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Posted Date: 17 May 2024

doi: 10.20944/preprints202405.1129.v1

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Article

Exploring Urban Lighting Design Effect on Citizens' Emotions through the Application of Kansei Methodology

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Abstract: Outdoor lighting design is a multidisciplinary topic that involves, among other aspects, design, energy savings, protection of nocturnal biodiversity and profitability, all of which are important functional and regulatory requirements. However, they do not necessarily consider user needs, which make perception and emotional response difficult parameters in the lighting design process. The studies carried out on lighting and its impact on emotions have mainly been done indoors. The objective of this work is to propose a methodology to evaluate emotional response to the illuminated nocturnal urban space with the purpose of providing knowledge to create emotionally efficient luminous spaces that improve people's perception and well-being. The instrument used was the survey (online questionnaires), based on Kansei engineering, created to incorporate the emotional variable in product design. The research was carried out with participants from Peru, Spain, and Germany. The results collected the reaction of the participants to different types of night-time luminous spaces presented, which contributes to a better understanding of user needs and activities regarding the space. This knowledge is intended to help designers meet their expectations.

Keywords: lighting design; emotions; aesthetic descriptors; technical descriptors; Kansei engineering

1. Introduction

The European Union has made significant strides toward achieving almost all the 17 Sustainable Development Goals (SDGs) [1]. Eurostat data indicates that SDG 11, "Sustainable Cities and Communities," emphasizes the necessity for elevated living standards among citizens [2]. As urbanization continues to rise globally, it becomes imperative to comprehend the connections between urbanized environments and the well-being and health of individuals [3]. With these in mind, there is a recognized and actively promoted role for citizens in various aspects of the European Green Deal. The Conference on the Future of Europe has brought attention to the importance of participatory processes, particularly in the context of the European Green Deal [4]. The current research is driven by a commitment to enhancing outdoor environment quality in urban areas and improving the well-being of residents.

During last 100 years urban planning development has approached three different paradigm shifts driven by the following: technical conditions for roads and cars; road safety and visibility conditions for pedestrians and cyclists; and environmental conditions and its effects on dark skies, plants, animals and people [5]. Outdoor lighting is revealed as a powerful tool to support Sustainable Development Goals [6], which must be considered and balanced to make sustainable decisions. It is a complex issue that involves multiple aspects, e.g., energy consumption, lighting pollution, aesthetics and safety [7]. To date, some researchers have provided insights into the body of knowledge involving city lighting, from different perspectives: energy performance, smart cities, user satisfaction, etc [8–12]. Research is still limited in fields such as environmental science, psychology, biology, medicine and astronomy, specifically the effects of LED lighting on animals, plants and mainly people [13]. There is a noticeable lack of research on sustainable cities at night and the impact of light pollution from outdoor lighting on humans, flora and fauna in the context of the UN's SDGs [14,15]. Until now the issue of cities for the future has not been treated in a comprehensive manner

and this is due mainly to the lack of understanding of complex issues that are interrelated, therefore more studies are required to help further understanding [5,16].

Despite the links already demonstrated between the built environment and health and well-being [17,18], specifically psychophysical well-being [19–22], there are fundamental aspects that have been paid less attention. Lighting adds different meanings to people's experience of space: cognitive-affective, associative and motivational [23–27] directly influencing affect, emotion, mood, attention, imagination, perception, memory, judgment, closeness, openness and communication [28,29]. So, when designing a lighting system, it is essential to consider physical, physiological, and psychological requirements. It is important to develop architectural lighting planning that acts as a filter between people and their environment [30].

Lighting is fundamental to people's social lives and the best way to create the link between lighting design and urban spaces is through the concept of "legibility", originally developed by urban planner Kevin Lynch in the 1950s [31]. Making the urban night space a legible space gives the user the ability to "read" their environment, their routes and shapes depending on their perception and understanding of places and how they are connected to each other. It is important to develop architectural lighting planning that acts as a filter between people and their environment [30]. Lighting designers need to understand how different users in fact read the social space, their map or image of that space." [32]

The façades of buildings delimit the social space and in the urban environment, they are a decisive factor in the perception of the citizen [33,34], determining the order and the way in which different objects in the visual environment are observed, this can help to understand the linkages between urbanized environments and wellbeing and health [35,36]. The challenge is understanding why there are places that encourage certain moods. In 1998, neuroscientists Fred H. Gage and Peter Ericsson announced the discovery that the human brain can produce new neurons favoured by richly stimulating environments [37], this was the birth of neuroarchitecture [38]. Recent research focuses on the application of the scientific method in the design of architectural spaces, known as Evidence-Based Design (EBD), which links scientific evidence and design parameters with user outcomes. New technological advances and interdisciplinary approaches enable the scientific community to employ neurophysiological and traditional techniques to measure user experiences, offering tools for the study of cognitive and emotional response [39–41].

One of these tools is Kansei engineering (also referred to as affective engineering), which is a consumer-oriented method of product design. It is defined as "translating technology of a consumer's feeling and image for a product into design elements" [42–45]. The applications of Kansei engineering are numerous, especially in product development [48–50], recent studies address the effect of indoor lighting design [46,47] but in the field of urban lighting the studies are still limited [51,52]. Traditionally, research aiming at user responses to lighting environment comes from the field of psychology or engineering, not considering parameters of lighting design that could effectively cater to specific user needs.

This study focuses on urban lighting design, exploring its effect on citizens' emotions. A methodology based on Kansei engineering is developed in response to the question: How does lighting of facades within the urban space influence people's emotions?

2. Methodology

The methodology proposed is based on Kansei engineering and is performed using surveys. Surveys are a common research method used worldwide and considered suitable for gathering self-reported quantitative and qualitative data from a large number of respondents [53,54]. The use of an online mechanism offers significant advantages over more traditional survey techniques [55], as from just a few clicks, it is possible to get an answer from anyone, anywhere in the world, at any time. The authors used an online tool to implement the survey questionnaire.

Kansei Engineering translates people's feelings into concrete design elements since it works with symbolic attributes and people's perceptions expressed in their own language. It enables linking the object of study with the user, seeing the object from a perspective that goes beyond its function and use, seeking the perfect balance between function-use of the object and acceptance-enjoyment of the design on the part of the user. This technique provides a method based on the selection of symbolic

attributes (words or aesthetic descriptors) and user perceptions (emotions) generated from user language.

Figure 1 shows the main methodology elements. The product to be studied is “the facades of buildings within an urban space” called from now on “luminous space”, the citizen “user” through the questionnaires containing “aesthetic descriptors” to express the “emotions”.

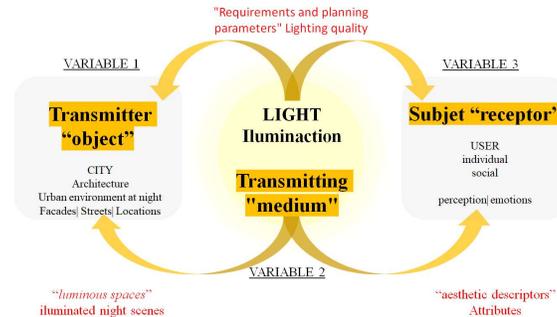


Figure 1. Methodology elements.

The answers to these questionnaires are intended to evaluate the reaction of users to variations in façade lighting within the urban space and thus provide design solutions that improve people's perception and well-being, with the aim to create emotionally efficient bright urban spaces (Figure 2).

