COMPARATIVE LIGHTNING STUDY FOR ART GALLERIES

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Abstract - An important aspect of the museum viewing experience is that the viewer visually adapts to the ambient illumination, and this adaptation would not be achieved by side-by-side viewing or any other form of simultaneous presentation. The subjects were each taken to the comparison situation, where one of the artworks was on display at the preset illuminance. When a setting had been made, the experimenter recorded the control reading and asked if the subject could see any differences between the two situations, using five categories of difference: brightness, clarity ,acceptability of overall color appearance, brightness or colorfulness of individual colors, naturalness of individual colors .

Key words: illumination, brightness, clarity, color appeareance, art gallery.

1. INTRODUCTION

The study called for a pair of identical "art gallery" settings to be viewed sequentially. An important aspect of the museum viewing experience is that the viewer visually adapts to the ambient illumination, and this adaptation would not be achieved by side-by-side viewing or any other form of simultaneous presentation. Two adjacent partitioned offices measuring 8 ft. 6 in. by 6 ft. 9 in. by 7 ft. high were lined with white Fome-core, and three pairs of identical prints of artworks were presented in these simulated "art gallery" settings. The comparison situation was lit by an MR lamp that was preset by the experimenter to an illuminance of 50 lux. The test situation was lit alternately by an MR lamp identical to the one in the comparison situation, or by the three-band source adjusted to have CCT and chromaticity matched to the comparison source. The subjects were each taken to the comparison situation, where one of the artworks was on display at the preset illuminance. Then they were taken to the test situation, where the identical artwork was on display, and they were told to adjust the control "to match the appearance of this situation as closely as possible to the appearance of the previous situation." When a setting had been made, the experimenter recorded the control reading and asked if the subject could see any differences between the two situations, using five categories of difference:

1. brightness
2. clarity
3. acceptability of overall color appearance
4. brightness or colorfulness of individual colors
5. naturalness of individual colors .

2. ILLUMINANCE SETTINGS

Table 1 shows means and standard deviations for the illuminance settings made by the subjects in the test situation, and these data are illustrated in figura 1 and figura 2. In every case the illuminance in the comparison situation was preset to 50 lux, and it is apparent that subjects set the illuminance in the test situation to match the illuminance in the comparison situation.

Table 1. Mean Illuminance in Lux and Standard Deviation (in parenthesis) for Settings by the 16 Subjects to Match the Appearance of a Comparison Condition Where the Illuminance Had Been Preset to 50 Lux

	Low CCT		Intermediate CCT	
Artwork	MR	3 B	MR	3B
Picture owe	47.9	53.0	49.4	50.9
	(6.1)	(8.5)	(9.1)	(14.1)
Picture two	49.6	50.5	52.4	52.9
	(7.5)	(11.1)	(10.8)	(10.5)
Picture three	50.7	51.7	51.9	51.0
	(6.3)	(8.2)	(9.5)	(12.9)

