SOCIOTECHNICAL ENVIRONMENTS

PROCEEDINGS OF THE 6TH STS ITALIA CONFERENCE 2016

EDITED BY
STEFANO CRABU
PAOLO GIARDULLO
FRANCESCO MIELE
MAURO TURRINI

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What Does Light Do? Reflecting on the Active Social Effects of Lighting Design and Technology

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The studies about the social effects of lighting describe lighting as an important social means and an agent that can influence people emotional, behavioural and social experiences despite cultural, social and individual differences. A cross–cultural analysis of studies about lighting report that higher lighting levels induce greater arousal, activating louder conversations or a more general communication meanwhile a domestic environment with low lighting levels influences more relaxed and intimate disclosure. Certain lighting atmospheres are appraised as more hospitable for people, while some patterns of lighting distributions can affect people proxemics.

In this paper, we investigate the active role of lighting in setting the social relationships between people by providing a theoretical framework based on an extensive literature review and by presenting the results of several designed lighting probes. From the user confrontation through qualitative and quantitative analysis, we reflect on the sociality of lighting that act for social intimacy/inclusion or social exclusion, with a subtle agency on people.

***Keywords**: Lighting agency; psychosocial effects; social lighting*

Introduction

The majority of the studies related to lighting have been focused on visual performance with lighting ensuring optimal vision and comfort in carrying out visual tasks (Boyce, 2003). More than solely vision, lighting can have a physiological influence on individuals by setting their circadian rhythm (Rea, 2002). In addition to this, the visual perception is much more complex because it is influenced by cultural associations, interpretations and expectations which can derive from social and personality features

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(Veitch and Newsham, 1996). Lighting can also have psychological effects and can influence appraisal, affect and behaviours (de Kort and Veitch, 2014; Illuminating Engineering Society, 2017). Behaviours can be considered as a function of personal factors, defined by culture, memory, personality, previous experiences, and as a function of environmental factors which constitute the tactile, thermal, acoustic and visual experience of the space. Allowing the vision and perception of the environment, lighting can also contribute to affect behaviours. In this regard, several studies (Kobayashi, 2013; Magielse and Ross, 2011; Veitch and Gifford, 1996) have investigated the implications of certain luminous conditions in defining socially including / excluding spaces and social negotiations (fig. 1).

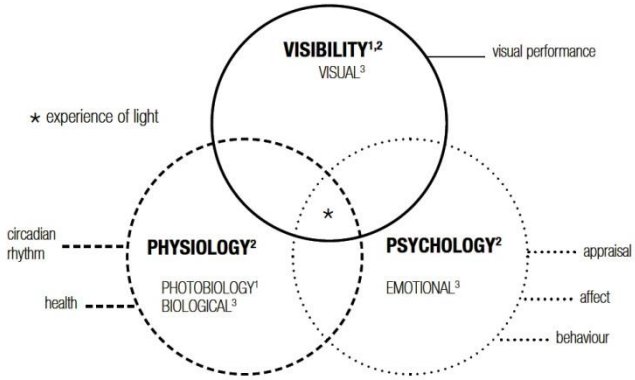

Figure 1 The multiple effects of the lighting experiences. Diagram adapted from Veitch and Newsham (1996)[1], Kobayashi (2013)[2] and Magielse and Ross (2011)[3].

Research question

Lighting, as a material and immaterial agent, is manipulated in a social way to lit places and to influence social experiences, depending on people social and cultural associations (Bille and Soresen, 2007). This paper wants to highlight the many ways lighting can influence and act on sociality (social appraisal and behaviours) with a particular focus on new lighting technologies (Solid State Lighting and Digital Controls).

Methodology

Initially, an extensive literature review was performed through scientific journals of Lighting, Interior and Interaction design, Psychology and Social Sciences, by using the keywords 'lighting', 'social interaction', 'social light', 'lighting behaviour', 'light agency'. A content analysis was operated and, even if not exhaustive, the selected references provide a robust theoretical framework to the topic.

Subsequently, three case studies (CS) has been designed and performed through experimental lighting design probes, conducted in the field and in the laboratory. Investigations were based on hybrid research techniques with both a qualitative and quantitative approach: observations documented with videos and photography, audio–recorded semi structured interviews (50 in CS1; 40 in CS2; 20 in CS3) and surveys (40 questionnaires in CS2). Those were analysed and compared to obtain a deeper understanding about the social agency of lighting in the urban environment.