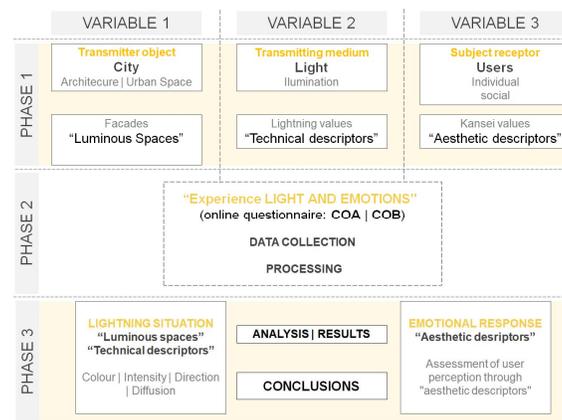


Figure 2. Methodology.

3. Variables

The variables involved in the development of the methodology used are 3:

3.1. "Luminous Spaces"

Variable 1 are images (stimulus) of “luminous spaces”. The lighting satisfies, on one hand, the functional need of the users (free circulation), and on the other hand, it fulfills a purely aesthetic factor of beautification of the city. The selection process of the “luminous spaces” was developed from professional lighting design projects, carried out by different architectural studios together with the most recognized lighting manufacturers on the market, such as Erco, Zumtobel or Siteco.

The selection of the “luminous spaces” responds to the objective of representing different situations that arise within urban spaces in terms of the use of the building, architectural style, geographical location, population density, etc. In addition, an analysis was carried out according to the classification of the German regional office and planning, which distinguishes cities and municipalities according to the number of inhabitants and the importance they have for their respective region considering small city (5,000- 10,000), medium city (20,000-50,000 inhabitants) and large city (cities between 1000,000-5000.00 inhabitants).

The process of searching for the different “luminous spaces” started from a selection of almost 90 images of which 15 were chosen, the most representative in terms of their architectural style and use of space. The “luminous spaces” selected are:

Luminous space 1 (Figure 3) in a small city.

A road on the outskirts of the city. Functional lighting for public road lighting and accent lighting for façade lighting. The road and the façade have an intense clear illuminance, differing only in color temperature, the road having a cold color temperature and the façade warm.



Figure 3. Luminous space 1. Source: SITECO _Streetlighting Traena/1. www.siteco.de_

Luminous space 2 (Figure 4) in a small city.

A footpath near the city. It has functional lighting for public lighting of pedestrian streets and accent lighting highlighting a church tower in the distance. The pedestrian street and the church tower have a dim light illuminance, and both have a warm color temperature.



Figure 4. Luminous space 2. Source: SITECO _Streetlighting_ Balgheim/1. www.siteco.de_

Luminous space 3 (Figure 5) in a small city.

Building facades around a square. It has accent lighting for façade lighting. The square has a soft light illuminance resulting from the accent lighting, the environment is dark, and it has a warm color temperature.



Figure 5. Luminous space 3. Source: ERCO GmbH, www.erco.com. Photography: Dirk Vogel, Dortmund / DE.

Luminous space 4 (Figure 6) in a small city.

Building facades in streets of the old town. It has accent lighting for façade lighting. The streets have very dim light illuminance resulting from the accent lighting, the environment is dark and has a warm color temperature.



Figure 6. Luminous space 4. Source: ERCO GmbH, www.erco.com. Photography: Dirk Vogel, Dortmund.

Luminous space 5 (Figure 7) in a medium city.

Building facades on the boardwalk, in a coastal city. It has accent lighting to illuminate the facades of buildings along a boardwalk. The lighting of the facades of buildings stands out, which has clear and bright illuminance, intense and warm color temperature.



Figure 7. Luminous space 5. Source: ERCO GmbH, www.erco.com. Photography: Thomas Mayer, Neuss.

Luminous space 6 (Figure 8) in a medium city.

Façade of a single-family home. It has accent lighting to illuminate the façade of the home. The façade lighting has a clear and intense illuminance, the environment is dark and has a warm color temperature.



Figure 8. Luminous space 6. Source: ERCO GmbH, www.erco.com. Photography: Tomas Södergren, Stockholm.

Luminous space 7 (Figure 9) in a large city.

Commercial building façade. It has accent lighting to light the facade of the commercial building and advertising lighting, the environment is also illuminated with functional lighting for public street lighting. This bright space is perceived as dark despite being illuminated with quality color temperature, where the advertising lighting stands out.



Figure 9. Luminous space 7. Source: ERCO GmbH, www.erco.com. Photography: Dirk Vogel.

Luminous space 8 (Figure 10) in a large city.

Facade of a museum within the city. It has accent lighting from inside the building through the windows and skylights that overlook the garden, the environment is kept illuminated thanks to the uniform light that comes from the interior and presents two color temperatures, one warm for the facades and another cold for the garden area.



Figure 10. Luminous space 8. Source: ZUMTOBEL group, www.zumtobel.com.

Luminous space 9 (Figure 11) in a large city.

Facade of a public building within the city. It has accent lighting for the facade of the building, the environment is dark and has a warm colour temperature.



Figure 11. Luminous space 9. Source: ERCO GmbH, www.erco.com. Photography: Frieder Blicke, Hamburg.

Luminous space 10 (Figure 12) in a large city.

Facade of an art gallery building in front of a square within the city. It has accent lighting for the facade of the building, the environment is dark and has a warm colour temperature.



Figure 12. Luminous space 10. Source: ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg.

Luminous space 11 (Figure 13) in a large city.

Bridge and architectural landmark within the city. It has functional lighting for the public lighting of the bridge and accent lighting highlighting the tower of a church in the distance, the environment is dark and has a warm colour temperature.



Figure 13. Luminous space 11. Source: ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg.

Luminous space 12 (Figure 14) in a large city.

Facade of a cathedral in a square within the city. It has accent lighting for the cathedral and surrounding buildings, the environment is dark and has a warm colour temperature.



Figure 14. Luminous space 12. Source: ERCO GmbH, www.erco.com. Photography: Moritz Hillebrand, Zürich, Timm Lange, Düsseldorf.

Luminous space 13 (Figure 15) in a large city.

Facades of the sales stalls inside a market within the city. It has functional lighting that is required for work lighting and atmospheric lighting that fulfills the functional lighting in circulation areas, the environment is dark and has a warm colour temperature.



Figure 15. Luminous space 13. Source: ERCO GmbH, www.erco.com. Photography: Thomas Mayer, Neuss.

Luminous space 14 (Figure 16) in a large city.

Facade of an office building within the city. It has functional lighting that is required for work lighting and to illuminate the public lighting of the avenue busy with vehicular traffic, the environment is clear and has cold a colour temperature.



Figure 16. Luminous space 14. Source: ERCO GmbH, www.erco.com. Photography: Frieder Blicke.

Luminous space 15 (Figure 17) in a large city.

Facade of a hotel within the city. It has accent lighting for the hotel building, highlighting architectural elements and prioritizing the main entrance, the environment is dark and has a warm colour temperature.



Figure 17. Luminous space 15. Source: ERCO GmbH, www.erco.com. Jackie Chan, Sydney.

3.2. Technical Descriptors

Variable 2 is the “technical descriptor”. It is urban lighting, the “transmitting” medium, which has a leading role at night, and depends on the different parameters and lighting requirements of each “luminous space”, it transmits a certain stimulus (positive or negative) to users.

