Guidelines for lighting arrangements to improve visual experience in exposition

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Abstract	:	Aim of the WP 5 is to measure the visual attributes of materials through subjective responses, providing a connection between the visual appearance, evaluation and metrological characterisation of a material. The visual attributes, gloss, goniochromatism etc. can be easily recognised, categorised and scaled by subjects. Whilst some of these appearances have a traditional metrological definition, new material appearances are not well described in metrological terms, or even by subjective perception. In this report, from the findings of D5.2.4, D5.3.2, D5.41, D5.4.2, and JRP ENG05 we propose in a schematic way a guideline for lighting arrangements to improve visual experience in exposition when goniochomatic samples or samples at different glossiness and colour are involved.
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reliable optical measurements with traceability to SI system to describe the overall appearances of modern surfaces: LE-CNAM (Coordinator), PTB, CSIC, INRIM, MIKES, CMI, Innventia, Katholieke Universitet Leuven, Universitat d'Alcant, and Callaghan Innovation. See http://www.xdreflect.eu/ for more information.

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SUMMARY

This deliverable is a short guidelines for the arrangements of lighting exhibition able to improve subjects visual experience using the findings of D5.2.4, D5.3.2, D5.41, D5.4.2. and JRP 09ENG05.

The suggestions are presented as tables describing lighting geometry and sources characteristics, and their influences on the perceived qualities of materials. The use of LED sources is well considered in all suggestions because LED are the lighting source of the future, considering also the current distribution on the market, requirements about energy Efficiency and EU20/20/20 targets. To improve the visual experience of observers is, first of all, very important to assure observers visual comfort: suggestions on visual comfort and a rank of parameters of interest is provided, as well tables about the influences of light source spectral power distribution on perceived qualities of Sparkling, Graininess, Brightness and Colour. A dedicated table is presented for Cultural Heritage materials.

It was chosen to present the data as tables because it allows an easy recognition of the most relevant parameters.

1 INTRODUCTION

The appearance of a product is important for EU economy: industrial artefacts are evaluated by their appearance, especially automotive, cosmetics, packaging and plastics products: appearance is one of the most critical parameters affecting customers choice. CIE is working [4] on the definition and measurement of Appearance, but a mathematical modelization of Total Appearance is still far from being defined for several reasons [5], mainly: complexity, available knowledge on the quantities defining appearance and measurement methods and accuracies. Measuring the total appearance of an object or of a scene, is a very complex exercise [6], that will deeply influence the design of a lighting system: the full knowledge of how a material is perceived when lighted it will open a new way on lighting design. But the results on total appearance are too far, one suggested approach is to study the appearance for simplified conditions, investigating the perceived attributes defining artefact, conditions of observation and illumination and materials characteristics [5]. This guidelines is based on this approach.

Materials characterization, related to light interaction, is implemented using methods, quantities and measurements conditions initially defined for CRM (Certified Reference Materials,e.g. ceramic or glass tiles) for units maintenance and dissemination that are not representative of industrial artefacts, but useful for applications related to production tolerances or device calibration, but useless for appearance prediction because conditions of observation (including geometry and spectral behaviour of lighting, geometry and viewing conditions) are very far from reference materials, as also the conditions of measurements from the real condition of perception. The result is that CRM do not provide adequate references for applications related to the analysis of perceived qualities, also because a full understanding of appearance is very far from being understood.

INRIM performed several visual experiments in order to test different appearance qualities of goniochromatic materials, considering attributes like: sparkling, graininess and brightness. The suggestions provided in this guideline are based on the results of D5.2.4, D5.3.2, D5.41, D5.4.2 and on previous knowledge of INRIM on the design of lighting for very precious Cultural Heritage Artefact [7]. Even if the commitment with Euramet of INRIM was to test only on D5.4.1 the influences of SSL and not SSL sources, the results achieved and the spread on the market of LED sources, pushed to do deeper investigations on appearance evaluation of different perceived qualities in presence of SSL and not SSL lighting sources as contribution to researches on SSL appearance influences and to increase knowledge of lighting designers about shop lighting: Gaininess and Sparkling results highlighted a strong dependence on the lighting source.

2 Lighting arrangements guidelines

In order to provide a guideline on lighting arrangements able to improve visual experiences during exhibition it is necessary to consider that in the last years a great improvement and push forward on installation and use of LED source arrived. LED sources are considered the most efficient lighting sources avalialable. The first generation of LED sources didn't encounter great appreciation by users and consumers mostly because false claims on performances on energy saving and very low perception attributes (especially about colour rendering). Euramet recognize the EU need and in 2010 funded a three years project on LED JRP ENG05, to improve metrology of SSL product to assure unambiguous data on photometric, energetic performances as well to implement a metric for human perception of SSL. The ENG05 proposed metric for human perception was used to provide results on witch this guide is based.

