3 Integrated Glare Metric for Various Lighting Applications

3.1 Description of research

The brightness of light sources, be they electric luminaires or windows, may have a negative effect on the performance of visual tasks (disability glare) but it may also cause a feeling of discomfort without having a directly measurable effect on visibility: discomfort glare. This psychological effect has been extensively studied since the 1940s, when the increase in general illumination levels started to lead to complaints about discomfort from excess light. In general, discomfort is known to increase with increasing luminance of the light source, increasing light source size (at a fixed luminance), decreasing background luminance, and decreasing distance of the bright object from the line of sight. However, discomfort tends to be lower when the light source is daylight rather than when it is electric light. The exact relationship of these quantities has been modelled by various formulae that predict discomfort based on stimulus parameters.

A first drawback of these glare formulae is that each formula is tuned to a set of lighting conditions specific for a given application (e.g. office lighting, sports lighting, road lighting, etc.). Well known examples of such formulae are the Unified Glare Rating (UGR) used for indoor electric lighting systems, the Daylight Glare Probability (DGP) and the Daylight Glare Index (DGI) used for glare from daylight, either through windows or outdoors, and a whole range of discomfort glare metrics, such as the Glare Control Mark, used in outdoor lighting.

A second drawback of such formulae is that they are specific for a type of lighting technology (e.g. luminaires based on fluorescent tubes with an opal exit window, daylight from windows). It is unclear that these formulae provide valid results for light sources other than those used for their development. With the transition to LED lighting, this limitation to specific lighting technologies has become even more problematic. A recent CIE publication (CIE 205:2013: Review of Lighting Quality Measures for Interior Lighting with LED Lighting Systems) questioned the validity of conventional lighting quality measures for interior lighting with LED lighting systems. The conclusion with respect to glare was that “a new glare evaluation system is needed as the present systems have been developed for circumstances different from LED lighting.”

Thirdly, the glare formulae in current use are based on a fit to empirical data and not based on an underlying physiological or psychological model of discomfort. Because of this it is possible that the glare formulae cannot accurately be extended to situations and lighting technologies that were not used to develop the existing formulae.

CIE recognizes the need for a comprehensive research program to develop a fundamental model of discomfort arising from excessive luminance that will apply to the broad range of applications and technologies.

3.2 Key research questions

- What physiological or psychological mechanism is responsible for discomfort arising from excessive luminance?
- Develop a model of the discomfort arising from excessive luminance, preferably based on parameters that can be related to the discomfort mechanism, which covers multiple application areas.
- Establish a glare metric method that allows the results to be generalized and applied to other application conditions and other lighting technologies.

3.3 Justification of the need for the proposed research topic

The current models for predicting discomfort by glare are all limited to very restricted applications, luminaire characteristics and circumstances. During the past decade many

lighting systems with very non-uniform luminance distributions have been introduced. Current glare models are unable to predict discomfort from such sources. Although glare problems have always been seen as relevant to lighting design but difficult to quantify, they have been thought to be too difficult to include in recommendations for most applications. With the metrics that are used now, discomfort that may be caused by many modern products is over- or underrated. Being able to predict discomfort arising from glare will be beneficial to end users because it will enable its prevention. Manufacturers will be better able to develop suitable products and to categorize the suitability of their products for various configurations and applications. This will facilitate better choices by lighting designers and specifiers. A single glare model covering as many as possible applications will mean an important simplification from the current situation with 20+ models and will allow cross-learning between application areas, which will help to build our understanding of lighting quality and comfort.

3.4 Related current activities in CIE

TC 3-53	Revision of CIE S 008 Joint ISO/CIE Standard: Lighting of Work Places - Part 1: Indoor
TC 3-56	Assessment of Discomfort Glare from Daylight in Buildings
TC 4-33	Discomfort Glare in Road Lighting
JTC 7 (D3/D1)	Discomfort caused by glare from luminaires with a non-uniform source luminance

3.5 Existing CIE publications

CIE 31-1976	Glare and Uniformity in Road Lighting Installations
CIE 55-1983	Discomfort glare in the interior working environment
CIE 112-1994	Glare evaluation system for use within outdoor sports and area lighting
CIE 117-1995	Discomfort glare in interior lighting
CIE 146-2002/ CIE 147-2002	CIE collection on glare
CIE 205:2013	Review of Lighting Quality Measures for Interior Lighting with LED Lighting Systems
CIE 213:2014	Guide to protocols for describing lighting