Within urban lighting we find different lighting parameters that serve as a tool when developing the lighting design. For this research work we have focused on two of them, illuminance (lux) and colour temperature (Kelvin), since they are the easiest to recognize or differentiate, using basic concepts such as light-dark when talking about illuminance or of warm-cold light when talking about colour temperature.

For this research, 15 “luminous spaces” were shown, and two lighting variations were incorporated into each of them, thus obtaining 3 categories of “luminous spaces” (Tables 1 and 2):

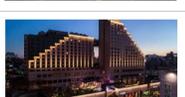
Category I, OPAQUE luminous space (dark, gloomy), those spaces whose urban elements and/or surroundings look dark.

Table 1. 1 to 5 “Luminous spaces” variations.

| Luminous spaces | category | urban elements | Lighting Parameters Values | |
|--|-------------|------------------|----------------------------|-----------------------------|
| | | | Illuminance (Lux) | Colour temperature (Kelvin) |
| 1a  | II penumbra | Building facade: | clara 3 a 5 | cold 4000 |
| | | Path: | claro 3 a 7 | cold 4000 |
| | | Surroundings: | dark 0 a 1 | -- |
| 1b  | III bright | Building facade: | clara 5 a 10 | warm 3000 |
| | | Path: | claro 5 a 10 | cold 4000 |
| | | Surroundings: | dark 0 a 3 | -- |
| 1c  | I opaco | Building facade: | dark 0 a 1 | -- |
| | | Path: | claro 1 a 3 | cold 4000 |
| | | Surroundings: | dark 0 | -- |
| 2a  | III bright | Tower : | clara 3 a 7 | warm 3000 |
| | | Path: | claro 5 a 10 | cálido 3000 |
| | | Surroundings: | dark 0 | -- |
| 2b  | II penumbra | Tower : | clara 1 a 5 | cold 4000 |
| | | Path: | claro 3 a 5 | cold 4000 |
| | | Surroundings: | dark 0 | -- |
| 2c  | I opaco | Tower : | oscura 0 | -- |
| | | Path: | dark 1 a 3 | cold 0 |
| | | Surroundings: | dark 0 | -- |
| 3a  | II penumbra | Building facade: | clara 1 a 5 | cold 4000 |
| | | Plaza: | clara 1 a 3 | cold 4000 |
| | | Surroundings: | dark 0 a 2 | -- |
| 3b  | I opaco | Building facade: | oscura 0 a 1 | -- |
| | | Plaza: | oscura 0 | -- |
| | | Surroundings: | dark 0 | -- |
| 3c  | III bright | Building facade: | clara 3 a 7 | warm 3000 |
| | | Plaza: | clara 3 a 5 | cold 4000 |
| | | Surroundings: | dark 0 a 3 | -- |
| 4a  | III bright | Building facade: | clara 3 a 7 | warm 3000 |
| | | Streets: | clara 1 a 5 | warm 3000 |
| | | Surroundings: | dark -- | -- |
| 4b  | I opaco | Building facade: | dark -- | -- |
| | | Streets: | dark -- | -- |
| | | Surroundings: | dark -- | -- |
| 4c  | II penumbra | Building facade: | clara 1 a 5 | cold 4000 |
| | | Streets: | clara 1 a 5 | cold 4000 |
| | | Surroundings: | dark -- | -- |
| 5a  | II penumbra | Building facade: | clara 5 a 10 | cold 4000 |
| | | Surroundings: | claro 5 a 10 | cold 4000 |
| 5b  | III bright | Building facade: | clara 5 a 10 | warm 3000 |
| | | Surroundings: | claro 5 a 10 | cálido 3000 |
| 5c  | I opaco | Building facade: | dark 0 a 3 | warm 3000 |
| | | Surroundings: | dark 0 a 3 | cálido 3000 |

Table 2. 6 to 15 “Luminous spaces” variations.

| Luminous spaces | category | urban elements | Lighting Parameters Values | |
|---|-------------|------------------|----------------------------|-----------------------------|
| | | | Illuminance (Lux) | Colour temperature (Kelvin) |
| 6a  | I opaco | Building facade: | oscura 0 a 3 | cold 4000 |
| | | Surroundings: | dark 0 a 3 | cold 4000 |
| 6b  | II penumbra | Building facade: | clara 1 a 5 | cold 4000 |
| | | Surroundings: | claro 1 a 5 | cold 4000 |
| 6c  | III bright | Building facade: | clara 1 a 5 | warm 3000 |
| | | Surroundings: | claro 1 a 5 | cálido 3000 |
| 7a  | I opaco | Building facade: | oscura 0 a 2 | cold 4000 |
| | | Streets: | oscura 0 | -- |
| | | Surroundings: | dark 0 | -- |
| 7b  | III bright | Building facade: | clara 3 a 7 | cálido 3000 |
| | | Streets: | clara 1 a 5 | cold 4000 |
| | | Surroundings: | dark 1 a 3 | cálido 3000 |
| 7c  | II penumbra | Building facade: | clara 3 a 7 | cold 4000 |
| | | Streets: | clara 1 a 5 | cold 4000 |
| | | Surroundings: | dark 1 a 3 | -- |
| 8a  | I opaco | Building facade: | oscura 0 | -- |
| | | Plaza: | clara 3 a 5 | cold 4000 |
| 8b  | II penumbra | Building facade: | clara 5 a 10 | cold 4000 |
| | | Plaza: | clara 3 a 5 | cold 4000 |
| 8c  | III bright | Building facade: | clara 5 a 10 | cálido 3000 |
| | | Plaza: | clara 3 a 5 | cold 4000 |
| 9a  | III bright | Building facade: | clara 5 a 10 | warm 3000 |
| | | Surroundings: | claro 3 a 5 | cálido 3000 |
| 9b  | I opaco | Building facade: | oscura 0 | -- |
| | | Surroundings: | dark 0 | -- |
| 9c  | II penumbra | Building facade: | clara 5 a 10 | cold 4000 |
| | | Surroundings: | claro 3 a 5 | cold 4000 |
| 10a  | I opaco | Building facade: | oscura 0 | -- |
| | | Plaza: | dark 0 | -- |
| | | Surroundings: | dark 0 | -- |
| 10b  | III bright | Building facade: | claro 5 a 15 | cálido 3000 |
| | | Plaza: | oscura 1 a 3 | warm 3000 |
| | | Surroundings: | claro 1 a 5 | cálido 3000 |
| 10c  | II penumbra | Building facade: | claro 5 a 10 | cálido 3000 |
| | | Plaza: | oscura 0 a 3 | cálido 3000 |
| | | Surroundings: | dark 0 a 3 | cálido 3000 |