When setting up a lighting arrangements it is necessary to consider three main factors, that will be described in details in the following:

- Observers, considering comfort and level of adaptation
- Lighting sources, considering the influences of on perceived qualities of Correlated Colour Temperature (CCT), spectrum and emission technology
- Artefact under exhibition, considering measured quantity related to the perceived quality of interest and when Cultural Heritage artefacts are involved it is necessary to abide by values published in reference standards for conservation purposes.

2.1 Observer

During an exhibition observer enjoiment is the target. this can be acheived fulfilling different needs. The main is visual comfort: if user or customer experience discomfort during an exhibition their overall judgement on the exhibition will be surely negative. If the comfort would be the target, unfortunately it is not easy to state this target. A widely accepted definition of human comfort does not exist: several metrics have been developed to quantify how much users appreciate environments, objects or interfaces in terms for example of usability and agreeableness in the domain of each sense [10]. Users can easily identify a comfortable environment even if it is not easy to describe why it is comfortable: subjects cannot express easily their feeling of well-being and satisfaction in term of single and clearly identifiable effects, but the state of well-being is clearly recognized. Conversely visual discomfort is related to a lot of symptoms that can be clearly identified: difficulty in doing a visual task, annoyance, stress, and even physical effects like headaches, pains, sore, itching, watering eyes. The sources

of discomfort are also more easily identifiable by subjects, such as glare, veiling reflection, and dim environment, shadows... Most of the today metrics of visual comfort are developed according to the "NON annoyance approach",e.g. comfort is not discomfort, for instance in lighting environment this is well represented by measurement of discomfort glare such as the CIE Unified Glare Ratio UGR[1] , the Visual Comfort Probability VCP [8]. It is necessary that with this recognized approach visual discomfort metric can well represent the low value of comfort scale but not the high value of comfort scale. Findings demonstrated that:

- Available metrics for discomfort glare are still applicable if the SSL sources or luminaires do not significantly differ, in term of intensity and luminance distribution, from fluorescent light, so in order to improve and assure better performance and reliability on the results, it is better to equip SSL lighting with diffuser or to design set up able to hide from the direct view the SSL;
- For special kind of lighting set up, like "task related lighting" like to highlights objects in showcases, the direct vision of SSL is well tollerated and the glare doesn't play a relevant role in discomfort, but only if the uniformities on background and target are high as well as the contrast between object and background
- UGR luminaire values (for lower values) has the highest weight in comparison to all other parameters involved in the visual comfort evaluation in open exhibition
- Flicker, in order to avoid flicker perception it is necessary to use frequency higher than 50 Hz when pulsed SSL are involved.

Fig1 shows a ranking of the different parameters influencing visual comfort in LED lighting exhibition following from results of JRP09ENG05. It is to note that only [8] provides a ranking of parameter for assuring a good lighting quality in indoor lighting valid for traditional lighting (i.e. fluorescent lamps), for some cases a good accordance is shown.

2.2 Lighting source

Results from D5.2.4, D5.3.2, D5.4.1 and D5.4.2 pushed INRIM to compare subjects performances in qualities evaluation under SSL and not SSL sources, even if the commitment with Euramet of INRIM was to compare them only on D5.4.1. The results achieved pushed to do deeper investigations on appearance evaluation of different perceived qualities in presence of SSL and not SSL useful when lighting set up involves SSL sources. The light source illuminating a scene has a spectral power distribution that defines colours on the scene itself. D5.2.4, D5.3.2, D5.4.1 and D5.4.2 demonstrated also that it influences the perception of selected qualities like Sparkling, Graininess, and Brightness.

Task related lighting		Compartment lighting	
Parameter	**Weight**	**Parameter**	**Weight**
Light distribution (uniformity on target)	100	Glare (low UGR value)	100
Contrast object/background	100	Lighting levels	33
Background uniformity	100	Contrast object / background	33
Target averaged luminance	80	CCT effects	11
Lighting levels	75	Colour rendering	6
Luminaire appearance	50	Light distribution (uniformities)	not relevant
Glare (low UGR value)	50	Luminaire appearance	not relevant
CCT effects	not considered	Mixing effects of CCT in the visual field	not relevant
Colour rendering	not considered	Target averaged luminance	not considered
Mixing effects of CCT in the visual field	not considered	Background uniformity	not considered

Figure 1: Ranking of Parameters affecting visual comfort of observers

In Fig.2 the influences of lighting source and geometrical conditions (e.g. diffuse or direct lighting) on perceived qualities of tested materials are shown.

