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The International Commission on Illumination – also known as the CIE from its French title, the Commission Internationale de l'Éclairage – is devoted to worldwide cooperation and the exchange of information on all matters relating to the science and art of light and lighting, colour and vision, photobiology and image technology. More information can be found from the CIE website: <http://www.cie.co.at/>.

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PROGRAMME

All times are Australian Eastern Daylight Time (AEDT, UTC/GMT +11 hours).

09:10	Welcome		Tony Bergen Peter Blattner	President, CIE Australia President, CIE
Session 1. Office Lighting and Daylighting				
09:20	Crispin Rock	Australia	Abrupt transitions in lighting around a threshold	
09:40	Kieu Pham	Australia	Monitoring manual blind use in large open plan offices	
10:00	Francisca Rodriguez	Australia	Refining the thresholds of perceived luminous variability in a virtual reality experiment	
10:20	Marta Waczynska	Poland	View out evaluation according to EN17037 – a comparison of the objective and subjective assessment	
10:40	Jennifer Long	Australia	Workshop: Visual ergonomics and digital display use: progress on the development of technical report CIE TC 3-58	
11:10	Break			
Session 2. Colour and Vision				
11:40	Dorukalp Durmus	USA	Reporting variation in melanopic and photometric measures	
12:00	Joelene Elliott	Australia	The detectability of vertical light intensity differences	
12:20	Mariana R C Papa	Australia	The effect of adaptation time on chromaticity perception	
12:40	Break			
Session 3. Photobiology and Wellbeing				
13:40	Sean Cain	Australia	Evening home lighting adversely impacts the circadian system and sleep	
14:00	Sung-Woo Choi	South Korea	Studies and clinical trials on the effects of 480nm light on humans during the day and night	
14:20	Ruth Genevieve Ong	Australia	Factors that influence night lighting conditions in patient rooms	
Session 4. Obtrusive Light and Sky Glow				
14:40	Mike Jackett	New Zealand	Is CCT really the best spectral index for predicting sky glow?	
15:00	Adrian Cupitt	Australia	Standardising artificial light at night surveys	
15:20	Break			
Session 5. Product Performance and Measurement				
15:50	Anders Thorseth	Denmark	Measurement of temporal light modulation and calculation of temporal light artefacts	
16:10	Steve Coyne	Australia	A matter of life and stress: predicting the lifetime of led lighting products	
16:30	Tony Bergen	Australia	Challenges in measuring ultraviolet radiation	
16:50	Mei Ying Boon	Australia	Estimating illuminance when viewing a virtual reality scene on the oculus quest using the unreal engine	
17:10	Concluding comments			
17:15	Close			
18:00	Virtual afterparty			

ABSTRACTS

Session 1

Office Lighting and Daylighting

ABRUPT TRANSITIONS IN LIGHTING AROUND A THRESHOLD

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A psycho-physical experiment was conducted to investigate the occupant acceptability of areas where there is an abrupt transition in brightness with the adjacent space and if the existence of a threshold changes the level of acceptability.

Previous studies about abrupt transitions in brightness have concentrated on the partition between internal artificially lit spaces and the external daylight area [1-3]. Results show that less abrupt transitions when walking between differently lit spaces are more acceptable. Other research has focussed on occupant comfort near to windows in commercial office spaces [4, 5]. The real-world situation of these studies has involved many different factors that have produced differing conclusions, however the addition of artificial light to the interior adjacent to windows is generally preferred as is a window view especially if it is more natural.

This experiment was conducted in a laboratory. Twenty-nine participants were placed in an area and exposed to five different lighting conditions that simulated varying abrupt transitions in brightness. Horizontal illuminance ranged from 320 lux to 7000 lux. Each condition was scored on a series of semantic scales. The experiment was repeated with a physical threshold at the abrupt transition.

Results showed that in conditions with illuminance levels similar to those found in a typical office daylight harvesting scenario, perception of comfort, brightness, naturalness and task clarity was less than a condition with more uniform illuminance.

It was also shown that the introduction of the threshold made the space feel more expansive in less uniform lighting conditions.