| Luminous spaces | category | urban elements | Lighting Parameters Values | |
|---|--------------|------------------|----------------------------|-----------------------------|
| | | | Illuminance (Lux) | Colour temperature (Kelvin) |
| 11a  | II penumbra | Tower: | clara 5 a 10 | cálido 3000 |
| | | Bridge: | claro 3 a 5 | cálido 3000 |
| | | Surroundings: | dark 0 a 3 | cold 4000 |
| 11b  | I opaco | Tower : | dark 5 a 10 | cálido 3000 |
| | | Puente: | dark 3 a 5 | cálido 3000 |
| | | Surroundings: | dark 0 a 3 | - - |
| 11c  | III bright | Tower: | clara 5 a 15 | cálido 3000 |
| | | Puente: | claro 3 a 7 | cálido 3000 |
| | | Surroundings: | claro 0 a 3 | cálido 3000 |
| 12a  | I opaco | Building facade: | dark - | - - |
| | | Plaza: | dark - | - - |
| | | Surroundings: | dark 0 a 1 | cálido 3000 |
| 12b  | III bright | Building facade: | claro 1 a 3 | warm 3000 |
| | | Plaza: | dark 0 a 2 | oscura 3000 |
| | | Surroundings: | claro 3 a 5 | cálido 3000 |
| 12c  | II penumbra | Building facade: | claro 1 a 3 | cold 4000 |
| | | Plaza: | dark 0 | - - |
| | | Surroundings: | claro 3 a 5 | cold 4000 |
| 13a  | III bright | Porch of arches: | clara 5 a 15 | warm 3000 |
| | | Path: | claro 1 a 3 | cálido 3000 |
| | | Surroundings: | claro 1 a 5 | cálido 3000 |
| 13b  | I opaco | Porch of arches: | clara 5 a 10 | cálido 3000 |
| | | Path: | dark 0 | - - |
| | | Surroundings: | claro 1 a 3 | cold 3000 |
| 13c  | III penumbra | Porch of arches: | clara 5 a 10 | cold 4000 |
| | | Path: | claro 0 a 3 | cold 4000 |
| | | Surroundings: | claro 1 a 3 | cold 4000 |
| 14a  | III bright | Building facade: | clara 5 a 10 | cálido 3000 |
| | | Streets: | claro 5 a 15 | cálido 3000 |
| 14b  | II penumbra | Building facade: | clara 5 a 10 | cold 4000 |
| | | Streets: | claro 5 a 15 | cold 4000 |
| 14c  | I opaco | Building facade: | oscura 1 a 5 | cold 4000 |
| | | Streets: | dark 0 | - - |
| 15a  | II penumbra | Building facade: | clara 5 a 10 | cold 4000 |
| | | Surroundings: | claro 3 a 5 | cold 4000 |
| 15b  | I opaco | Building facade: | oscura 0 | - - |
| | | Surroundings: | dark 0 | - - |
| 15c  | III bright | Building facade: | clara 5 a 10 | warm 3000 |
| | | Surroundings: | claro 3 a 5 | cálido 3000 |

Category II, luminous space PENUMBRA (weak shadow between light and darkness), those spaces where either the environment or part of the urban elements look dark.

Category III, BRIGHT luminous space (clarity, sharpness), those spaces whose urban elements and/or surroundings look clear.

3.3. "Aesthetic Descriptors"

Variable 3 are the "aesthetic descriptors" or attributes, which are the perception or emotion of the participant (response or reaction) selected to describe the "luminous spaces" presented through the lighting scenes.

The "aesthetic descriptors" are defined based on the work of José Luis Diaz and Enrique O. Flores [56], where they presented a detailed list of 328 terms of human emotion in Spanish. A selection of the positive and negative "aesthetic descriptors" that could be used to describe the "luminous spaces" was carried out, this gave rise to the basis for the final list used in the "Online Questionnaire A_COA" with 60 attributes. From this base list, a new filter was made, removing those "aesthetic descriptors" with similar meaning, for example, calm, stillness, serenity.

Furthermore, each "aesthetic descriptor" was analysed, as well as each of its synonyms, choosing only those that best expressed people's emotional reaction to the lighting scenarios. This resulted in a final list of 18 pairs of attributes which were ordered into 10 groups according to their meaning or definition and classified into four categories, which have been called perception categories (favourable, unfavourable, neutral, and indifferent). This final list of attributes was made in the official language of each country, that is, a list of "aesthetic descriptors" was prepared for Peru and Spain in Spanish and another in German for Germany. Table 4 shows a translation of the "aesthetic descriptors" into English.

Table 4. Aesthetic descriptors in English.

| | favourable | unfavourable | neutral | indifferent |
|-----------------|------------|--|---|------------------------|
| emotional group | 1 | I like it liking attractive fascinating | I don't like it disgust tasteless unpleasant | |
| | 2 | interesting happiness enthusiasm | boring sadness | apathy |
| | 3 | comfortable wellbeing | uncomfortable discomfort | |
| | 4 | tranquillity calm | restlessness suspense | |
| | 5 | trust security | fear unsafety | |
| | 6 | vitality | exhaustion | |
| | 7 | relaxing | stressful | |
| | 8 | pride (identity) | rejection | |
| | 9 | socialise (outgoing) | | isolate (introvert) |
| | 10 | harmonises | disturbs | |

Source: Authors.

3.4. "Light and Emotions Experience" (COA|COB)

The Survey used to perform this research is made up of two link questionnaires COA and COB and is named "light and emotions experience". The "aesthetic descriptors" used in COB are a result of the answers to COA.

The COA is the first part of the "light and emotions experience", using an "aesthetic descriptor" it seeks to obtain a response from the intuitive and spontaneous perception of the participant, it consists of three parts:

Part 1: Relevant general data of the participants such as gender, age, level of training, nationality, place of residence and date.

Part 2: Preferences for "luminous spaces", questions are asked so the participants choose an answer among the predefined options and thus give an opinion about their experience on the type

of lighting they relate to, as well as other aspects related to the influence of lighting on their well-being and their connection to the city. (Figure 18)

2.1 ¿Con qué tipo o tipos de iluminación identificas a tu ciudad?

Iluminación funcional (aquella iluminación que te permite ver)

Iluminación de acento (aquella iluminación que resalta edificios o monumentos)

Iluminación temporal o decorativa (aquella iluminación que se emplean en fechas especiales como navidad)

2.2 ¿Cuál tipo o tipos de iluminación de tu ciudad te gusta más?

Iluminación funcional (aquella iluminación que te permite ver)

Iluminación de acento (aquella iluminación que resalta edificios o monumentos)

Iluminación temporal o decorativa (aquella iluminación que se emplean en fechas especiales como navidad)

2.3 ¿Qué tipo de luz prefieres en tu entorno urbano?

Luz fría – luz blanca (aquella fluorescente)

Luz cálida, luz amarilla (aquella bombilla incandescente)

Luz de colores

2.4 ¿De regreso a casa, un día de invierno a mitad de la noche, qué camino estas dispuesto a elegir?

Camino corto con poca iluminación

Camino largo con buena iluminación

2.5 Marca aquellos aspectos en los que crees que la iluminación influye en tu bienestar:

Puedo realizar paseos

Puedo caminar por mi barrio y mi ciudad libremente

Me oriento mejor en el espacio urbano

Me siento seguro/a

2.6 ¿Crees que la iluminación de fachadas y de tu entorno urbano crea vínculos positivos con tu ciudad?

Sí, porque con una buena iluminación de la arquitectura y su entorno, me siento identificado/a y orgulloso/a de mi barrio y ciudad.

No, porque no necesito de una iluminación especial para sentirme orgulloso/a de mi ciudad.

Figure 18. COA-part 2. Source: Authors.

An example of this kind of question is:

What kind of lighting would you identify your city with?

- Functional lighting (to see)
- Accent lighting (to highlight façades and monuments)
- Temporary or decorative lighting (only used on specific dates, such as Christmas)

Part 3: A choice of “aesthetic descriptors” that describe the perception of the participants when observing the different “luminous spaces” is made. Here a closed question is asked in combination with an image, where the participant has the possibility of choosing one or more response options. Below, in Figure 19, the “luminous space 01” is shown as presented in the “light and emotion experience COA”, this was carried out in all the luminous spaces presented from 01 to 15 (image 17).



