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USER-CENTRIC MEASURES OF PERCEIVED LIGHT QUALITY: DEVELOPMENT OF TOOLS TO PROMOTE ENERGY EFFICIENT LIGHTING

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1. INTRODUCTION

Electricity for lighting constitutes a large share of the total energy use in buildings, about 20 % for households and 40 % for commercial buildings. At the same time, Europe is facing a shift towards more energy efficient lighting. The potential for energy savings is thus high, for office spaces at least 50 % [1]. Nevertheless, customers tend to prefer incandescent fixtures (light bulbs) as they are experienced to provide good comfort. To motivate building owners and users to convert to more energy efficient lighting, it is therefore necessary to prove not only financial advantages and energy savings, but also positive experiences and increased light comfort. However, knowledge, concepts and tools for communicating and measuring visual lighting quality are lacking.

Whereas light in the sense of radiation can be measured physically, the experience created when light hits the eye is far more complex. The process cannot be translated into physical terms, and yet it would be needed to ensure good light environments. The only established tool to measure lighting quality is the International Lighting Standard (EN 12464-1). It is based on photometry, which is in turn based on physical units and only measures a very limited part of the light experience. The lighting standards are thus insufficient as tools for creating good light environments and may even result in oversized lighting systems that affect both well-being and energy use negatively.

The aim of the research presented is to support the implementation of light environments that cater both energy efficiency and well-being by providing tools that support communication about perceived lighting quality between professionals in lighting design and procurement.

2. RESEARCH METHODOLOGY

Three parallel processes feed in to the development of a communication tool on lighting quality:

- i. Parameters describing objective experiences of lighting products (*sensory analysis*).
- ii. Parameters describing subjective experiences of light environments (*emotional perception*).
- iii. Experiences and practices from the *lighting industry* and professional customers.

Sensory analysis measures and interprets reactions on products and services as they are perceived by our senses. The scientific discipline was defined by Sidel and Stone in 1974 [2]. The analysis includes both qualitative and quantitative approaches, and measurements include both subjective consumer tests and objective measurements by trained panels. Since 2014, sensory methodology has been developed for lighting products [3]. Analytical (objective) assessments have been carried

out in a multisensory laboratory at RISE Research Institutes of Sweden at several occasions. A panel fulfilling specific criteria has been trained to assess light sources and fixtures.

To assess and describe *emotional perception* of lighting quality, Kansei engineering is combined with semantic methods from environmental psychology [4]. In Kansei engineering users' emotional preferences to product characteristics are quantified and represented by mathematical models. A product is defined by a domain with data characterizing both the product and the target group. Concepts are collected from different sources and validated through user studies [5]. To create such domain for lighting, a typology for light environments has been developed within this project. It is used to systematically collect and validate concepts, both in workshops and test studies [6].

Support from professionals is a prerequisite for implementing an extended definition of lighting quality. More than 30 representatives from the Swedish *lighting industry* and real estate industry have therefore been engaged in the research project. By taking part in a workshop series, they actively and iteratively contribute to the development and design of the communication tool. The purpose of the workshops is threefold; 1) practitioners provide input and feedback to methods and tools, 2) engagement as part of achieving acceptance and approval for the project outcome, and 3) provide an arena to intensify the discussion about perceived lighting quality among professionals.

3. COMMUNICATION TOOL

Tools aiming to support communication about light quality between professionals in lighting design and procurement are under development. The first phase of the development focused on collecting parameters, concepts and definitions describing perceived light quality, while the second phase includes structuring and visualizing the parameters to support communication. One possibility would be a tool similar to the aroma wheel for wine [7].

4. CONCLUSIONS

The research project is ongoing and the intermediate conclusions include:

- Assessments and physical measurements produce complementary information about lighting.
- A first draft of domain for visual and emotional experience of light, connecting concepts to specific characteristics of experienced lighting qualities, has been developed.
- Lighting professionals show considerable engagement in extending the definition of light quality to support light environments that cater both energy efficiency and well-being.

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