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MONITORING MANUAL BLIND USE IN LARGE OPEN PLAN OFFICES

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Solar blind shades play an important role in balancing visual comfort and daylighting levels in offices. However, this balance is difficult to conceive in large open plan offices where blind controls are shared by many occupants. Poorly conceived shading controls can lead to visual discomfort and condition users to leave blinds closed for prolonged periods; preventing daylight from being appropriately utilized. Previous studies have focused on relating blind use to lighting levels, however, in open plan spaces, other environmental factors such as distance and presence of other users would influence a user’s decision to occlude blinds [1,2]. This presentation highlights the results of observing user related patterns in two large open plan offices across a 5-month period. Observations of blind use were recorded, including distance from blinds, view direction, and presence and absence of other users. Time-series measurements of the approximated vertical eye illuminance *Eye E_v* were also collected at user workstations. A logistic regression compared the association between the *Eye E_v* and distance, along with heuristic clustering and qualitative classification to contextualise different patterns of blind users based on their frequency of use and associated *Eye E_v* levels in order of magnitude. The results indicated that distance from blinds had stronger association to blind use compared to *Eye E_v* (see Table 1) and that user related patterns were identified by frequency of use and their associated *Eye E_v* levels. The results of this study provide a framework to better understand user related patterns to blind use in open plan office settings (see Figure 1). The contribution of this research can better inform lighting design in improving shading control strategies in open plan offices.

Table 1. Logistic regression using 10-fold cross validation, comparing the strength of association between the *Eye E_v* and distance from blinds.

Coefficients	Estimate	p-value
<i>Eye E_v</i>	1.7251	0.3260*
Distance	-23.9951	< 0.05***
<i>Eye E_v</i> : Distance	19.113	0.420

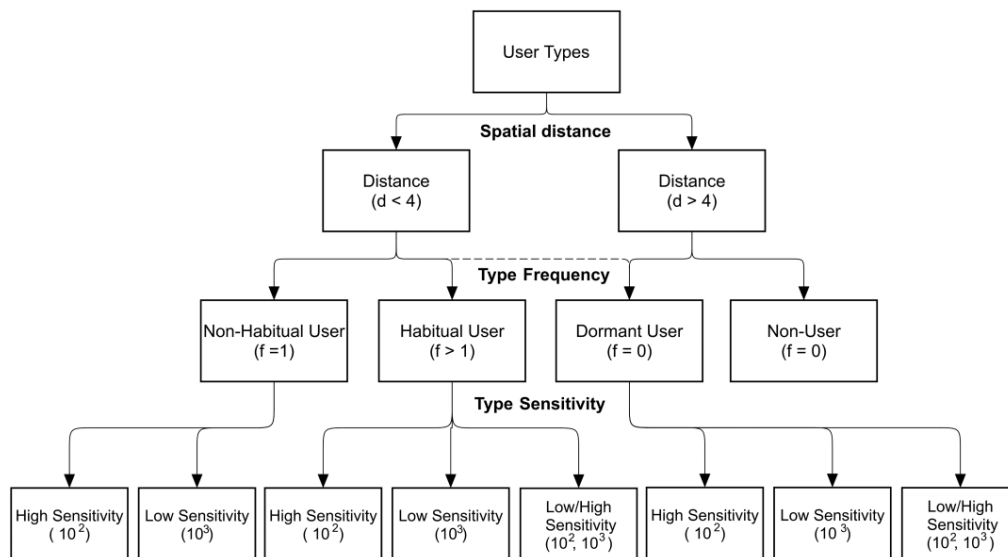


Figure 1: Framework to identify patterns of blind use in open plan offices.

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REFINING THE THRESHOLDS OF PERCEIVED LUMINOUS VARIABILITY IN A VIRTUAL REALITY EXPERIMENT**Francisca Rodriguez**¹, Veronica Garcia-Hansen¹, Gillian Isoardi², Alicia Allan³¹ Queensland University of Technology, Brisbane, Australia² Light Naturally, Brisbane, Australia³ The University of Queensland, Brisbane, Australia

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What constitutes good visual conditions in indoor settings is a matter of debate, as it depends on subjective assessments of what is visually comfortable or not [1, 2]. When it comes to investigating well-being responses motivated by luminous changes outdoors, the discussion of what is visually interesting remains. In previous research, we have proposed methods to classify, capture, and systematize lightness changes in window views [3], and demonstrated the adequacy of lightness changes to describe dynamic attributes in views [4]. The method to define lightness changes categories relied on the procedures of the CIE [5], which later distinguished between three lightness change types (i.e. Global, Local, and Minimal)[3]. These categories responded to a classification of lightness conditions informed by systematic imaging techniques [6], the sky conditions at the observation time [7], and the visual assessment of luminous variability outdoors. Yet, a more detailed definition of the subjective thresholds for these categories has not been tested with human surveys to date.