Lighting and social situations

As observed in normal daily life, different social situations require different lighting conditions: people favour higher lighting levels for demanding visual tasks and lower lighting levels for non–visual activities, this depending both on social and environmental factors (Biner et al., 1989; Butler and Biner, 1987). A study of Kobayashi et al. (2001) concluded that concentration and self–controlled behaviours (e.g. working, studying) are preferred in bright environments, meanwhile active impersonal and relaxed behaviours (e.g. dining and talking with friends) are preferred in bright non–uniform lighting. Conversely, self–centred and relaxed behaviours are preferred in dim, dark and non–uniform lighting condition in no or low control situations (e.g. relaxing, talking to a friend, dining with the partner). Limitations of these studies lie in the indirect way they were performed due to the weak link between subjective appraisal and real behaviours (Hayward and Birenbaum, 1980).

Lighting, positive affect and social appraisal

Lighting can influence people positive affect, impressions and mood, which in turn could lead indirectly to more positive behaviours in social situations. Lower lighting levels (150lux versus 1500lux) and warm white light induce calmer and more relaxed feelings which also influence a positive social attitude (Baron, Rea and Daniels, 1992).

The impressions of a socially inclusive environment can be guided by the spatial distribution of light which carry both environmental information and social meanings to which people react in consistent ways. Lighting can influence the experience of the space regarding orientation, mood, wellbeing and social interaction (Flynn et al., 1973; 1979). By changing the lighting conditions (spatial distribution, lighting levels, colour temperature), people can perceive an alteration of the space (Flynn, 1977; Flynn and Spencer, 1977): in particular, the impression of publicness derives by higher lighting levels with a more uniform distribution from overhead lighting fixtures meanwhile the impression of relaxation, from warm and non–uniform wall–lighting distribution with lower levels (Flynn, 1988).

Lighting influences on social behaviour

Lighting has psycho–social effects on people by influencing spatial behaviours, proxemics and communication.

Lighting and spatial behaviour

Involuntary human phototropism is the attraction toward bright lighting sources which can direct people's eyes (Hopkinson and Longmore, 1959), lengthen the attention of students to specific tasks (Giusa and Perney, 1974), drive people movements through brighter paths (Taylor and Socov, 1974) and orient the body posture facing an illuminated area to watch the taking place action (Flynn et al., 1973).

Lighting and proxemics

From the studies about proxemics, lighting affects the perception of the personal space bubbles (Hall, 1966) by providing organised visual cues to identify the occupation of a territory (Lam, 1992).

Adams and Zuckerman (1991) investigated the influence of light on the appropriate personal distance of standing females: under lower lighting, the distances on the sides and to the rear are bigger than the ones under brighter conditions due to feelings of inappropriate intimacy. Other studies showed that the social closeness between people is achieved under dim (Werth, Steidle and Hanke, 2012) and dark lighting conditions (Gergen, Gergen and Barton, 1973; Sommer, 1969) by increasing cooperation and affiliation between individuals.

Lighting can also negatively affect the impression of anonymity: dark or dim lighting conditions can enhance self–interested and dishonest

behaviours (Zhong, Bohns and Gino, 2010) because people feel unobserved. Brightness (being under the spotlight) instead reveals behaviours to others leading to more self–controlled behaviours (Steidle and Werth, 2014).

Lighting and communication

Lighting can influence communications between individuals both in the verbal (tone of voice, fluency of speech, type of content disclosure) and nonverbal behaviours (sociofugal/sociopetal orientation, body angling, seating posture, facing position and direction, gaze orientation and eye contact, facial expressions) (Altman, 1975).

Lighting and conversational volume

Studies about the effects of lighting on speaking volume report controversial results. Students talking in a university corridor were found less noisy under dim lighting conditions (10–270lux), due to the increased feeling of intimacy, and louder in brighter lighting conditions, due to the greater arousal (Feller, 1968; Sanders, Gustanski and Lawton, 1974). Similarly, Kobayashi (2013) found that couples spoke louder in bright conditions (table 800lux and ambient 500lux) and quieter in dim conditions (table 50lux and ambient lighting 1lux) meanwhile, in extremely non–uniform lighting (candlelight: table 3lux and ambient 0.1lux), the speaking volume depended on personality. Conversely, Veitch and Kaye (1988) found that higher lighting level (1274lux) resulted in decreased volume among students talking about fictional jobs.