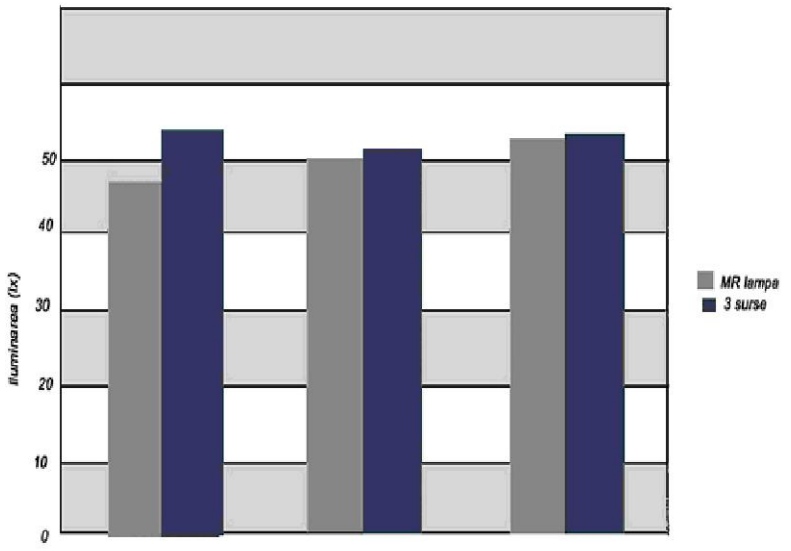

Fig. 1. Illuminance settings for low CCT

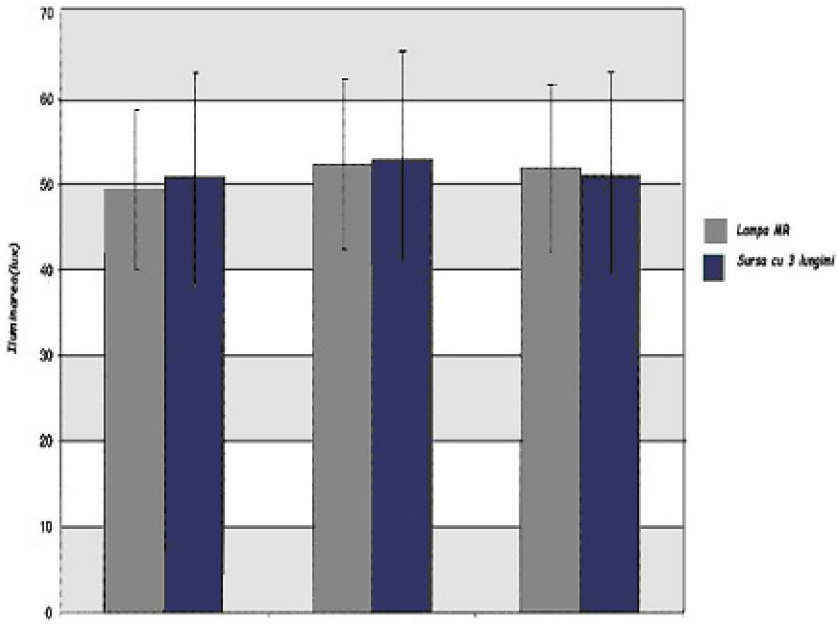

Fig. 2 Illuminance settings for intermediate CCT

3. ASSESSMENTS OF APPEARANCE

Tables 2–7 show the distributions of the subjects' assessments of the appearance of the experimental condition in the test situation relative to the matching condition in the comparison situation. It can be seen that there are few instances of subjects reporting anything more than a slight difference between the appearances of the two rooms. In fact, all of the mean values correspond to fractional parts of a slight difference, and in many cases the reported difference of appearance between the three-band source and the comparison MR source was less than the reported difference between identical MR sources.

Table 2. Subjective Assessment Ratings for picture owe CCT–2850 K

Criterion	Light Source	Rating	Average Rating					
−3	−2	−1	0	+1	+2	+3		
Brightness	MR			1	12	3		+0.12
3-B			2	10	3	1	+0.19	
Clarity	MR		1	2	10	3		−0.06
3-B		2	4	6	4		−.025	
Overall color	MR			1	10	5		+0.25

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appearance									
3-B			1	8	5	2		+0.5	
Individual colors	MR				14	2			+0.12
3-B			1	13	2			+0.06	
Naturalness	MR			2	13	1			0
3-B		1	2	9	3	1		+0.06	

Table 3. Subjective Assessment Ratings for picture two CCT 2850 K

Criterion	Light Source	Rating	Average Rating						
−3	**−2**	**−1**	**0**	**+1**	**+2**	**+3**			
Brightness	MR		1	4	10	1			−0.31
3-B		1	3	8	4			−0.06	
Clarity	MR			2	14				−0.12
3-B		2	1	9	3	1		0	
Overall color appearance	MR			1	14		1		+0.06
3-B		2	4	6	3	1		−0.19	
Individual colors	MR			3	11	2			−0.06
3-B	1	3	2	5	4	1		−0.31	
Naturalness	MR			1	14	1			0
3-B		2	4	9	1			−0.44	

Table 4. Subjective Assessment Ratings for picture three CCT 2850 K

Criterion	Light Source	Rating	Average Rating						
−3	**−2**	**−1**	**0**	**+1**	**+2**	**+3**			
Brightness	MR			1	11	3		1	+0.31
3-B				6	8	2		+0.75	
Clarity	MR		2	3	11				−0.44
3-B	1		1	7	6	1		+0.25	
Overall color appearance	MR			2	10	3	1		+0.19
3-B		1	4	6	5			−0.06	
Individual colors	MR			5	8	2	1		−0.06
3-B	1	2	1	9	3			−0.31	
Naturalness	MR			3	11	1	1		0
3-B		2	3	7	4			−0.19	

Table 5. Subjective Assessment Ratings for picture owe CCT 4200 K

Criterion	Light Source	Rating	Average Rating						
−3	**−2**	**−1**	**0**	**+1**	**+2**	**+3**			
Brightness	**MR**			**2**	**11**	**2**	**1**		**+0.13**
3-B			2	10	4			+0.13	
Clarity	MR			3	11	2			−0.06
3-B		1	6	7	2			−0.38	
Overall color appearance	MR			2	14				−0.13
3-B		2	6	7	1			−0.56	
Individual colors	MR			1	14	1			0
3-B		1	1	11	3			0	
Naturalness	MR		1	1	14				−0.19
3-B		1	4	11				−0.38	

Table 6. Subjective Assessment Ratings for picture

two CCT 4200 K									
Criterion	**Light Source**	**Rating**	**Average Rating**						
−3	**−2**	**−1**	**0**	**+1**	**+2**	**+3**			
Brightness	MR			4	10	2	1		0
3-B			2	12	2			0	
Clarity	MR				13	3			+0.19
3-B			1	13	2			+0.06	
Overall color appearance	MR		1	2	11	1	1		−0.06
3-B		3	5	5	3			−0.50	
Individual colors	MR		1	4	8	2			−0.25
3-B		3	3	7	3			−0.38	
Naturalness	MR			2	14				−0.13
3-B		1	4	9	2			−0.25	