In this presentation, we outline a way to refine these outdoor luminous variability thresholds by revising the findings of a subjective evaluation of views in a virtual reality experiment. We presented 48 participants with a sample of immersive outdoor scenes ($n = 16$) showing a controlled number of lightness conditions and correlated average mean scores for three questions involving variability and predictability of luminous conditions outdoors. Representative view scenes with high and low scores were revised using imaging techniques and concurrent vertical illuminance data to examine what was perceptually considered as luminous change over time. This work builds on novel approaches to describe views as a function of lightness changes, by informing quantitative procedures with human data.

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VIEW OUT EVALUATION ACCORDING TO EN17037 – A COMPARISON OF THE OBJECTIVE AND SUBJECTIVE ASSESSMENT

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Introduction

This paper presents an empirical research approach to assess a view out as view of the exterior through the window, based on the criteria (horizontal sight angle, outside distance of the view and a number of visible layers) described in the European standard EN17037:2018 [1]. The research focuses on the comparison between the objective computational simulation and subjective assessments made by users of the space. The article presents an ongoing research with so far 192 responders.

Method

In this view study the computer-based simulations results are compared with results obtained from the direct questionnaires distributed among the architecture students. The study focuses on spaces representing two adults' learning environments [2–4]: A: selected classrooms at the university campus with various orientations and view out settings and B: variety of home study rooms, which replaced standard classrooms during the pandemic. The research consists of three steps: 1. objective evaluation of the selected views using computer simulations; 2. subjective assessment of the selected views and users' satisfaction with them, using a direct questionnaire; 3. comparison of the results from different settings.

Results

The emerging results of the university building [5] indicate that the evaluation of the view out, which is based only on the quantitative criteria as found in EN17037 does not correspond to the 'good view out' in terms of a quality assessment (satisfaction with the view). The study clearly demonstrates a potential to include the parameters relating to the view quality in future standardisation efforts.

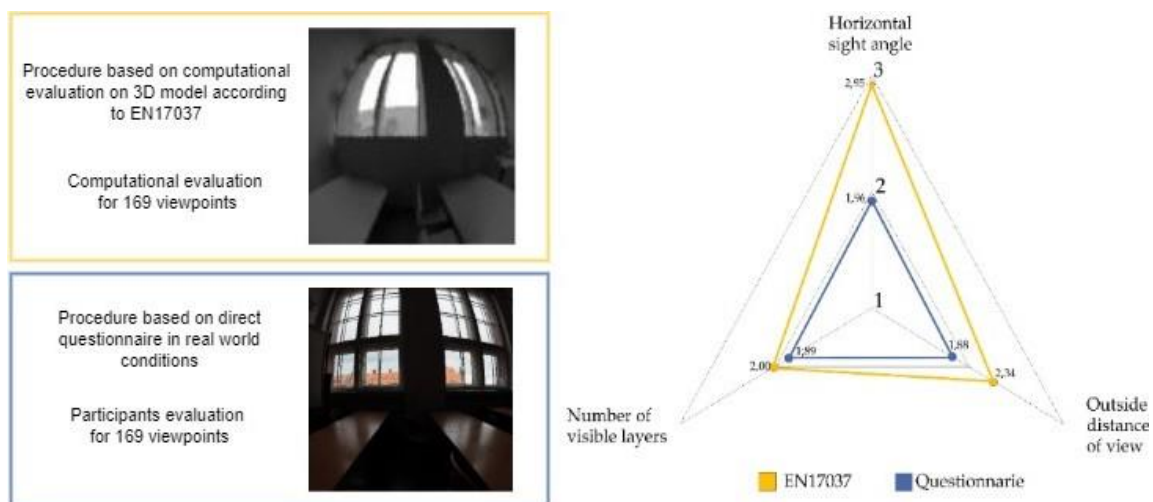


Figure.1. The graphical representation of the method and the first outcomes of the study [5].

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WOKRSHOP: VISUAL ERGONOMICS AND DIGITAL DISPLAY USE: PROGRESS ON THE DEVELOPMENT OF TECHNICAL REPORT CIE TC 3-58**Jennifer Long**^{1,2}¹ Jennifer Long Visual Ergonomics, Katoomba, Australia² School of Optometry and Vision Science, UNSW, Sydney, AustraliaCorrespondence: jlong@visualergonomics.com.au

In 1984 the CIE published a technical report CIE 60:1984 "Vision and the Visual Display Unit Workstation". Some of the content of this technical report has withstood the test of time, but it refers to obsolete display technology and lighting equipment. Subsequently, the CIE has withdrawn the technical report from circulation.