Lighting and communication disclosure

Controversial results were also found in studies exploring the influence of lighting in communication disclosure. Gifford (1988) found that higher illuminance levels (900lx) and a homelike setting increased the arousal, which in turn increased both general and auto–referential written communication with a known friend. Differently, lower lighting levels (150lx) increased intimate social interaction and higher disclosure in a counselling room (Miwa, 2006).

Lighting and personal distance

Carr and Dabbs (1974) found that dim lighting is preferred in situations requiring intimacy but, when intimacy is considered inappropriate (e.g. during an interview), it has negative visual (decrease in eye gaze length) and paralinguistic (increase of pauses) effects. Accordingly, Kobayashi (2013)

found that darker conditions influence an increase in eye contact and leant forward posture which is higher in male–female and female–female couples.

Case studies: from indoor to outdoor social lighting

The agency of lighting able to transform the impression from a very intimate and private, to a public, formal and detached one has been investigated in outdoor settings through a series of lighting probes, designed and prototyped using LEDs lighting sources and digital controls aided with sensors. Lighting scenarios and adaptive luminous scenes through implicit interactions (Ju and Leifer, 2008) has been tested in order to follow or support different social activities and behaviours for sociality explorations (Casciani, 2014b).

The first case study has been set up in a Living Light Lab at the Eindhoven University of Technology Campus (Living Light Lab, 2017) to explore the lighting influence in space territorialisation and personalization. Overt behaviours of 50 users were observed (focusing on body language, gestures, head movements and detournament) and 50 semi–structured interviews were conducted with audio recordings, followed by the transcript and clustering of quotations for analysis.

The same space was used to perform the second case study: seven lighting scenarios different in terms of the tonality of white (3000K –6000K) and lighting distribution (uniformity, non–uniformity and a layered approach with both dimmed ambient lighting and accent lighting) have been designed and tested with 40 participants (27 male–13 female, 77.5% students; ave. age 23 years old–55% Dutch, 12.5% Chinese, 5% Turkish). The subjective appraisal of the sociality of lighting (privacy / publicness, cosiness / detachment, safety) was assessed through a revised atmospheric survey (Vogels, 2008) 40 questionnaires were administered followed by semi–structured interviews.

Finally, in the third case study, the sociopetal/sociofugal behaviours and social proximity were investigated in the Environmental Testing Room at the Politecnico di Milano (Laboratorio Luce, 2017). Three lighting scenarios different in terms of the tonality of white lighting (3000K–5000K), distribution (direct–direct/indirect) and intensity has been prototyped under a lighting shelter with integrated sensors for monitoring presence and body posture. 20 participants in couples (14 female–6 male, 80% students; average age 25 years old–50% Italian, 15% Turkish, 5% Lebanese 5% Russian) performed role–play of different social activities (e.g. talking with a

known friend, meeting a stranger in the city, discussing for a job, counselling). They were videotaped for research purpose and interviewed about the experience (20 interviews).

Social appraisal of street lighting

The first exploration started from the notion of 'environmental experience' (Canter, 1986) that describes the space as a unit of physical attributes, emotional cognitions and human activities.

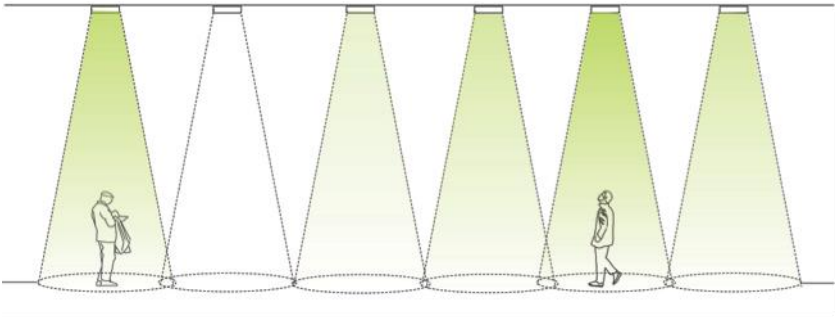

Figure 2 The lighting environmental experience set up for investigating territorial space personalization.

The influence of lighting was investigated in terms of space personalization and people territorialisation by following users movements with slow and subtle lighting events occurring in a linear causal way for navigating the space. People were detected by two sensors which in turn, triggered the lighting in relation to their position and behaviours. Lighting was turned on for welcoming people in the space, illuminating the path and showing the foreground with warm white and higher lighting levels (fig. 2).

