

An applied research to assess the experience of the colour of urban lighting: a pilot study in Milano downtown

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This paper presented an exploratory research about the colours of urban lighting of Milan Downtown. The analysis has been performed in two ways: by measuring urban artificial lighting and by surveying citizens about the perceived urban luminous impressions. Mapped in an objective and subjective way, the urban lighting atmosphere resulted as a mixture of planned public lighting and private lighting with commercial and advertising aims. Private installation, by using extensively coloured and dynamic lighting, are strongly influencing the nightly experience of the city.

Received 2 July 2014; accepted 24 July 2014

Published online: 8 December 2014

Introduction

Urban lighting design is a complex design field which includes economic and political issues, technological advances, historical, cultural and social aspects. As described by Schivelbush [1], European public lighting evolved parallel to the western society and it has represented the power of the authority (e.g. State, Government, Police) aiming at ensuring urban security. This top-down approach has historically excluded citizens from the urban lighting planning. Conversely, urban lighting deeply influences the experience of the city [2] by creating a safer and more accessible nightly environment and by establishing a stronger relationship between people and the public realm. Light has not only just an aesthetic role but it is useful for way-finding and for communicating information: not only providing a good vision at night, lighting determines the way the city is perceived at night [3]. In this regard, the assessment of the urban nightly experience from the perspective of people was hypothesised as crucial in defining a more social oriented and sustainable lighting Masterplan.

In addition to this, the introduction of LEDs based lighting with intelligent control systems has brought to the urban lighting practice a wider range of possibilities with the promise of new aesthetic paradigms in terms of dynamic and coloured lighting and also in terms of possible energetic and costs' reductions. This technological revolution has already impacted the urban scenario by transforming, both in a permanent and temporary way, the night-time image of the cities. If, coloured and dynamic lighting are used by professional lighting designer to accent urban elements, enriching the nocturnal experience, often they appear in the city as "found lighting effects" [4] for marketing and advertising scopes. These lighting installation are not strategically designed by professionals or integrated into the lighting masterplan but have a determinant influence on the luminous urban impression.

Research aim and research question

The research was firstly aimed at exploring the complex luminous canvas of urban night-time by understanding the impact and weight of the traditional/orderly public lighting systems and the unconventional/uncontrolled private ones in determining the after dark atmosphere of the city. A secondary aim was investigating and making visible the experiential and social layer [5] of the lit city through experiments based on people observation and participation: how does coloured lighting influence people? What kind of lighting colours and features are contributing to make a place more sociable to congregate at night? What is mostly defining the lighting experience of lively city after dark: public or private lighting? The research would like to show insights of the connection between the attributes (spectral power distribution and quantity) of urban lighting at night and people experience.

Methodology

Conceived both as a case-study and a tool for a bottom-up approach, this research was aimed at investigating the nocturnal lit image of the city with an exploratory field study and an extensive user-oriented approach that comprises:

1. An objective accurate observation and analysis of the urban lighting in situ.
2. A subjective inquiry of the inhabitants' experience of the lighting systems.

Objective lighting quality of the environment

The first phase implicated technical evaluations using instruments and objectives parameters in order to access the quality of lighting in the area. This objective evaluation [6] was mainly based on the observation of existent lighting systems and was performed through measurement with the following instruments:

- Portable Illuminance meter with integrated power supply (battery) installed in a movable chart for measuring the horizontal illuminance along straight paths at 15cm from the ground, recording data on a portable PC.
- CCD Luminance Meter calibrated to measure the luminance of the photographed scene.
- Spectro Radiometer for analysing the spectral distribution of the lighting sources and deriving colour rendering index (CRI) and correlated colour temperature (CCT).
- Camera, tripod and maps in order to take notes about lighting features.

Subjective lighting quality of the environment

The second modality was based on the collection of perceptive-evaluative impressions of the inhabitants of the city through images and video based surveys followed by qualitative analysis of collected contents. This phase was aimed at collecting raw but focused subjective evaluations [5] about the perception of the lighting atmosphere of the city centre. In particular, the study comprised:

1. *A picture-based survey*: an experimental on-line survey based on five preselected visual stimuli of urban lighting of Milan Downtown. 15 participants (46% male and 54% woman, 33,3% has lived in Milan, 33,3% are living in Milan and 33,3% have visited Milan; average age 39 years old) were asked qualitative questions about the general lighting atmosphere through indirect observation.
2. *A video-based survey*: in order to provide a limited reproduction of the experience of dynamic lighting, an experimental on-line survey based on two short videos was elaborated and distributed to the same participants. Videos were elaborated with equal length of about 15 seconds (defined as the best duration for having a proper understanding and impression of the lighting behaviour without being too long and boring) and no sounds in order to define the same audio experience.