3.1 ¿Qué EMOCIÓN te transmite esta imagen de la escena 01?
 Marcar mínimo una y máximo tres PALABRAS o ATRIBUTOS que describen tu emoción:

| | | |
|-----------------------------|-----------------------|-----------------------|
| me gusta | <input type="radio"/> | no me gusta |
| interesante | <input type="radio"/> | aburrido |
| cómodo | <input type="radio"/> | incómodo |
| tranquilidad | <input type="radio"/> | intranquilidad |
| confianza | <input type="radio"/> | miedo |
| vitalidad | <input type="radio"/> | agotamiento |
| relajante | <input type="radio"/> | estresante |
| orgullo (identidad) | <input type="radio"/> | rechazo |
| sociabilizar (extrovertido) | <input type="radio"/> | aislarse (introverso) |
| armoniza | <input type="radio"/> | perturba |

Figure 19. Luminous space 1. COA-part 3. Source: Authors.

COB is the second part of the “light and emotions experience”, where we sought to delve deeper into the participants’ perception of the “luminous spaces” presented. For this purpose, a questionnaire was developed based on the answers most selected by the participants in the COA, which are accompanied by direct and specific questions about the “image-perception-emotion” linking each of the “luminous spaces” to get a concrete answer. COB consists of three parts:

Part 1: Relevant general data like COA.

Part 2: Scale questions are formulated so the participant answers whether they agree or disagree with the question asked using a scale from 1 to 5, where 1 means that you do not agree “at all”, 5 means that you “completely” agree, and 6 means that you “don’t know” (Figure 20).

| | 1 | 2 | 3 | 4 | 5 | 6 |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 2.1 Cuando es de noche, me siento más segura(o) con una iluminación brillante e intensa. | <input type="radio"/> |
| 2.2 Cuando busco desconectar después de un día agotador, prefiero caminar por calles que tengan una iluminación tenue. | <input type="radio"/> |
| 2.3 Las calles y plazas poco iluminadas que son solo ejes y puntos de paso, no me invitan a quedarme e interactuar en ellos. | <input type="radio"/> |
| 2.4 Un edificio bien iluminado me invita a contemplarlo e ingresar en él y descubrir sus espacios. | <input type="radio"/> |
| 2.5 Con una buena iluminación me siento segura(o) y me oriento mejor. | <input type="radio"/> |
| 2.6 Con una iluminación adecuada ahorramos energía y además protegemos el medio ambiente. | <input type="radio"/> |

Figure 20. COB-part 2. Source: Authors.

An example of this kind of question is:

At night, I feel safer with bright and intense lighting.

Part 3, Preferences for “luminous spaces”, here 3 “luminous spaces” are presented, with different lighting parameters, along with specific questions, so that the participant can choose the “luminous space” that best suits them linked to the “aesthetic descriptor” of the question asked. In addition, the participant will also be able to give a rating on a scale of 1 to 6 for each “aesthetic descriptor” according to the “luminous space” chosen (Figure 21).

Escena 01a
Escena 01b
Escena 01c



Escena 01a
Escena 01b
Escena 01c

3.1 ¿En cuál de los escenarios de iluminación te sientes más intranquila/o?

3.2 ¿Cuál de los escenarios de iluminación te transmite confianza?

3.3 ¿Cuál de los escenarios de iluminación te desagrada más?

3.4 A partir de las respuestas de arriba, ¿Cómo valorarías cada uno de los atributos colocados?
Por favor da una valoración del 1 al 6 a las siguientes afirmaciones que aparece a continuación, donde 1 es “para nada”, 5 es “completamente” y 6 es “no sé” si no sabes cómo valorarlo.

¿Cómo valorarías (en una escala del 1 al 6) en la pregunta:

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 3.1 la «intranquilidad» que te transmite la escena de iluminación escogida? | <input type="radio"/> |
| 3.2 la «confianza» que te transmite la escena de iluminación escogida? | <input type="radio"/> |
| 3.3 el «desagrado» que te transmite la escena de iluminación escogida? | <input type="radio"/> |

Figure 21. Luminous space 1. COB-part 3. Source: Authors.

3.5. Process and Participants, Group Selection

Within the process of developing the online questionnaires, the validity of their content was also carried out by experts or specialists in the subject of lighting, architecture, and emotions, who evaluated the relevance, clarity, and coherence of the test.

The “light and emotions experience” (COA | COB) was carried out in Peru, Spain, and Germany. The choice of these countries was due to personal bond and therefore the ease of accessing information and getting participants. The participants were divided into two groups: group 1, common participants, non-architects or designers, and group 2, architects.

The collaboration of at least 120 people was sought in each of the questionnaires and more than 750 links were distributed, from which the incomplete ones were discarded, leaving 84 participants in the COA and 123 participants in the COB.

3.6. Data Correlation and Validation

To verify if there is a correlation between the categorical or qualitative variables, “luminous spaces” and the “aesthetic descriptors”, a chi-square test was carried out.

In this test, a margin of error of 0.05 was used and the following hypotheses were proposed:

H0. null hypothesis: the type of lighting does not influence people’s emotions.

H1. alternative hypothesis: the type of lighting does influence people’s emotions.

After the analysis, it was observed that in most cases in all three countries, the calculated chi-square is greater than the theoretical chi-square, that is, it rejects the null hypothesis, with which it was concluded that the type of lighting does influence people’s emotions or in other words, the observed difference is not a product of chance.

Despite this, two more tests were carried out since in Peru, Spain, and Germany the number of participants in the “light and emotions experience” reached a total of 120 people and does not correspond to a large sample that is needed for chi-square testing. For this reason, a second test was carried out with the Fischer method, which accepts small samples. Finally, to corroborate these results, a third test was carried out, with the chi-square, increasing the number of replications or permutations up to 2000 replications, as shown below (Table 5).

Table 5. Results of data correlation and validation.

| Test 1: chi-square | | | |
|----------------------------|-------|--------------------|-----------|
| Pearson's Chi-squared test | X2 | grados de libertad | pvalor |
| España | 11522 | 817 | < 2.2e-16 |
| Peru | 13859 | 774 | < 2.2e-16 |
| Alemania | Nulo | 645 | Nulo |

| Test 2: Fischer | |
|--|-----------|
| Test de independencia, Test de Fischer | pvalor |
| España | 0.0004998 |
| Peru | 0.0004998 |
| Alemania | 0.0004998 |

| Test 3: Augmented chi-square | | | |
|---|-------|--------------------|-----------|
| Pearson's Chi-squared test with simulated p-value | X2 | grados de libertad | pvalor |
| España | 11522 | 817 | 0.0004998 |
| Peru | 13859 | 774 | 0.0004998 |
| Alemania | Nulo | 645 | Nulo |

Source: authors.

In all calculations the P-value is less than 0.05, therefore, it can be concluded that there is an association between the variables (“luminous spaces” and “aesthetic descriptors”), the dependent variables.