Table 7. Subjective Assessment Ratings for picture three CCT 4200 K									
Criterion	**Light Source**	**Rating**	**Average Rating**						
−3	**−2**	**−1**	**0**	**+1**	**+2**	**+3**			
Brightness	MR				10	6			+0.38
3-B		1	2	8	5			+0.06	
Clarity	MR			2	9	3	2		+0.31
3-B		1	4	8	2	1		−0.13	
Overall color appearance	MR			3	11	2			−0.06
3-B		3		8	2	2		0	
Individual colors	MR			2	10	3	1		+0.19
3-B		2	1	6	4	3		+0.31	
Naturalness	MR				13	3			+0.19
3-B		1	1	8	3	3		+0.38	

The brightness and clarity criteria attracted very few comments from the subjects. The color appearance of the picture owe print illuminated by the three-band source attracted several comments. Some subjects who rated the difference favorably described the test situation as appearing "more white," while others who rated it unfavorably criticized the nonuniformity of color appearance. Despite painstaking adjustment, the blending of the colored light sources in the test situation was imperfect, and this shortcoming was more evident when viewing the achromatic print than when viewing the chromatic artworks. The colors were described as "less vivid" or "faded," particularly the red pigment. However, at the lower CCT there was some favorable comment that the blue pigment appeared brighter, and also unfavorable comment that there was an overall cooler appearance. These comments are understandable. Incandescent filament lighting enhances the apparent saturation of red colored surfaces, particularly at the lower CCT, and reduces the apparent saturation of blue surface colors.The appearance of the picture three painting under the three-band source attracted a variety of both favorable and unfavorable comments. At the lower CCT, favorable assessments ("colors seem to look better") were matched by unfavorable assessments (colors "more washed out"). At the higher CCT, flesh tones were criticized.

4. CONCLUSIONS

Subjects had been instructed to match the appearance of the test gallery to the comparison gallery. Thornton would have predicted that they would select a lower illuminance for the three-band source because, he claims, this source has greater visual clarity; but this was not the case. The subjects matched the illuminance in the test gallery to the illuminance in the comparison gallery in every case, indicating that illuminance effectively evaluated the overall sense of equality of appearance despite the very different spectral compositions of the two types of lighting. The fact that the three-band source provides a given illuminance with substantially lower irradiance on the illuminated object offers a significant benefit for conservation. For the light sources used in the experiment, the irradiances in watts per square meter (W/m2) to provide 50 lux on the artworks are shown in table 8.

Table 8. Irradiances in Watts per Square Meter for Illuminance of 50 Lux

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	MR Lamp	Three-Band Source
Low CCT (2850 K)	0.22	0.13
Intermediate CCT (4200 K)	0.20	0.14

It is conventional to assess the exposure of illuminated museum exhibits in terms of lux hours per year (lx h/y), so that an object lit to 50 lux and exhibited for 3,000 hours per year is exposed to 150,000 lx h/y. This measure does not distinguish between the different irradiances of light sources at the same illuminance. If the light source in this example is a regular MR lamp, then changing to a three-band source at the same illuminance would reduce the exposure by 41% and would be equivalent to only 89,000 lx h/y of exposure to the regular MR lamp. Looked at another way, it would take 1.7 years of exposure to the low CCT three-band source to subject the object to the same effective exposure as would occur in one year with a regular MR lamp at the same illuminance.

Table9. Mean Sums of Squares of Ratings for the Five Criteria, Based on Data for the Three Artworks

Criterion	CCT 2850 K		CCT 4200 K	
MR	3-B		MR	3-B
Brightness	0.542		0.667	0.500	0.438
Clarity	0.458		1.083	0.438	0.604
Overall color appearance	0.417		0.958	0.375	1.104
Individual colors	0.375		1.062	0.438	1.063
Naturalness	0.271		0.771	0.208	0.792

Table 10. Mean Sums of Squares of Ratings for the Three Artworks, Based on Data for All Five Criteria

Artwork	CCT 2850 K		CCT 4200 K	
	MR		3-B	MR	3-B
Picture owe	0.250		0.575	0.275	0.563
Picture two	0.175		0.988	0.450	0.688
Picture three	0.488		0.762	0.450	1.15

Moving on to consider the second research question, there are two approaches to developing practical light sources that could gain the conservation advantage of the three-band source. A new type of filter could be developed that would convert the continuous spectrum of a regular MR lamp into a three-band spectrum. While this filter would achieve high radiant luminous efficacy (lm/W(r)), the luminous efficacy of the lighting system in terms of lumens per watt of electrical power input would be poor. It must be recognized that whenever a filter is added to a lamp, it is necessary to increase the lamp wattage to maintain the illuminance. A more efficient approach would be to develop a new lamp type specifically for museum applications in which a three-band spectrum is generated by efficient conversion of electrical power. While this latter approach offers the prospect of a superior solution, the development costs are likely to be much higher. It should not be presumed that the museum community will respond with enthusiasm to this initiative. There is a long history of museum directors, particularly art museum directors, insisting that natural light is the only true light for the museum experience.

The distinctly unnatural spectral power distribution of the three-band source favored by this study is likely to be regarded with strong suspicion, whatever the visible difference in the lighting. A further study in a real art gallery directed toward gaining critical evaluations of museum professionals is recommended.

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