The results of the analysis were compared and used to gather:

- *Maps of urban lighting representing the territory*, evidencing correlation between public and private lighting elements in the city centre and lighting elements features such as distributions, colours and levels from a quantitative and qualitative point of view.
- *Urban lighting impressions*: nocturnal subjective atmosphere [7] of the city.
- *Critical insights*: definition of new lighting guidelines based on the social experience of the city for optimising and improving urban lighting applications.

Case study: Milan downtown

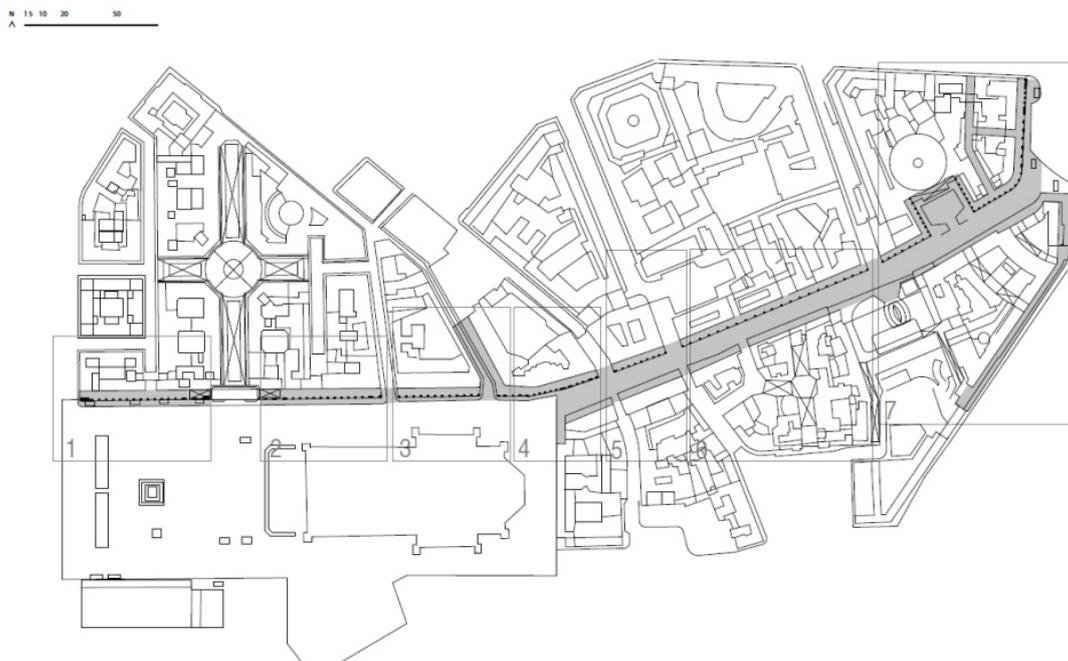


Figure 1: Pedestrian zones taken into consideration in the study: passages as galleries and porticos.

Developed and tested in a specific case-study area, Milan Downtown, in a zone comprised between the two main squares of the city centre (Duomo and San Babila), the study explored mainly the pedestrian passages such as galleries and porticos (Figure 1), chosen for complexity and richness of social activities and lighting. The research about observation and measurements was run in a 6 months period (November 2011 – April 2012) meanwhile the surveys were performed in a four months period (September 2012 – December 2012):

Results and insights

The selected pedestrian streets were found to be “*Great Good Places*” [8], containers of overlapping urban functions, suitable for transit at slow speed, serving sitting and watching, talking and playing activities in between outdoor and indoor spaces. Based on street dimensions and geometric features such as the presence of cover and pillars, streets were classified into four categories: main pedestrian streets, pedestrian porticos, pedestrian galleries and secondary alleys (Figure 2):



Figure 2: Pedestrian street classification in the selected case study area.

Objective analysis: quantity of lighting, horizontal illuminance levels and private lighting contribution

From a quantitative point of view, illuminance and uniformity of illuminance were analysed taking into account Lighting Guides of practice, normative and recommendation in relation to the specific zone classification. The recommended illuminance of this area takes into account expected pedestrian movements and night activities. The related classification was CE3 and CE4/S2 in accordance with UNI 11248-2012 [9] with recommended average maintained illuminance levels defined by CIE 115 (Commission International de L'eclairage) [10] (Table 1).

More than quantity, in the IESNA handbook [11], it is stated that, in pedestrian streets, the appearance of the zone is the most important factor in terms of visual needs. In order to access the amount of light of the zone, horizontal illuminance (E_h) measurements were conducted on a day of the week with the weakest rate of pedestrian movement (between 19:00 and 20:00) in order not to have problems of crowd flows. Shops were closed and opened.

