



Investigating the Interactions among Visual Comfort Components in Buildings and Their Impact on Sustainable Performance

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ABSTRACT

Visual comfort, as a fundamental aspect of indoor environmental quality, significantly influences occupant satisfaction, health, and productivity. Recent studies indicate that daylight, glare, and view quality directly impact spatial experience and quality of life. However, most research has focused on only one of these components, with less attention given to their dynamic interactions. Furthermore, building design approaches developed to reduce energy consumption have neglected health-related dimensions and user experience of visual comfort. This paper reviews the existing literature to analyze current trends and identify limitations. The findings indicate that energy-oriented approaches have considered daylight solely as a means to reduce energy load and ignored human aspects and user experience. Unidimensional approaches have focused on one or two components of visual comfort and neglected outdoor view quality. In contrast, holistic approaches have demonstrated that the simultaneous combination of energy, daylight, and visual quality analysis can lead to both energy savings and improved user well-being. However, even in comprehensive approaches, most studies have focused on office and educational uses, while residential use has been severely neglected. Furthermore, few studies have addressed the dynamic interaction of all three components within an integrated framework. From a theoretical perspective, this paper proposes a new conceptual model emphasizing dynamic interaction and balance among the three components. From a practical standpoint, architects should consider openings, shading, and view quality simultaneously in the design process. The most significant gap identified is the lack of research in residential environments, highlighting the need for user-centered future studies in this context. These gaps provide an opportunity to develop integrated frameworks that simultaneously address energy performance, occupant well-being, and environmental sustainability. Addressing these research gaps is essential for achieving truly human-centered and sustainable architectural design. Future studies should prioritize multi-criteria optimization approaches that balance energy efficiency objectives with visual comfort and occupant health outcomes.

Introduction

Visual comfort is one of the main pillars of the quality of the indoor environment of buildings, which has a direct impact on the physical and mental health, productivity, concentration and satisfaction of users. Two fundamental factors in the formation of this comfort are daylight and access to external views. In addition to its environmental function and reducing dependence on artificial lighting, natural light increases vitality and reduces symptoms of depression. On the other hand, views to the outside reduce stress and improve the quality of life by creating a visual connection with nature. Despite this evidence, building design faces the fundamental challenge of balancing energy savings and visual comfort for users. Energy-oriented solutions such as downsizing windows or using radiation control shades, although reducing energy loads, severely limit the quality of natural light and access to external views. Also, building optimization algorithms often prioritize energy indicators and ignore the visual preferences of users. On the other hand, most of the existing research has been conducted in a unidimensional manner (daylight only, glare only, or vision only) and has not addressed the simultaneous interaction of these three components. This article aims to systematically review related research, identify existing trends, analyze theoretical and practical gaps, and explain the need to develop integrated frameworks that simultaneously address energy performance, user well-being, and environmental sustainability. The importance of this research is that it provides a comprehensive picture of visual comfort as a multidimensional phenomenon and reveals the need for user-centered design in built environments, especially residential use, which has received less attention. This article is an analytical-synthetic review of the literature, which aims to provide a basis for the development of multi-criteria assessment tools in sustainable architectural design.

Method

This research is a systematic review with an analytical-synthetic approach. The study population included all scientific articles published in the field of visual comfort, daylight, glare, and view quality between 2015 and 2025. A systematic search was conducted in reputable databases including ScienceDirect, Scopus, Web of Science, and Google Scholar using the combined keywords “Visual Comfort,” “Daylight,” “Glare,” “View Quality,” “Energy Efficiency,” and “Occupant Well-being.” Inclusion criteria included: (1) publication in reputable scientific journals with a high impact factor, (2) direct relevance to at least two components of visual comfort, energy, or occupant health, and (3) presentation of quantitative or analytical findings that could be used in research synthesis. Articles that addressed only one component (e.g., only energy or only glare) and articles unrelated to indoor building environments were excluded from the review period. Finally, from the initial 78 articles, 30 articles were selected for the final analysis based on thematic relevance, comprehensiveness, and methodological quality. The data extraction process was carried out qualitatively using the Directed Content Analysis method, and the information was classified into three main categories: (1) energy-oriented approaches, (2) unidimensional approaches to visual comfort, and (3) holistic and integrated approaches. To increase the validity of the findings, two researchers reviewed the articles and reached a final agreement. The main limitation of this review was the inability to perform quantitative meta-analysis due to the heterogeneity of the methodology and measurement indicators in different studies.

Results

A systematic review of the literature revealed that research in the field of visual comfort can be classified into three general categories:

The first category, energy-oriented approaches, which were mainly dominant in the early years of the study period (2015–2020). These studies considered daylighting solely to reduce energy load and ignored human aspects and user experience. The findings showed that the

optimization algorithms in these approaches prioritized energy indicators and excluded indicators such as glare and visual quality, which resulted in reduced user satisfaction

The second category, unidimensional approaches, focuses on one or two components of visual comfort. Some of these studies confirmed the positive impact of daylight on health and productivity but did not consider glare and external vision. Others only analyzed glare, and a group focused only on the quantity of daylight and ignored the role of vision quality and scenery. The important finding of this group was that despite identifying minor factors, they presented an incomplete and disjointed picture of visual comfort.

The third group, holistic and integrated approaches, which have grown significantly mainly since 2021. These studies have shown that the simultaneous combination of energy, daylight and visual quality analysis can lead to both energy savings and improved user well-being. Smart shading systems, machine learning-based design frameworks, and visual quality quantification based on adaptive user behavior are among the achievements of this approach. However, a key finding of the present review was that even in comprehensive approaches, most studies focused on office use (more than 60% of articles) followed by education, and residential use was severely neglected (only 2% of articles). Also, few studies have addressed the dynamic interaction of all three components (light, glare, and vision) in an integrated framework, and most of them have considered one of the components as a marginal variable.

Conclusions

A systematic review of the literature showed that visual comfort is a multidimensional phenomenon and depends on the simultaneous interaction of daylight, glare control, and external vision quality. Purely energy-oriented or one-dimensional approaches, although effective in solving part of the problem, have in practice led to reduced satisfaction, decreased mental health, and increased dissatisfaction of users due to ignoring the human dimension. In contrast, holistic approaches have shown that it is possible to design integrated frameworks that can simultaneously improve energy performance, enhance visual quality, and ensure user health. From a theoretical perspective, this paper proposes a new conceptual model for visual comfort, emphasizing the dynamic interaction of the three components, in which “balance” plays a key role instead of “single-criteria optimization”. From a practical perspective, the findings indicate that architects and designers should design openings, shading, and landscape quality simultaneously in the design process, rather than giving absolute priority to energy or just light. The most important gap identified is the lack of research in residential environments, which doubles the need for future studies with a user-centered approach in this context. It is suggested that future research should focus on developing multi-criteria assessment tools based on combined indicators (such as the integrated visual comfort-energy index) and conducting field studies in residential buildings with direct user participation, in order to reduce energy consumption and provide a desirable and health-oriented spatial experience for residents. Also, applying machine learning methods and dynamic simulations to predict the combined behavior of these components is one of the promising research directions to fill the existing gap.

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