4. Results

Regarding the profile of the participants, Peru and Spain had a greater participation of females, who represent 58% of the total participants in the COA and 67% of the total participants in the COB, while in Germany, males had the greatest participation with 54% of the total participants in the COA and 62% of the total participants in the COB. According to the age range, there is coincidence between the three countries, since most participants belonged to the age group between 40 and 65 years, which represented 67% of the total participants in the COA and 65% in the COB in Peru and Spain, while in Germany they represented 49% in the COA and 55% in the COB. Furthermore, it was observed that in terms of the results according to nationality in Peru and Spain, up to 8 different nationalities participated, Peruvians had the largest number of participants with 54% in the COA and 45% in the COB. In Germany, 4 different nationalities participated, with Germans standing out in participation with 90% in the COA and 98% in the COB. Likewise, when analysing the results by profession, it is observed that of all the people who participated in these three countries, the vast majority are not

architects, which is considered positive since the “light and emotions experience” was directed at the common inhabitant.

4.1. COA

The main objective of the “light and emotions experience” COA was to find out the participants' perceptions of the “luminous spaces” (variable 1) presented in the questionnaire, by choosing 3 “aesthetic descriptors” (variable 3) as shown in Tables 6 and 7. This resulted in the optimization of the aesthetic descriptors for use in the COB. As can be seen in Tables 5 and 6, column 3 shows the aesthetic descriptors in Spanish, column 4 shows their optimization, column 5 shows the aesthetic descriptors in German and column 6 shows their optimization. As an example, “luminous space 1” (Table 6) has been rated with two unfavourable aesthetic descriptors, (uneasiness and I don't like it) and with a favourable one (trust) in Peru and Spain, while in Germany they rated it with 3 favourable aesthetic descriptors (safety, I like it and fascinating) and one unfavourable one (I don't like it). After the analysis of these results, the aesthetic descriptors that formed part of the COB were, uneasiness, trust, and dislike (replacing I don't like it) in Peru and Spain; while in Germany they were security, I like it and exciting. The descriptors that were modified are marked in Tables 5 and 6.

Table 6. Category of perception: **F** = Favourable | **D** = unfavourable – Emotional groups: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10.

| Variable 1 | Variable 3 PERÚ SPAIN | | Variable 3 optimized | Variable 3 GERMANY | | Variable 3 optimized |
|--|----------------------------|--------------------------------|-------------------------|-----------------------|--------------------------------|-------------------------|
| Espacio luminoso 1  | D 4 | restlessness | restlessness | F 5 | security | security |
| | F 5 | trust | trust | F D 1 | I like it I do not like it | I like it |
| | D 1 | I do not like it | unpleasant | F 7 | exciting | exciting |
| Fuente: SITECO Streetlighting Traena, Traena/1. www.siteco.de | | | | | | |
| Espacio luminoso 2  | F 1 | I like it | I like it | F 1 | I like it | cozy |
| | F 7 | relaxing | relaxing | F 3 | feel comfortable | feel comfortable |
| | F 4 | tranquillity | tranquillity | F 10 | harmonizes | harmonizes |
| Fuente: SITECO Streetlighting Balgheim, Gemeidne Balgheim/1. www.siteco.de | | | | | | |
| Espacio luminoso 3  | F 2 | interesting | interesting | D 1 | I do not like it | I do not like it |
| | F 10 | harmonizes | harmonizes | D 2 | boring | boring |
| | F 10 | I like it | attractive | F 2 | exciting | enthusiasm |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Dirk Vogel, Dortmund / Deutschland | | | | | | |
| Espacio luminoso 4  | F 1 | I like it | liking | F 1 | I like it | liking |
| | F 10 D 1 | harmonizes I do not like it | disturb | D 1 | I do not like it | cozy |
| | F 2 | interesting | interesting | F 10 | harmonizes | harmonizes |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Dirk Vogel, Dortmund / Deutschland | | | | | | |
| Espacio luminoso 5  | F 1 | I like it | I like it | F 1 | I like it | I like it |
| | F 6 | vitality | vitality | F 3 | feel comfortable harmonizes | feel comfortable |
| | F 2 F 10 | interesting harmonizes | happiness | F 8 | attractive | attractive |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Thomas Mayer, Neuss | | | | | | |
| Espacio luminoso 6  | F 1 | I like it | attractive | F 3 | feel comfortable | feel comfortable |
| | F 5 | trust | trust | F 1 | I like it | I like it |
| | F 4 | tranquillity | calm | F D 5 | attractive I do not like it | security |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Dirk Vogel | | | | | | |
| Espacio luminoso 7  | F 9 | socialize | socialize | D 1 | I do not like it | I do not like it |
| | F 6 | vitality | vitality | D 4 | restlessness strain | restlessness |
| | D 1 | I do not like it | tasteless | D 2 | boring | boring |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Dirk Vogel | | | | | | |

Source: Authors.

Table 7. Category of perception: **F** = Favorable | **D** = unfavorable – Emocional groups: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10.

| Variable 1 | Variable 3 PERÚ SPAIN | | Variable 3 optimized | Variable 3 GERMANY | | Variable 3 optimized |
|---|----------------------------|-------------------------------|-----------------------------|-----------------------|---|-----------------------------|
| Espacio luminoso 8  | F 2 | interesting | interesting | F 2 | exciting | exciting |
| | F 1 | I like it | I like it | F 8 D | I like it harmonizes attractive I do not like it | attractive |
| | F 10 | harmonizes | harmonizes | F 9 | socialize | socialize |
| Fuente: ZUMTOBEL_group, www.zumtobel.com. Photography: xxx | | | | | | |
| Espacio luminoso 9  | F 1 | I like it | attractive | F 2 | I like it exciting | exciting |
| | F 2 | interesting | enthusiasm | F 8 | attractive | attractive |
| | F 6 | vitality | vitality | D 1 | I do not like it | charmless |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg | | | | | | |
| Espacio luminoso 10  | F 1 | I like it | I like it | F 1 | I like it | I like it |
| | F 10 | harmonizes | harmonizes | F 10 | harmonizes | harmonizes |
| | F 8 | pride (identity) | pride (identity) | F 3 | feel comfortable | feel comfortable |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg / Deutschland | | | | | | |
| Espacio luminoso 11  | F 1 | I like it | liking | F 8 | attractive I like it | attractive |
| | F 8 | pride (identity) | pride (identity) | F 2 | exciting | exciting |
| | F 2 | interesting | interesting | F 10 | harmonizes | harmonizes |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg / Deutschland | | | | | | |
| Espacio luminoso 12  | F 1 8 | I like it pride (identity) | attractive | F 1 | I like it | cozy |
| | F 2 | interesting | enthusiasm | F 10 | harmonizes | harmonizes |
| | F 10 | harmonizes | harmonizes | F 2 | exciting | exciting |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Moritz Hillebrand, Zürich/Schweiz, Timm Lange, Düsseldorf/Deutschland | | | | | | |
| Espacio luminoso 13  | F 2 | interesting | interesting | F 1 | I like it | I like it |
| | F 4 | tranquillity | calm | F 10 D | feel comfortable harmonizes discomfort | harmonizes |
| | D 1 | I do not like it | unpleasant | F 7 D | relaxing exciting I do not like it | relaxing |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Thomas Mayer, Neuss | | | | | | |
| Espacio luminoso 14  | F 6 | vitality | vitality | D 7 | stressful | stressful |
| | F 1 | I like it | attractive | F 1 | I like it | I like it |
| | D 2 7 | interesting stressful | stressful | F 2 | exciting | exciting |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle | | | | | | |
| Espacio luminoso 15  | F 2 | interesting | interesting | F 2 | exciting | exciting |
| | F 1 | I like it | I like it | F 1 | I like it | I like it |
| | F 10 | harmonizes | harmonizes | F 10 | harmonizes attractive | harmonizes |
| Fuente: © ERCO GmbH, www.erco.com. Jackie Chan, Sydney / Australien | | | | | | |

Source: Authors.