Lighting Class	Average illuminance over whole of used surface E in lx	Uniformity of illuminance $F_u(F)$	Threshold increment f_{η} in %	
			High and moderate speed	Low and very low speed
C0	50	0,40	10	15
C1	30	0,40	10	15
C2	20	0,40	10	15
C3	15	0,40	15	20
C4	10	0,40	15	20
C5	7,5	0,40	15	25

Table 1: Illuminance values for pedestrian street categories.

As expected, the results presented a wide range of illuminance values, comprised between a minimum of 25 Lux with an average of 300 Lux and a maximum pick of 850 Lux. This was determined primarily by the presence of private lighting: shops, cafes, bar, restaurants, cinemas and theatres were highly contributing to the E_h of the examined zone (Figure 3).

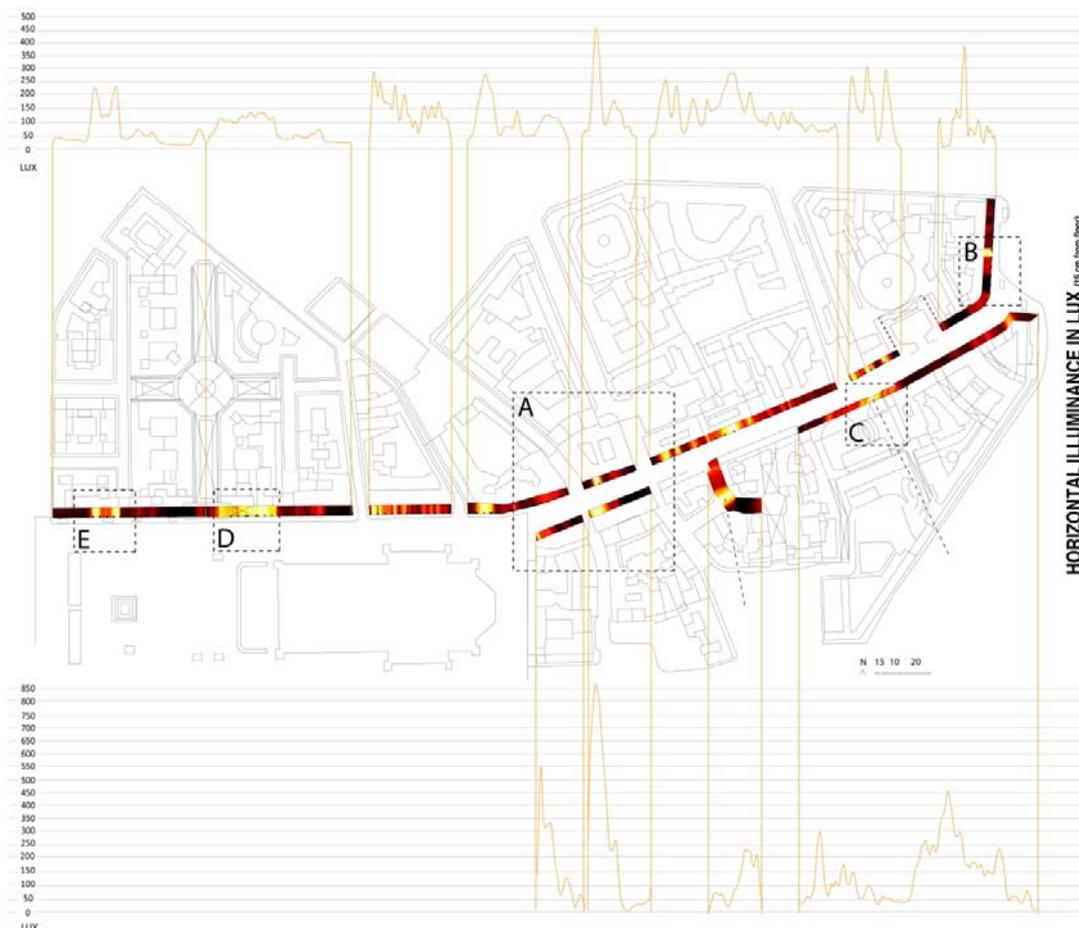


Figure 3: Measured horizontal illuminance correlated with different private elements of lighting.