2.3 Artefact

The artefact is the main actor of a lighting set up: its properties contribute to the definition of the lighting conditions, source selection and illuminance falling on the surface. It is because the artefact the environment must be lighted: to sell it (for industrial products) or to enjoy it. This is clearly evident when the artefact is something related to Cultural Heritage, but except for conservation constraints, the same approach can be used also for industrial artefacts, because visual Appearance is fundamental in our interaction with the real world. As reference Fig.3 shows the limiting values (as prescribed in [3], [9] and [2]) to abide by lighting exhibition of Cultural Heritage Materials. While influences of LED sources on colour perception are shown in Fig. 4

Parameters	Suggestions about geometry	Lighting Source		Sparkling perception	Graininess perception	Brightness Perception
	Direction of illumination	Source type	CCT			
Condition of observation Subjects are free to observv the condition without restriction on the direction of observation	Direct, all specular reflections toward the observer should be minimized	SSL	Colder CCT enhance the sparkle and graininess perception (e.g. in SSL a source of 4000K is already considere cold white for its blue content)	The sparkling is perceived in coherence with measurement results of Sparkle Index and Sparkle area but the perception of sparkling is enhanced	not applicable	Difficult to state differences in brightness
		not SSL	The brigheness perception is enhanced with colder not SSL sources	The sparkling is perceived in coherence with measurement results of Sparkle Index and Sparkle area	not applicable	More difficulties in the perception of brightess related to a difficulties in perceiving the small differences
	Diffuse	SSL	Colder CCT enhance the sparkle and graininess perception (e.g. in SSL a source of 4000K is already considere cold white for its blue content)	not applicable	The Graininess is perceived in coherence with measurement results of Graininess but the perception of graininiess is enhanced	Difficult to state differences in brightness
		not SSL		not applicable	It is more difficult to perceive graininess with Fluorescent diffuse light	The brigheness perception is enhanced with colder not SSL sources, but it is difficult to state small differences

Figure 2: Suggestions on perceived qualities related to lighting source and condition of illumination

Document	Category of sensitivity	Sub category of snsitivity	Limiting illuminance [lx]	Limiting annual total luminous exposure [klx h/year]	Total luminous exposure before fading [Mlx h]	Limiting UV content [µW/lm]	Limiting UV irradiance [µW/cm²]	Limiting total irradiance range 400-4000nm [W/m²]
Publication CIE157:2002	High	Blue Wool 1	50	15	0,22	Note 1	n.p.	n.p.
		Blue Wool 2			0,6	Note 1	n.p.	n.p.
		Blue Wool 3			1,5	Note 1	n.p.	n.p.
	Medium	Blue Wool 4	50	150	3,5	Note 1	n.p.	n.p.
		Blue Wool 5			8	Note 1	n.p.	n.p.
		Blue Wool 6			20	Note 1	n.p.	n.p.
	Low	Blue Wool 7	200	600	50	Note 1	n.p.	n.p.
		Blue Wool 8			120	Note 1	n.p.	n.p.
		Blue Wool Over 8			-	Note 1	n.p.	n.p.
	Irresponsive		no limit	no limit	-	Note 1	n.p.	n.p.
Italian Decree law DM10/05/2001	Very High	n.p.	50	50	n.p.	10	0,05	1
	High	n.p.	50	150	n.p.	75	0,4	3
	Medium	n.p.	150	500	n.p.	75	1,2	10
	Low	n.p.	>300	no limit	n.p.	75	no limit	no limit
EN/TS 16163	High	n.p.	n.p.	15	n.p.	75	n.p.	n.p.
	Medium	n.p.	n.p.	150	n.p.	75	n.p.	n.p.
	Low	n.p.	n.p.	600	n.p.	75	n.p.	n.p.
	No sensitivity	n.p.	n.p.	no limit	n.p.	75	n.p.	n.p.

Figure 3: Requirements for Cultural Heritage materials Lighting

Subjectivel descriptors	Objective descriptors	Hues	Warm white LED CCT 3000 K	Cold white LED CCT 6300 K
Perceived illuminance	E_{max}/E_{min}; E_{min}/E_{mean}	Warm	Overestimated	Underestimated
		Cold	Overestimated	Underestimated
Perceived Colour of the light	CCT	Warm	Neutral	Cold
		Cold	Cold	Neutral
Colour Alteration	ΔH^*_{ab}	Warm	Decreased perception	Increased perception
		Cold	Decreased perception	Decreased perception
Colour Saturation	ΔC^*_{ab}	Warm	Decreased perception	Decreased perception
		Cold	Decreased perception	Decreased perception
Colour Brightness	ΔL^*	Warm	Decreased perception	Decreased perception
		Cold	Increased perception	Decreased perception
Dominant Colour	Red is physiologically perceived as dominant	Warm	Physiological coherence	Physiological coherence
	Green is physiologically perceived as dominant	Cold	Physiological incoherence	Physiological coherence
Lighting preference	-	Warm	Not preferred	Not preferred
		Cold	Absolutely preferred	Not preferred

Figure 4: Suggestions on perceived qualities related to colour whit LED lighting

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