Identification of a tool for evaluation of lighting solutions by users on the example of architectural lighting

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Abstract. This article devoted to description of investigation citizens perception the lighting solutions of architectural lighting at the historical centers of Saint-Petersburg and Copenhagen. The main purpose is recognition the factors of lighting solution attractiveness for further implementation in lighting design. The experiment where every respondent should take evaluation of one or the other lighting solutions has been done for research this area. The questions creation and data analysis occurred by using the Mehrabian and Russell psychological model (PAD) also method S-O-R (stimuli, organism, response). As the result such factors of attractiveness as luminance, color, artistry (imagery), contextual correlation have been determined. This research has been conducted within master thesis at CLD ITMO University

1. Introduction
Architectural lighting (AL) is one of the main factors of the city light environment formation also its touristic and financial attractiveness. However, a high level of global urbanization and increasing city quantity has led that a city lighting process has become more typical and massive, in this case citizens' opinion and local city infrastructure feature are not be taken into the account.

The main purpose of the research - is recognition the factors of lighting solution attractiveness, toolkit allowing to make a connection between result expectations and architectural lighting design itself. Lighting is the most essential tool which with combination of architectural features create the unique artistry look [1]. Lighting designers transfer semiotic image, officials oriented by already existing solutions in other countries, trying to achieve same result, but it is total dangerous for city light environment in general [2, 3]. Whatever ideas and concepts of architectural, lighting designers or officials have, there is an ordinary user, who lives there, understands this territory and responses to changes [4].

The task this investigation was analysis and observation user's interest, construct feedback relatively AL. The idea of construct such dialog occurred based on the global trend of space humanization (Human Centered Design, Democratic Lighting), where personal and community values, social aspects, dynamic of the social interactions are the basic of design [5, 6].

1.1. Comparing and description architectural lighting feature in Saint-Petersburg and Copenhagen
For more suitable object analyzing the embankments' facades in Saint-Petersburg and Copenhagen (Denmark) had been chosen. A part of the investigation was in Copenhagen, where the one of tasks was research capital light environment and its features. Copenhagen is differing a lot from Saint-Petersburg: the historical part in fact does not have AL. The city can be described as "the dark capital", however
there is a logical explanation. A point of that it is a consequence of Copenhagen's municipality plan, where the purpose is decreasing a level of carbon dioxide emission [7]. The major tasks such vision was: decrease level of light pollution; lighting design in accord with nature; decrease of power consumption; increase a role of daylighting. At the result, step-by-step Danish capital municipality realized a strategy of humanization of the city and light environment. Another feature, which likely has influence on city light environment by indirectly, is the Denmark historical past. There is an unofficial law "Law of Jante" by Askel Sandemose that affects people's worldviews. So, the culture factor in light preferences formation reflects in user's demand and the attitude towards solutions, form their own understanding of lighting quality.

2. Methodology
The experimental part of the research is to use the survey method as a tool to obtain information from people (users) with combination of two psychological models, S-O-R [8] and Mehrabian-Russell (PAD) [9]. The main idea is comparing the primary reaction of a person and any criteria (e.g. luminance, contrast, color). In this investigation these are tools for correlation of lighting parameters and subjectively assess users. The questioning was conducted as an electronic one in social networks.

The practical part of the research itself consists of three stages: selection of lighting solutions based on comparison of light parameters, conducting surveys, data analysis [10]. For exploration possible perception features of lighting solutions in the inhabitants of different countries, the experiment was conducted as part of a research internship in Denmark, the survey was divided into two options: for Russian-speaking and English-speaking users. For each selected lighting solution 4 questions were formulated using the Likert evaluation system [11] and one question with an open answer. The questions have been drafted in such a way that each answer can be interpreted in the methods described above. The first two questions refer to the first psychological model of PAD to get an emotional response from users. The next two are for correlation of the received data with such parameters as luminance and color. The last question complements the information from the answers to the first four questions, but at the same time is an important source of data such as the nature of luminance distribution, the contrast of facade elements with each other, and the interaction of the entire building with its surrounding context.

Figure 1. Examples of questions from the bilingual survey: a – for Russian-speaking, b – for English-speaking.
Respondents aged between 18 and 55 years participated in the online survey. The total number of participants is 206, including 100 men and 106 women. All respondents were initially familiarized with the procedure without describing the experiment itself. It’s necessary for achieve more clear results. The buildings of the classical system of form formation located on the embankment of St. Petersburg and Copenhagen were chosen as the necessary incentives. At the same time the lighting solution was analyzed in terms of such criteria as: luminance (intensity), luminance distribution, contrast (luminance or colorful) between the object and the background, as well as additional information was taken into account the category of the building, its function and status. An example of output information is illustrated in Figures 2 and 3. Figure 4 shows the selected seven lighting solutions.