In particular, in the portion of porticos located near terrace restaurants or bar (A, Figure 3) opened till late at night, higher E_h values were recorded (between 450 Lux and 850 Lux). These levels were extremely high in comparison to the standard ones and were determined by the presence of lighting emitted from the shop windows, from private projectors located over the outdoor passages and tables. In addition to this, highly diffusive and clear materials of pavements, columns and walls were

contributing to the general perception of brightness. Higher level of illuminance was found also near the theatre in front of San Babila square (B, Figure 3). Where shops were located, the lighting levels were heterogeneous with elevated E_h determined by shop windows lighting emitting from inside also after the closing time. (C, D and E, Figure 3). In these portions, lighting levels were between 50-350Lux. Secondary streets were not measured but, from the observation, it was evident that the sole presence of traditional lighting fixtures determines lower illuminance values.

Objective analysis: quantity of lighting such as colours of lighting and public/private lighting contribution

The pedestrians downtown of Milan is highly lit with direct and diffuse lighting distributions, contributing to the general high luminance under the porticos. A layered approach was found under the passages and galleries where public lighting was highly complemented with private lighting. The general atmosphere was warm white with a CCT comprised between 3000K and 3400K determined both by public and private contribution. Private lighting systems, for interior retail lighting, contributed to the white warm atmosphere with a CCT of 3000K. (Figure 4) White public lighting was generally determined by the use of heterogeneous lighting sources with an average lower CRI (Ra 25-90): High Pressure Sodium (Ra 25) and Vapour Mercury lamps (Ra 50) were used together with the newest ones like metal halide lamps without any designed logic. Those newest lighting sources combined lighting efficiency and lighting quality (3000K, Ra 89-90).

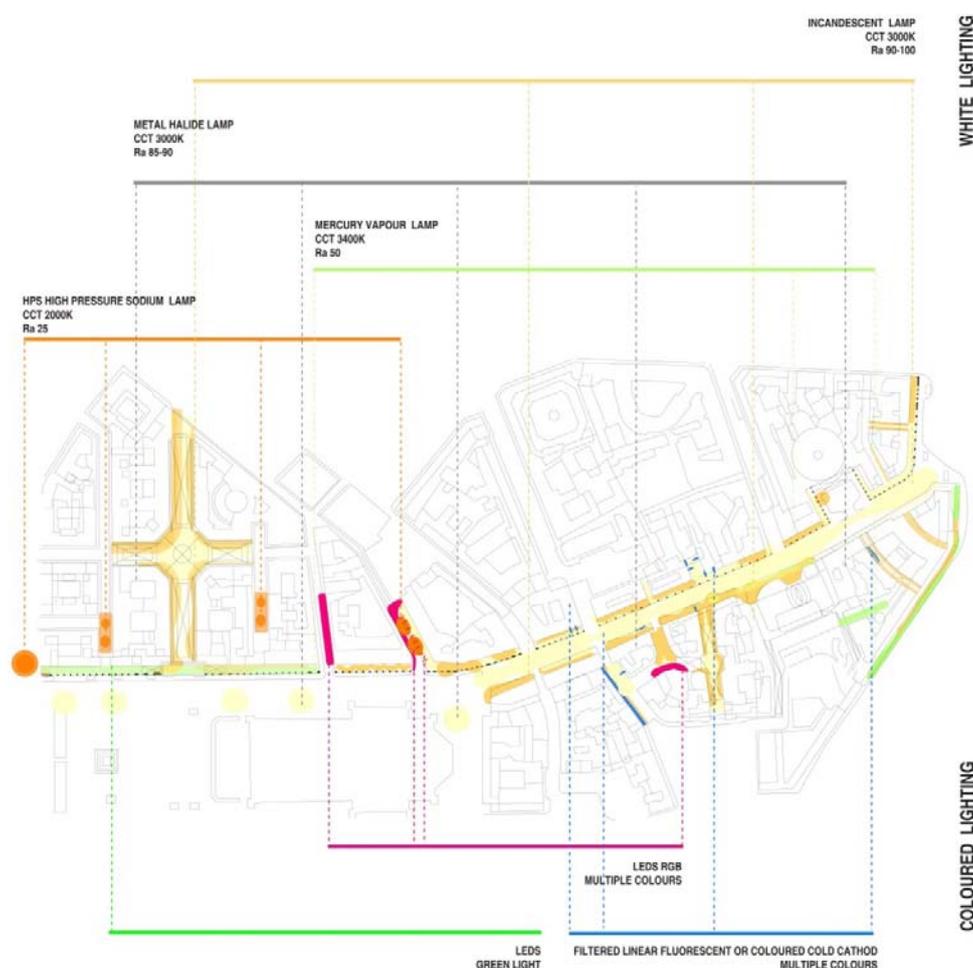


Figure 4: Mapping the coloured urban lighting in Milan downtown.

