。

青色照明に関する研究の多くは人間の生理反応を指標に研究されており、喫煙行動は、青色照明を浴びる時間が 5 分程度と短く、例えばアミラーゼを用いた最短の研究時間でさえ、15 分程度の時間を要する。このように、青色照明の効果を得るためには、照明下に長時間滞在する必要があることが示唆された。エコロジカルな研究方法も含めてさらなる検討が必要と思われる。