4.2. COB

Tables 8 to 10 show the selection of the “aesthetic descriptor” in each country according to the variation of the “luminous space”. As an example, in luminous space 1 the selected variations are:

1a, category of perception II – PENUMBRA,
 1b, category III – BRIGHT
 1c, category I- OPAQUE.

Table 8. Selection of the “aesthetic descriptor” for “luminous spaces” 1 to 5.

| | | Variable 1 | Variable 2 | PERÚ | SPAIN | GERMANY |
|--|----|---|-------------|--------------------------|--------------------------|--------------------------------|
| | | | | Variable 3 | | |
| luminous space 1 + variations | 1a |  | II penumbra | | | |
| | 1b |  | III bright | 28,68% trust | 25,44% trust | 19,17% exciting |
| | 1c |  | I opaque | | | 19,17% I do not like |
| Fuente: SITECO Streetlighting Traena Traena/1. www.siteco.de | | | | | | |
| luminous space 2 + variations | 2a |  | III bright | 31,78% I like it | 25,44% I like it | 25,83% feel comfortable |
| | 2b |  | II penumbra | | | |
| | 2c |  | I opaque | | | |
| Fuente: SITECO Streetlighting Balzheim Gemeinde Balzheim/1. www.siteco.de | | | | | | |
| luminous space 3 + variations | 3a |  | II penumbra | | | |
| | 3b |  | I opaque | | | |
| | 3c |  | III bright | 28,68% attractive | 21,05% attractive | 27,50% enthusiasm |
| Fuente: © ERCO GmbH. www.erco.com. Photography: Dirk Vogel, Dortmund / Deutschland | | | | | | |
| luminous space 4 + variations | 4a |  | III bright | 29,46% liking | 27,19% liking | 22,50% liking |
| | 4b |  | I opaque | | | |
| | 4c |  | II penumbra | | | |
| Fuente: © ERCO GmbH. www.erco.com. Photography: Dirk Vogel, Dortmund / Deutschland | | | | | | |
| luminous space 5 + variations | 5a |  | II penumbra | | | |
| | 5b |  | III bright | 28,68% vitality | 28,95% happiness | 30,83% attractive |
| | 5c |  | I opaque | | | |
| Fuente: © ERCO GmbH. www.erco.com. Photography: Thomas Mayer, Neuss | | | | | | |

Source: Authors.

Peru, Spain, and Germany chose the luminous space 1b of category III – BRIGHT to link it to the favourable aesthetic descriptor “trust”, with a majority rating between 4 and 5. While in Germany it was linked to the favourable aesthetic descriptor “exciting” with a rating of 5. With the same number of votes and a rating of 5, Germany also chose the luminous space 1c of category I-OPACO, linking it to the aesthetic descriptor “I don't like it”.

Table 9. Selection of the “aesthetic descriptor” for “luminous spaces” 6 to 10.

| | Variable 1 | Variable 2 | PERÚ | SPAIN Variable 3 | GERMANY |
|--|---|-------------|--|--|---|
| luminous space 6 + variations | 6a  | I opaque | | | |
| | 6b  | II penumbra | | | |
| | 6c  | III bright | 21,71% trust | 23,68% attractive | 18,33% cozy 18,33% security |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Tomas Södergren, Stockholm | | | | | |
| luminous space 7 + variations | 7a  | I opaque | | | 24,17% I do not like |
| | 7b  | III bright | 30,23% vitality | 31,58% vitality | |
| | 7c  | II penumbra | | | |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Dirk Vogel | | | | | |
| luminous space 8 + variations | 8a  | I opaque | | | |
| | 8b  | II penumbra | | | 15% attractive 15% socialize |
| | 8c  | III bright | 21,71% I like it | 21,05% I like it 21,05% interesting | |
| Fuente: ZUMTOBEL group, www.zumobel.com. Photography: xxx | | | | | |
| luminous space 9 + variations | 9a  | III bright | 30,23% enthusiasm 30,23% vitality | 28,07% vitality | 24,17% attractive |
| | 9b  | I opaque | | | |
| | 9c  | II penumbra | | | |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg | | | | | |
| luminous space 10 + variations | 10a  | I opaque | | | |
| | 10b  | III bright | 22,44% I like it | 19,30% I like it | 30,00% feel comfortable |
| | 10c  | II penumbra | | | |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg / Deutschland | | | | | |

Source: Authors.

Table 10. Selection of the “aesthetic descriptor” for “luminous spaces” 11 to 15.

| | | Variable 1 | Variable 2 | PERÚ | SPAIN | GERMANY |
|---|-----|---|--------------|---------------------------|---------------------------|---|
| | | | | Variable 3 | | |
| luminous space 11 + variations | 11a |  | II penumbra | | | |
| | 11b |  | I opaque | | | |
| | 11c |  | III bright | 24,81% liking | 21,05% interesting | 25,83% attractive |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle, Hamburg / Deutschland | | | | | | |
| luminous space 12 + variations | 12a |  | I opaque | | | |
| | 12b |  | III bright | 30,23% enthusiasm | 27,19% enthusiasm | 30,83% enthusiasm |
| | 12c |  | II penumbra | | | |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Montiz Hillebrand, Zürich/Schweiz, Timm Lange, Düsseldorf/Deutschland | | | | | | |
| luminous space 13 + variations | 13a |  | III bright | 24,81% interesting | 27,19% interesting | 31,67% I like it |
| | 13b |  | I opaque | | | |
| | 13c |  | III penumbra | | | |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Thomas Mayer, Neuss | | | | | | |
| luminous space 14 + variations | 14a |  | III bright | 20,93% vitality | 26,32% vitality | 23,33% I like it |
| | 14b |  | II penumbra | | | |
| | 14c |  | I opaque | | | |
| Fuente: © ERCO GmbH, www.erco.com. Photography: Frieder Blickle | | | | | | |
| luminous space 15 + variations | 15a |  | II penumbra | | | |
| | 15b |  | I opaque | | | |
| | 15c |  | III bright | 20,16% I like it | 25,44% interesting | 27,5% I like it 27,5% exciting |
| Fuente: © ERCO GmbH, www.erco.com. Jackie Chan, Sydney / Australien | | | | | | |

Source: Authors.

The following tables show the predominant selection for each case. Table 11 refers to the favourable responses and Table 12 to unfavourable ones.

Table 11. “Luminous spaces” vs favourable perception.

| category of the luminous space | | Perú | Spain | Germany | category of the perception |
|--------------------------------|---------------|--------------------|--------------------|--------------------|----------------------------|
| 1b | III - BRIGHT | trust | | fascinating | FAVOURABLE |
| 2a | III - BRIGHT | I like it | | lively | FAVOURABLE |
| 3c | III - BRIGHT | attractive | | enthusiasm | FAVOURABLE |
| 4a | III - BRIGHT | | liking | | FAVOURABLE |
| 5b | III - BRIGHT | vitality | happiness | attractive | FAVOURABLE |
| 6c | III - BRIGHT | trust | attractive | security | FAVOURABLE |
| 7b | III - BRIGHT | | vitality | | FAVOURABLE |
| 8c | III - BRIGHT | I like it | | | FAVOURABLE |
| 8b | II - PENUMBRA | | | atractivo | FAVOURABLE |
| | | | | socialise | FAVOURABLE |
| 9a | III - BRIGHT | enthusiasm | | attractive | FAVOURABLE |
| | | vitality | | | FAVOURABLE |
| 10b | III - BRIGHT | I like it | | animado | FAVOURABLE |
| 11c | III - BRIGHT | liking | interesting | attractive | FAVOURABLE |
| 12b | III - BRIGHT | | enthusiasm | | FAVOURABLE |
| 13a | III - BRIGHT | interesting | | I like it | FAVOURABLE |
| 14a | III - BRIGHT | vitality | | I like it | FAVOURABLE |
| 15c | III - BRIGHT | I like it | interesting | fascinating | FAVOURABLE |

Source: Authors.