The juxtaposition of white and HPS lamps 2000K were providing information about the hierarchy of secondary and primary streets. Coloured lighting in the city centre derived mainly from signs, billboards and small, medium, large displays that belonged to private stakeholders. Advertising luminous signs were generally located under the porticos without following a urban planning, defining an uncontrolled and chaotic visual effect. Modern signs and displays were integrated in shop windows and were equipped with RGB LEDs, creating multiple chromatic effects and digital performances, contributing to the general atmosphere of the visual scene.

Subjective analysis: Luminous atmosphere of Milan

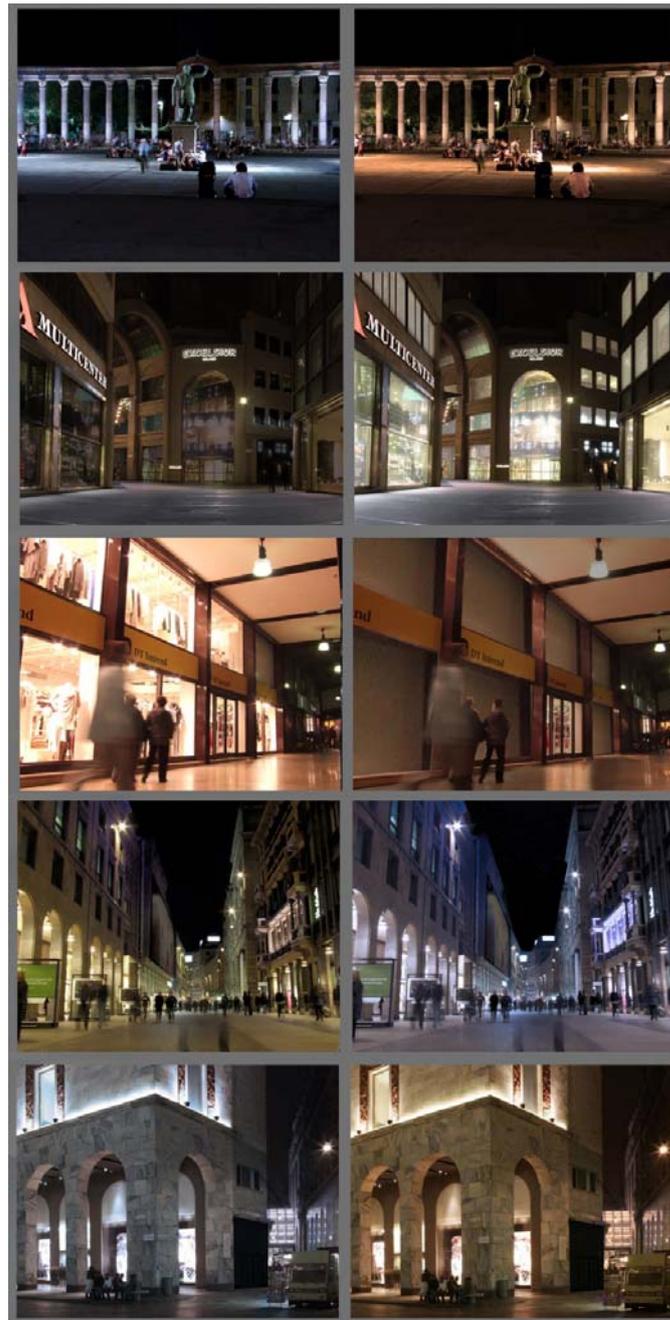


Figure 5: Sample of images used for the subjective tests (top to bottom): Colonne San Lorenzo, Excelsior, Corso Vittorio Emanuele, Porticos with shops, Via Santa Radegonda/Rinascente.

The subjective exploration of the urban night of Milan focused on the affective human perception (evaluative or emotional response to the perceived environment) [12]. A small sample of inhabitants and users of Milan were invited to participate to a qualitative survey in order to investigate the luminous atmosphere of the city centre (Figure 5) in contrast with the suburban areas.

People found Milan Downtown a contradictory place, pleasant and interesting even if the luminous atmosphere was considered traditional. On the other hand, a lack of identity and meaningful luminous scene was evidenced. It was defined both “*Full of life, there is always something, a detail that capture my interest*” but also described as “*anonymous, not particularly suggestive, where lighting is not the main element to take into account thinking about it*”. The opposite affective quality of the space was also evident by comments that described it a lively area full of brilliant but disturbing lights, a place “*really heterogeneous because there is the main sacral centre, the Dome, with its kind of religious respect with the contradiction of myriad of shops surrounding it and shining with a brilliant and attractive lighting invading the square*” (Figure 6).