Interviews highlighted different levels of positive impressions and approval: lighting was found to be significant in personalizing the space and giving a sense of control, evocating a positive company meanwhile having a reassuring power. Adaptive lighting was defining a subtle relationship with people through unconscious and not–invasive perception.

In many cases, people were detouring, watching around or trying to see if lighting was following them. Hence lighting determined an impression of subtle management and active personalization of the luminous atmosphere. Even implicit, the interaction with lighting was found to contribute in restoring an intimate connection with the space. Besides this, the direct bodily interaction with lighting increasing both levels and personal control,

as found by Haans and de Kort (2012), ensures security perception and comfort of the individuals, without creating embarrassment.

Social appraisal of square lighting

From the studies of Flynn performed in indoor spaces, the subjective appraisal of seven differed lighting scenarios (distribution, contrast between light and shadows and correlated colour temperature) was performed through a pairwise comparison to assess sociality in terms of safety and security perception, privacy/publicness and cosiness/detachment comfort and liveliness impressions.

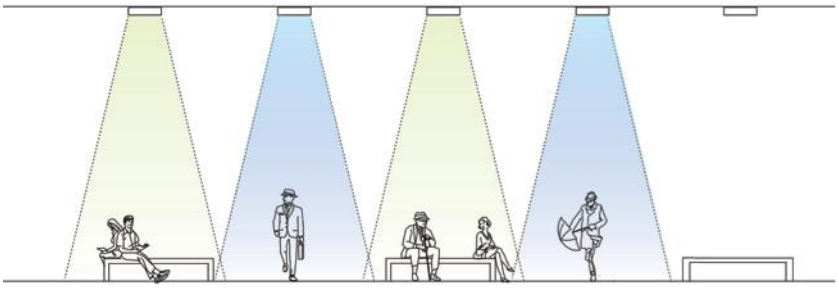

Figure 3 The lighting environmental experience set up for investigating privacy/publicness, cosiness/detachment of the different lighting conditions.

From both qualitative and quantitative results, (Casciani, 2014a; Casciani and Rossi, 2015) people found warm white lighting more suitable for socialisation and contributing to the perception of cosiness and hospitality in comparison to cold white lighting that was found too much technical and not convenient for social activities. The interviewed participants were continuously referring to past experiences and interpretation: warm lighting preference, for instance, was associated to traditional public lighting with an 'orange–yellowish colour' and to domestic lighting 'with a feel at home touch'.

The bright and uniform lighting atmosphere was associated with safety perception and extreme functionality. Differently, a layered approach with a dim ambient lighting and spotlighting on meaningful visual cues was associated with a more evocative atmosphere for social inclusion, enhancing conversation and fostering social interaction. The luminance contrast ratio of lit and dim spaces influenced higher emotional effects which were

evident during the interviews: the environment was found comfortable, interesting, mysterious and reassuring. Even if not statistically significant, the preference for more light for safety issues depended both from gender (e.g. female) and personality characteristics (femininity), meanwhile the interest and attraction toward the shadow–light juxtaposition were connected to past experiences of positive social situations: 'It reminds me the lighting you find in a club. You can focus on people and decide to be in the darkness or in the light'.

Similar trends about impressions of privacy/intimacy and interest/appeal influenced by lighting in public squares were found by Nasar and Bokharaei (2017) by using quantitative surveys mediated through virtual simulations.

Social behaviours in a public/private shelter

Based on the studies of Kobayashi (2013) and Magielse and Ross (2011), sociopetal/sociofugal behaviours, social proximity, social appraisal and lighting control consciousness occurring during the implicit interaction were investigated in the third case study. The lighting experience was designed so that if the couple was leaning backwards (social detachment), the atmosphere would change in cold white and direct/indirect lighting. If leaning forward (social proximity), the atmosphere would change in a direct warm white spotlight (fig. 4 and fig. 5).