In 2020 the CIE approved a revision of CIE 60 so that it will be relevant to modern technology. The objective is to consolidate current scientific knowledge about visual ergonomics and digital displays so that it is accessible and usable for end users and for people who provide advice for workplace design. An 8-member committee comprising members from Australia, Europe, the UK and the US has been formed (CIE TC 3-58) to complete the work.

It is anticipated that the basic structure of CIE 60:1984 will be retained, namely, (1) the way in which digital displays are used, (2) health aspects of digital displays, and (3) visual requirements of digital display work and appropriate visual conditions. Photographs used within CIE 60:1984 to supplement the text (for example images of visual display elements, computer workstations and lighting) will need to be replaced with modern images and diagrams.

By far, the greatest challenge for the committee will be to construct a future-proof document, particularly since display technology, lighting equipment and lighting metrics are currently in a state of flux. It is anticipated that the new technical report will be finalised by 2023.

This session will be a very short workshop, and participants are invited to provide feedback/suggestions for content they would like to see included in the new technical report.

ABSTRACTS

Session 2

Colour and Vision

REPORTING VARIATION IN MELANOPIC AND PHOTOMETRIC MEASURES

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Circadian metrics quantify non-image forming effects of lighting. While static spectral power distributions (SPDs) can be quantified with a single metric [1], multi-channel LEDs (mcLEDs) generate a wide range of spectra. Therefore, a single-numbered metric is not adequate to describe the performance of mcLEDs. Descriptive statistics, as shown in Table 1, are limited in reporting the variability of mcLED outputs, due to a lack of representation of the trade-offs between different measures.

Table 1. Descriptive statistics showing the variability in a multi-channel LED system

	E_{mel} (W/m ²)	LER (lm/W)	Φ_v (lm)
Minimum	1.15	216	961
Maximum	18.75	377	20589
Average	9.98	315	11631
Standard deviation	2.91	18	3503

Quantifying mcLED output using a 3D graph of selected metrics can highlight trade-offs, as shown in Fig. 1. Selected metrics for each dimension of the graphical representation can be relevant to the application, such as circadian (e.g., melanopic irradiance [2]), photometric (e.g., luminous efficacy of radiation (LER), and colorimetric (e.g., correlated colour temperature (CCT)) measures.

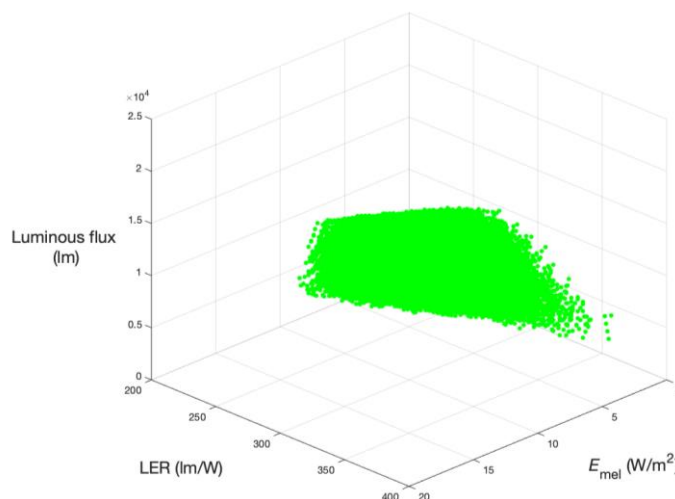


Figure 1: Three-dimensional representation of a multi-channel LED output exhibits the complex relationship between melanopic irradiance, luminous efficacy of radiation (LER), and luminous flux.

Each dimension of the 3D graph can be discretised to unit voxels using significant intervals. The voxelization can provide a new metric to quantify and compare mcLED systems. The voxelization method has been previously used to characterise colour rendition variability in mcLEDs [3]. Voxel-based metrics can also be used in spectral optimisation studies to identify optimal solutions in terms of circadian synchronisation, energy efficiency, and lighting quality [4,5]. Future work will focus on the identification of the unit voxel size and quantification of the resulting volume.