The city centre was described as “*warm*” with a colour of light of “*yellowish white*” or “*white tending to yellow*”. Conversely, the atmosphere of the suburban areas of the city was described in a negative way, both inhospitable and unpleasant because lighting was found “*just functional but also sometimes disorienting and contributing to create a scenery where people are driven only to pass by. Lighting is not predisposing to conviviality*”. (Figure 6) More than this, people referred negative features of lighting such as “*too high and too cold*”.

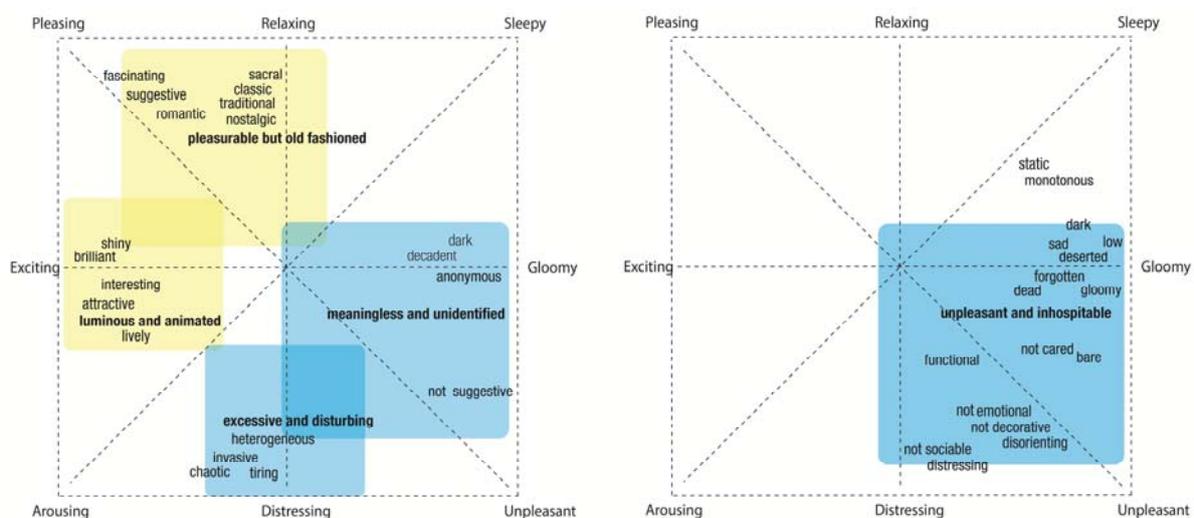


Figure 6: Luminous atmospheric quality of the city centre of Milan (left) and luminous atmospheric quality of the suburban areas of Milan (right).

Preferred colour lighting in Milan

In order to gather information about the impression and preference of colour of lighting in the city centre, 5 different situations of Milan Downtown were used as lighting stimuli in a qualitative survey. In particular, three places in the city centre where people use to meet and stay (e.g. Corso Vittorio Emanuele, Colonne San Lorenzo, Via Santa Radegonda/Rinascente) and two situations with high contribution of lighting from the shop windows (e.g. Excelsior and pedestrian porticos) were selected. A pair-wise comparison was performed asking which of the condition was preferred in relation to sociability, comfort, liveliness. The compared lighting variables were:

1. Warm white lighting and cold white lighting.
2. Lighting and no lighting from shop windows.

Statistical analyses (Likelihood ratio tests) were run to identify trends and differences in the preference of different lighting atmospheres (Table 2).

	Pair-wise comparison		Lighting atmosphere evaluation			Lighting features evaluation	
	Condition 1	Condition 2	% rating condition 1 sociable	% rating condition 1 lively	% rating condition 1 comfortable	% rating condition 1 luminous	% rating condition 1 warm
Urban areas	Condition 1	Condition 2	% rating condition 1 sociable	% rating condition 1 lively	% rating condition 1 comfortable	% rating condition 1 luminous	% rating condition 1 warm
Colonne San Lorenzo	WCCT	CCCT	80*	66.7	86.7**	73.4	93.4**
Via Santa Radegonda/Rinascente	WCCT	CCCT	93.4**	60	73.4	73.4	93.4**
Corso Vittorio Emanuele	WCCT	CCCT	73.4	60	86.7**	53.4	100**
Excelsior	WCCT	CCCT	60	40	66.7	53.4	73.4
	OPEN	CLOSED	66.7	80*	60	100**	46.7
Porticos with shops	WCCT	CCCT	86.7**	66.7	86.7**	46.7	93.4**
	OPEN	CLOSED	86.7**	93.4**	66.7	93.4**	73.4

Table 2: Results of Likelihood ratio tests with statistical relevance of $p=0.05^*$ and $p=0.01^{**}$.