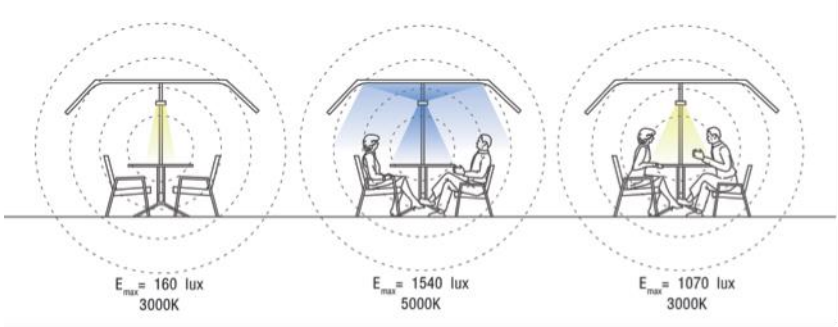

Figure 4 The micro–lighting environmental experience set up for investigating sociopetal/sociofugal behaviours and social proximity.

Despite the lighting system was not expressing evidently how to be controlled, a group of the participants interacted explicitly to explore it further and to understand the meaning of the lighting transformations. They were not constraining their behaviours, but rather showing interest and

testing the lighting system through explorative behaviours and gestures which made visible evidence of personal control and occupation of territory. The majority of participants were guessing, during the experience, the reason for lighting changes. The interviewed participants expected the interaction to occur through voice volume recognition, movement and distance detection but also through emotions, thoughts and mood monitoring.

During the experience, different kind of interaction occurred: indirect engagement with lighting (as it was designed), direct interaction between people triggered by lighting (talking about the meanings of the light changes), direct interaction between people and lighting triggered by the researcher (in the interview phase).

The lighting system was found supportive during the role–play by the majority of the participants, useful to assist the performance of fictional social activities in the background of the participants' attention. During the interviews, people addressed the warm lighting as more intimate, comfortable and cosier, defining a more intimate zone and a supportive atmosphere in social situations. Warm and spotlight condition were found to fit intimate situations in defining a closer relationship and shaping a more private condition. Feeling to be surrounded by darkness and to be less exposed allowed to talk more openly about personal information. The warm spotlighting condition suggested, provoked and supported more privacy, intimacy and closeness by defining a personal territory. When the dimly lit environment was brightened, it suddenly tended to invite less intimate interaction, by signalling the transition between one mood to another, as was also noted by Knapp, Hall and Horgan (2014).

Cold direct/indirect lighting was found more formal and detached, helping in maintaining the distance between individuals by showing the faces and the surroundings; people felt more exposed and revealed in a luminous condition which defined an open shared territory.

The majority of the participants said to enjoy the lighting system during the interviews: the system was found as effectively accommodating the luminous atmosphere in relation to the proxemics impressions of people, even if they reported the occurrence of too harsh and sudden lighting transformations. Interviews also revealed that the social agency of lighting in this experiment was determined by cultural association that have been accumulated through generations of past experiences. Many times, people mentioned that 'the lighting recalls about' previous lighting atmospheres in order to define if it was appreciated and supportive in the social activities.

Participants also gave suggestions and further possible applications in different settings which are out of the discussion of this paper.

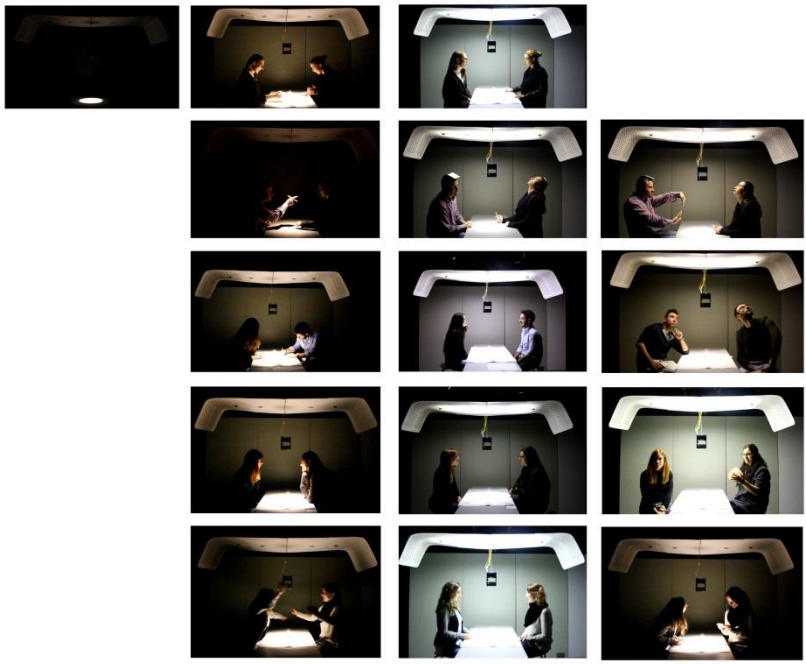

Figure 5 Some screenshot of the role–play videotapes: the first column show the scene with no people; the second column shows moments of social closeness; the third column shows situations of social detachment; the fourth column shows people exploration of the lighting systems and its functions.