Table 12. “Luminous spaces” vs unfavourable perception.

| category of the luminous space | | Perú | Spain | Germany | category of the perception |
|--------------------------------|------------|------|-------|------------------------|----------------------------|
| 1c | I - OPAQUE | | | I don't like it | UNFAVOURABLE |
| 7a | I - OPAQUE | | | I don't like it | UNFAVOURABLE |

Source: Authors.

After analysing the citizen response to the COB in the three participating countries, the reaction of the participants to the “luminous spaces” is classified based on the size of the city:

In a small city, both Peru, Spain and Germany chose the “luminous space” from category III – BRIGHT to link it to the category of favourable perception. Furthermore, in Germany they chose a category I – OPAQUE to link it to an unfavourable perception category.

In a medium-sized city, both Peru, Spain and Germany unanimously chose the “luminous space” from category III – BRIGHT to link it to the category of favourable perception.

In a large city in Peru and Spain they unanimously chose the luminous space from category III – BRIGHT to link it to the category of favourable perception. However, Germany chose the “luminous space” of category III – BRIGHT to link it to the favourable perception category, but they also chose a “luminous space” from category II – PENUMBRA to link it to a favourable perception category and a “luminous space” of category I – OPAQUE to link it to an unfavourable perception category.

5. Conclusions

The Kansei engineering method has made establishing relationships between the sensations experienced and the physical characteristics of the luminous space possible

From the point of view of outdoor lighting design planning, Kansei methodology can contribute to a better understanding of user needs within the urban space, serving as a guide to specialists when making lighting decisions, and thus meeting their expectations. Therefore, it is considered a very useful and recommended instrument not only from the beginning of lighting projects, but also applicable to lighting master plans.

The method used contributes to a multidisciplinary design approach, performing a simultaneous analysis of all the requirements and design parameters (architectural, psychological, biological, environmental and social) that intervene from the first design phases of the project, which will allow qualitative lighting solutions aimed at user satisfaction with the urban night space.

From a comprehensive point of view, the instrument generated enables identifying not only quantitative values of the urban night space (luminous spaces and technical descriptors) but also qualitative values (aesthetic descriptors), which are both decisive instruments when measuring user satisfaction.

The “Light and emotions experience” showed differences in terms of the gender of the people who participated between the Spanish-speaking countries and Germany, since in Peru and Spain the largest number of participants were female (58% COA | 67% COB). While in Germany males (54% COA | 62% COB) had the greatest participation. On the other hand, very similar results were observed in terms of the age range in these three countries, where the majority ranges between 40 and 65 years (PE-ES 67% COA | 65% COB) (DE 49% COA | 55% COB). Likewise, of all the people who participated in these three countries, the vast majority are not architects or designers, which is considered positive since the experience of light and emotions was basically aimed at the common inhabitant (PE-ES 84% COA | 67% COB) (FROM 85% COA | 98% COB).

The “luminous spaces” generated a similar reaction in Peru, Spain and Germany in terms of the participants' perceptions of the images shown, highlighting: acceptance of category III which has light illuminance (Em) and a warm or warm-cold colour temperature (k) and rejection of category I, which has dark illuminance (Em) and a warm or cold colour temperature (k).

Considering the “technical descriptors” in a bright space, the combination of lighting parameters that are well received are clear illuminance with a warm or warm-cold colour temperature. But if the “luminous space” has dark illuminance, it will always be perceived in a negative way, regardless of colour temperature.

From the point of view of “aesthetic descriptors”, the majority of people in the three participating countries selected “aesthetic descriptors” in a positive emotional group. Furthermore, participants in Peru and Spain significantly coincided in their preferences regarding bright space not only in the choice of favourable perception, but also in the choice of the aesthetic descriptor. In the case of Germany, like Peru and Spain, they coincide in most of the “luminous spaces” in terms of choosing the favourable perception, but they differ from the emotional group, since they chose another aesthetic descriptor.

In addition, the participants in Germany, unlike Peru and Spain, also chose aesthetic descriptors that belong to a negative emotional group, linking them to two “luminous spaces”.

Regarding the geographical classification of the city and the use of urban space, the participants in Peru, Spain and Germany perceived “luminous spaces” in a small, medium or large city in a similar way. The size of the city or its urban configuration did not play an important role when choosing their preferences. Likewise, regardless of the use or activity of the observed light space, the participants almost always linked favourable “aesthetic descriptors” to those “luminous spaces” where the illuminance is clear and has a warm or warm-cold colour temperature, which shows that people's comfort, “feeling good”, “feeling safe” within the urban space during night-time hours has more to do with lighting than with the urban space itself. In other words, during the night we perceive the city differently than during daylight hours. In this sense, lighting through clear illuminance allows us to see, orient ourselves. and avoid accidents, thus having an important role in our perception, since it allows us to feel safe trusting and confident, etc. In addition, the choice of colour temperature was also important when choosing or rejecting “luminous spaces”, where the majority preferred a warm colour temperature, which is light that relaxes, calms and is preferred by participants.

From a social and geographical perspective, Peru and Spain responded in a very similar way when choosing the “aesthetic descriptors”, where most participants preferred the aesthetic descriptors belonging to the category of favourable perception. Germany, however, chose aesthetic descriptors from the favourable and unfavourable category. What can be stated in general is that Peruvians and Spaniards perceive the urban nocturnal space in a very similar way when identifying it with the category of perception and that despite belonging to different geographical spaces, they are more united by history, culture, and language. Germany, despite its geographical proximity to Spain, sharing the same continent, the same schedule, the same seasons of the year, etc., perceives the urban nocturnal space choosing the category of perception differently. On the other hand, while Peru chose aesthetic descriptors from the favourable perception category for 12 “luminous spaces” from the 15 presented, Spain chose this category for 8 “luminous spaces” and Germany only for 6.

This shows that participants in Spain, despite having responded very similarly to participants in Peru, when performing a more detailed analysis, their responses are closer to those of the participants in Germany than to those from Peru. Therefore, it can be stated that the perception of urban nocturnal space by Spaniards and Germans is similar when identifying a space with an “aesthetic descriptor” from a positive or negative emotional group. The perception of Peruvians compared to Germans has significant differences at the level of the perception category and the emotional group. In this sense, it can be concluded that the cultural and geographical aspect will significantly influence people's perception, so it is crucial to take them into account when making decisions regarding the lighting project, as stated in the hypothesis.

The positive perception of warm colour temperatures coincides with the environmental recommendations since this is the least harmful to the environment. Therefore, it is important to take this into account when choosing the colour temperature.

Acknowledgments: Project PID2020-114873RB-C32 (Monitoring of public spaces and the stimuli of urban materials in citizens), financed by MCIN/ AEI /10.13039/501100011033.

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