From the survey, it was evident that the sociability of a place was associated to warm CCT of white lighting that was found more comfortable to be and to stay with people. Warm lighting was associated to hospitality and calmness. Liveliness was associated to a higher quantity of lighting, generally provided by shop windows that contributed to a perceived more luminous space. Lit/open shop windows were considered more positive for sociability than the closed/turned-off ones.

Dynamic lighting from shops

A deeper subjective analysis was run in order to understand the impact of dynamic shop windows in the luminous atmosphere of the city centre. The same sample group of participants was asked to give some example of dynamic lighting referring to the city centre of Milan: the majority was not able to find an example of changeable lighting in relation to the presence of people or timing during the night. The only given examples were the lighting coming from the shop windows, eventually turned off during closing time. The centre was described as "invaded by the lights of LEDs screens that every shops is using in different ways, it seems that the lighting signs are more organised, nice and original in comparison to the random and uncontrolled lighting signs that cover, negatively, the façade of the buildings". In relation to this, people were asked to describe the atmosphere of two digital dynamic lighting of the centre of Milan (e.g. Rinascente and Excelsior shop windows represented in Figure 7).



Figure 7: Sample of videos used for the subjective survey: Rinascente shopping windows (left) and Excelsior shopping windows (right).

For Rinascente, people seemed to generally appreciate the dynamic abstract simplicity of the luminous dots of the façade because of the unconventional effects created in the old city centre. The façade was found as attractive and a reason to slow down and have a look on the signalling, exciting luminous dynamics. On the other hand, negative feedbacks referred to disturbance and useless or meaningless functions (Figure 8). For the Excelsior’s windows, people seemed to have contrastive impressions: on one side, they were intrigued by the dynamic videos projected providing interest and joy and a pleasant positive impression for relaxation. On the other side, negative impressions came from the feeling of something useless made just for advertisement, consuming energy without providing an extra valuable experience (Figure 8).

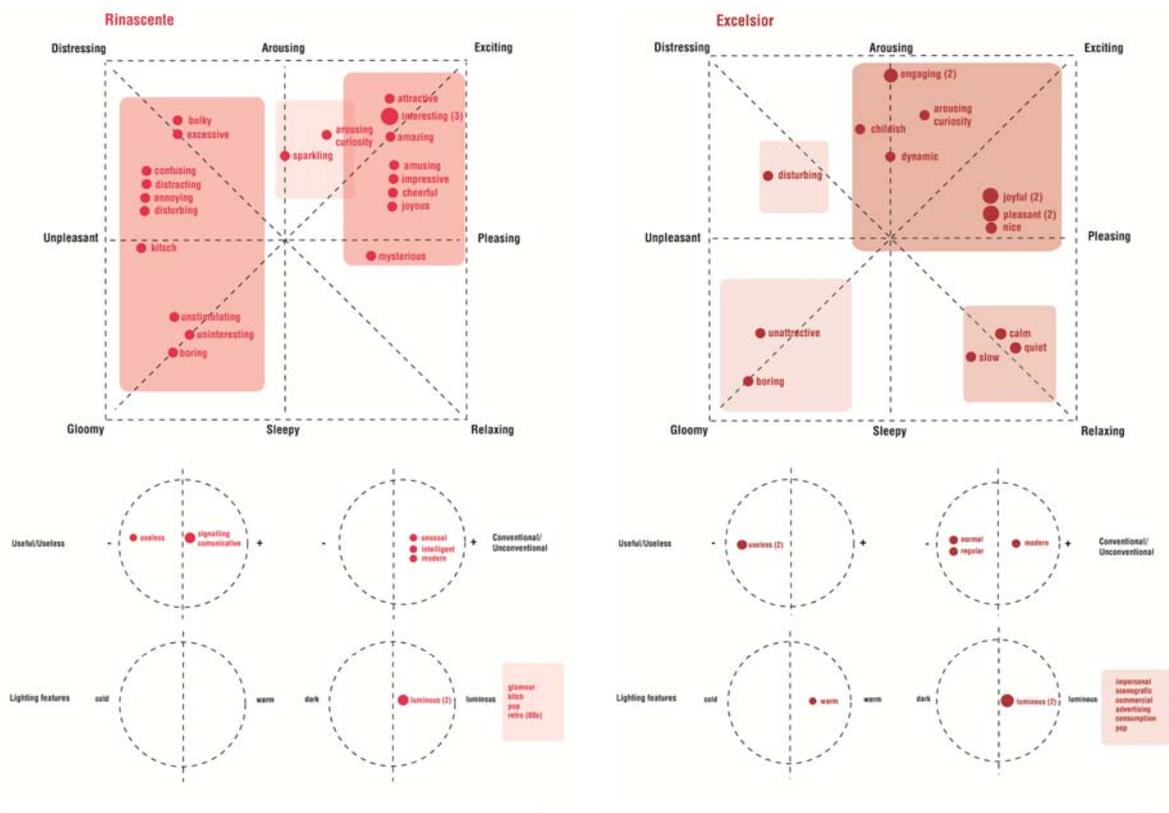


Figure 8: Luminous atmospheric quality of the digital dynamic shop windows of Rinascente (left) and luminous atmospheric quality of the digital dynamic shop windows of Excelsior (right).