2.1. Mehrabian-Russell Model Results Processing

At the result of questioning all responses have been analyzed with using PAD model and represented through cycling diagrams:

**Figure 2.** Example of lighting solution attributes.

**Figure 3.** Example of photo fixation of a lighting solution.

**Figure 4.** Selected lighting solutions.
For illustrating more clear perception difference two disputable lighting solution have been selected whose analysis is presented below. All diagrams and indexes on a right match with English-speaking survey, on a left - Russian-speaking. Also, worth to note that parameters on the horizontal axis with rating scales diagrams illustrated below meet from the worst responses (not at all) to the best ones (really like it). In the end of data analysis about the Solution №2 from English-speaking respondents it has been defined that this lighting project arised controversial feeling. On the one side, a warm flood light makes a cozy and comfortable atmosphere. On the other hand, the high lighting contrast between the center and the boundaries of the building, according to people' replies, caused fear, discomfort and suspicion. At the same time Russian-speaking users had this very contrast expressed by the appearance of such words as "secret" and "mystery", expressing emotions more positively.

Comparison of the results on Solution № 6 was evaluated by two groups in diametrically opposed way. Such bright illumination turned out to be not usual for English-speaking respondents. There were a lot of negative responses where frequent words of description were: "too bright", "discomfort for eyes", "strong contrast". In opposite, the Russian-speaking citizens, in addition to comments on the high luminance, noted and commented on the interaction of lighting used with the architecture features, any
advantages and disadvantages. Such diagrams clearly illustrate the difference in lighting preferences between cultures, and the answers can also be used to draw conclusions about a greater awareness of lighting among foreign users.

2.2. *S-O-R* model results processing
The second stage of user assessment analysis was already conducted using the “stimulus-organism-response” model (Figure 8).

![Figure 8. Cyclic S-O-R diagram.](image)

Judging by the diagram, there is a general tendency of changes in the emotional state and increasing interest in the lighting solution at significant luminance indicators (in two of the four values the luminance indexes exceeds the normal values of 30 Cd/m²), but in cases with Solutions № 5 and № 6 strong overestimation and strong understatement of this parameter leads to ambiguous and even negative reaction. Other parameters in each light project brought both positive and negative contribution. Also, negative estimation concerning addition of colour light is visually shown, however in several solutions’ addition of luminaries with certain colour, as an option of leveling of lacks the general AL was offered. A brief conclusion on each lighting solution based on user comments. From the point of view of foreign residents, high luminance of 45.29 cd/m² (Solution № 6) is a fundamental factor of negative assessment. Luminance 25.3 cd/m² (Solution № 3) caused the greatest positive response, luminance 13 cd/m² (Solution № 5) caused the most emotional response in the form of discussion, where opinions were divided between "mysterious" and "dull" evaluations.

3. Conclusion. Factors of lighting solutions attractiveness in terms of user evaluation
Based on the results of the experimental study of preferences of urban residents regarding architectural lighting, we can highlight the factors of attractiveness of the lighting solution: *luminance, color, artistry (imagery), contextual correlation*. Luminance is the most important human factor because it forms the basis for the image of the object. In St. Petersburg city dwellers prefer lighting solutions with increased luminance, as it forms a certain sense of "understanding" the object. The second factor is color. The overwhelming number of respondents considered unacceptable the use of coloured light in the AL of
the presented facades. Artistry (imagery), is a set of several indicators: Contrast (luminance or colorful) between object and background, luminance distribution, and concept idea. By this we mean the artistic task that lies at the heart of the project when it comes to lighting. Such a task should be thought out, justified and informative for the user of the environment. Contextual connection means the interaction of the surrounding light background and the light architecture of the structure.

In conclusion, within of the research work carried out to increase the attractiveness factor is recommended: to use luminance in the range of values 25-30 cd/m2; refrain from using coloured light on classic architectural buildings. Preferred color temperature is 3000-3500 K. Color rendering index of the light device Ri not less than 80. With working with the solution to achieve a uniform distribution of brightness by aligning the average value of contrast to the ratio 1/3. When solving the conceptual connection with the environment not to use the ratio of 1/7 luminance of the object and the background (in accordance with the norms is characterized as significant). For "alignment" of contrast it is necessary to work with the surrounding objects. It should be noted that the objects used in the study have a lighting solution based on their daily image. In order to create a complete lighting solution for the perception of the embarkments panoramas, it is recommended to stay close with such a concept. To confirm the accuracy of the results of the investigation should further study the formulated factors of attractiveness of light solutions. The study of social aspects of lighting based on a qualitative method makes it possible to identify both positive and negative features of AL. Such research can make an educational contribution to the formation of the residents’ perception that the city lighting, and architectural lighting, particular. Also, it plays an important role in connecting the social life of people and urban space. Carrying out such "educational", research has the ability to improve the level of light culture of users, which may later have an impact on the formation of a more demanding request for urban lighting, increasing the criteria for the professional level of the light environment of the city and its developers.

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