A men–female couple felt embarrassment during the experiment when displaying and sharing publicly their personal and social information through lighting and showed a veiled annoyance due to the intimate lighting condition which was considered too inappropriate. In the other cases, with male–male and female–female couples, lighting was not creating problems in this regard. The personal or shared behavioural transformations disclosed by lighting were not causing evident discomfort. Other than this, the possible negative feedback determined by visual disclosure should be also considered when designing socially adaptable lighting systems.

Despite of the small number of combined couples of this experiment, according to the study of Kobayashi (2013), gender seems to differentiate impressions, attitudes and behaviours about social lighting in closeness situations.

Concluding remarks

This paper, rather than providing a conclusive answer, has an exploratory nature, by addressing a series of different perspectives and tackling various issues in the realm of psycho–social effects of lighting on sociality. The gathered insights result preliminary but useful to extend the investigation about a more human–centric perspective of LED lighting design and digital controls applications.

The majority of the reviewed studies have an international span (North America, Europe and Japan) and show similar trends toward the social agency of lighting, even though heterogeneous cultures have been involved in the mentioned studies. On the other hand, the majority of these studies were performed in controlled laboratory settings or by recreating specific indoor situations (e.g. counselling, office and conference rooms) and only a small amount were realised in real spaces to study overt behaviours and the implications of light on people sociality.

Through the case studies explorations, lighting resulted not to be the solely determinant factor to make a place more social or sociable. In fact, lighting can act as a feature which complements the environment to its social quality and use. Despite of this, certain luminous atmospheres have a social evocativeness across different cultures and can contribute to design and set more human and social oriented experiences in terms of safety, intimacy and hospitality both in indoor and outdoor settings.

In particular, warm white lighting and the lighting distribution in the space can affect the personal and interpersonal space requirements along with the territorial and social behaviours. In this, past experiences, cultural sensitivities and individual taste have a determinant role in defining the social agency of lighting atmospheres. If people can manipulate lighting assigning a social meaning. Lighting, in turn, seems to have the agency of manipulating people as well, with a subtle influence on social behaviours inducing background reactive and proactive human–light interactions (Ju and Leifer, 2008).

The results of the experimental case studies highlighted the fact that the effect of lighting is delicate, especially when social activities take place. Even

though the explorations demonstrated that lighting has a subtle influence on the social behaviours of the participants, it is still recognised in its rooted social meanings. Therefore it is also unconsciously influencing and leveraging deeper social meanings. In this regard, light acts supportively of social behaviours in specific real or fictional social applications to accommodate or compensate for more private/intimate or public/detached situations. Light acts to enforce interpersonal relationships, supports social negotiations, contributes in communicating proxemics information and defining more socially including or excluding environments.

From this paper, it is also evident that behaviours are not only socially based or bound up on cultural association but are also rooted in luminous atmosphere, conceived as the intermediate state between light, the environment and human perception. For this reason, the influence of certain 'lightscapes' (Bille and Soresen, 2007) on people behaviours should be always read as mediated by contextual, cultural, environmental, personal and social factors. Despite of this, similarities between lighting cultures and personal background in relation to the social appraisal of a lighting situation were found during the case studies, particularly in assessing the impression of intimacy, cosiness and romantic atmosphere compared to a detached, formal and tense luminous environment.

In addition to this, the case studies present an initial contribution to the design of socially adaptive public lighting in contemporary cities which advocate for a deep investigation of different environments and various other situations. This inquiry seems to be crucial in the future development of the so–called smart cities where the lighting scenarios and behaviours should be designed in order to influence, positively, the social use of the city. In fact, the research about the influence of lighting on sociality can concur to create better and more meaningful experiences through the use of new technologies (e.g. Internet of Things and digital lighting). The use of the adaptive luminous micro–environment, in particular, confronted people with a new level of awareness about future possibilities of lighting and choices which were not present before.

In this sense, further investigations, through the use of luminous 'provotypes' (Aliasgari and Clark, 2016) are seen as a possible further step of investigation to foster the social dimension of lighting in more active ways, incentivizing social uses, agency and exchanges.

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