Conclusions

The study was useful to derive an overview of the nocturnal luminous atmosphere of Milan Downtown that was generally perceived as a positive space for convivial togetherness after dark due to coloured urban lighting. In this regard, warm white lighting was associated to sociability, cosiness, relaxed atmosphere meanwhile luminous extra-lighting from private installation was associated to a lively and arousing atmosphere. Coloured lighting was generally associated to positive interest and surprise but also to negative feedbacks in relation to visual disturbance and lack of particular meanings. The urban downtown was found rich in appreciated lighting effects: people were found to like lighting variety pervading buildings' walls and pedestrian sidewalks. Public or private, the unexpected and unconventional "found lighting effects" were perceived as enriching and animating the experience of the city at night even if a much stronger relation to the space and to people was desired. The research showed that this variability of lighting provides means for exploration and stimulate the senses. [13].

Insights from the research suggest that urban lighting design should be focused on quality instead of quantity and should not be defined in a rigid order but rather it should provide a layered framework of different lighting stimuli for an overall, designed, visual and emotional nocturnal cityscape. Social-oriented lighting should ensure a warm comfortable ambient lighting to create a cosy, restful and reassuring space. It should be also combined with other lighting stimuli: complexity and variety are more appreciated than uniformity [14]. Dynamic lighting can provide possibilities for excitement and points of emphasis and interest within the space [15]: it means that the enrichment of the nocturnal public domain is not reached by flooding everything with light, but focusing elements with light for commanding attention, attracting interest and creating a charming atmosphere [16]. More than this lighting should follow the social layers of the night, adapting to social activities and patterns of use for fulfilling the growing environmental demand.

City planning: private with public

The analysed space evidenced a continuous overlapping between private and public interests in pedestrian urban zones of porticos and galleries: if a sharp distinction of property exists in terms of ownership of the space, lighting and information invade the space by disrupting each boundaries. The luminous atmosphere was mainly defined by private choices that, on one side, created a positive and more rich visual environment, fully contributing to the night-time image of the city centre, but on the other hand, it was uncontrolled and confusing, overloaded with information that were mainly commercial and meaningless for people's purpose [17]. The analysis was crucial to understand how these two different lighting contributions can coexist in order to distribute and balance them both for people comfort and energy consumption reductions. The public lighting could be lowered and counterbalanced with the private lighting, eliminating the highest illuminance picks that are used for commercial purpose. Private lighting has to be considered as a positive element in the public urban space only if redesigned and regulated with criteria of minimum visual impact in order to harmonise them in a more coherent with the context.

Lighting design: from functionality to experience

Private lighting was found as generating unexpected and surprising effects, by creating interesting and spectacular "diorama" to be watched, with dynamic multi-coloured lighting performances that

provided different messages and contributed to influence the way people experience the city at night. Unconventional lighting effects were contributing to the positive atmosphere of the city, recalling people attention. The street was transformed in a sort of theatre and passers-by were the audience of these lighting performances that were a hybrid between sale, entertainment, information and advertising [1]. Meanings and information offered by these media displays were generally easy to understand but merely commercial or entertaining with the effect of provoking the eye for a short period of time without other relevant contribution. On the other hand, nowadays lighting for people is required not only to be functional and contributing to safety perception, but also to inform and enhance users' experiences [18] even if in an ephemeral way. In the future, more than propaganda and brand promotion, digital displays are required to make social statements, encourage participation, physically engage the occupants of the space or inform for orienting in a meaningful way. Lighting designers should include this range of new technologies (low and high resolution video displays, digital contents and interactive proximity based control systems) into their common used tools for designing lighting.

Research limitations and further study implementations

The study should have involved a wider sample of participant to the qualitative surveys in order to gather wider statistical results and also more relevant qualitative information on the atmospheric quality of the space. More than this, the indirect on-line surveys based on images and videos as lighting stimuli should be complemented with in-situ direct interviews for more direct feedback about the lighting of the space. Further implementation of this study would be the application of this double approach to urban lighting analysis as a tool for investigation other areas of Milan in order to understand people subjective impressions and to elaborate guidelines for social oriented urban lighting projects.

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