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THE DETECTABILITY OF VERTICAL LIGHT INTENSITY DIFFERENCES

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This line of research aims to characterise an occupant's ability to detect differences in lighting as a function of the proximity of the person to the illuminated area. This particular experiment focused on the illumination of vertical surfaces. By understanding how proximity influences the detection of differences in lighting, energy-saving techniques can be developed that do not negatively impact the appearance of architectural spaces. It was hypothesized that changes in vertical illuminance would be more difficult to detect when further from the observer.

Eighty participants viewed a 10 m x 2.4 m vertical surface (wall). Using a spatial five-alternative forced-choice (5AFC) method, they evaluated the brightness along the wall and identified the section that appeared dimmer than the others.

Eight different experimental conditions manipulated participant position (seated at one of the two ends or in the middle of the wall) and eye movements (free viewing or fixation on a particular section of the wall). Each subject completed 10 repeated trials for each of the 20 test lighting conditions, in a randomised sequence.

The hypothesis not supported – participants' ability to detect differences in lighting was very poor for the end portions of the wall for all conditions, even when seated directly in front of it and fixating on it. Further analysis is underway and more detailed results will be presented.

THE EFFECT OF ADAPTATION TIME ON CHROMATICITY PERCEPTION

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Chromatic adaptation, the process by which colour perception changes in response to light exposure, can be capitalized on to improve the visual environment and reduce the energy consumed by lighting. Earlier research used the psychophysical method of hue scaling to measure the perception of 15 test chromaticities when observers were fully adapted to five different near-white, but slightly tinted, chromaticities. Further research characterized the effects of adaptation luminance. In this experiment, five subjects were immersed in neutral white adaptation light of 150 cd/m² for five minutes, then exposed to lighting of a different, near-white chromaticity for different durations (90 sec, 60 sec, 30 sec, 15 sec). Following adaptation, subjects viewed test light chromaticities for two seconds and their perceptions of the test chromaticities were reported. After each trial, the neutral adaptation light was presented for 90 seconds to “reset” the visual system to neutral adaptation before exposure to another near-white adaptation chromaticity, presented in a random sequence. The results show that adaptation time affects both the hue and saturation of the appearance of the test chromaticities.

ABSTRACTS

Session 3

Photobiology and Wellbeing

EVENING HOME LIGHTING ADVERSELY IMPACTS THE CIRCADIAN SYSTEM AND SLEEP

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The regular rise and fall of the sun resulted in the development of 24-h rhythms in virtually all organisms. In an evolutionary heartbeat, humans have taken control of their light environment with electric light. Humans are highly sensitive to light, yet most people now use light until bedtime. We evaluated the impact of modern home lighting environments in relation to sleep and individual-level light sensitivity using a new wearable spectrophotometer. We found that nearly half of homes had bright enough light to suppress melatonin by 50%, but with a wide range of individual responses (0–87% suppression for the average home). Greater evening light relative to an individual's average was associated with increased wakefulness after bedtime. Homes with energy-efficient lights had nearly double the melanopic illuminance of homes with incandescent lighting. These findings demonstrate that home lighting significantly affects sleep and the circadian system, but the impact of lighting for a specific individual in their home is highly unpredictable.

STUDIES AND CLINICAL TRIALS ON THE EFFECTS OF 480NM LIGHT ON HUMANS DURING THE DAY AND NIGHT

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Most LED lighting developments have focused on brightness and color qualities of white LEDs such as luminous efficacy, color rendering index, and power consumption [1, 2]. These properties are insufficient to represent the full performance potential of LED lighting. Recently, many researchers have been interested in light quality that could influence productivity, mood, safety, and health [3]. In fact, it has been found that light can visually and non-visually affect humans through the eye's retinal cells [4-6]. Non-visual effects refer to specific lights that could physiologically change hormones such as melatonin [7, 8]. The effect of light on the R, G, B cones and rods of retina cell photoreceptors was already known before 2000, yet only as visual information, until melanopsin of the retina was discovered in intrinsically photosensitive retinal ganglion cells (ipRGCs). As photoreceptors, ipRGCs are particularly sensitive to absorption of 480nm peaked blue light. It turns out that the wavelength of 480nm correlates with melatonin suppression and secretion, resulting in the change of lighting-requirements that can regulate alertness, sleep, and the circadian rhythm. In this research, we focused and analyzed the effects of light at 480nm wavelengths on humans through melatonin, HRV (Heart Rate Variability), EEG (ElectroEncephaloGraphy) and the test of attention. As a result, it was found that the wavelength of light had a direct effect on melatonin, and that DLMO, which is known as the start time of sleep, was also changed with HRV. Also, it was confirmed that the attention test results changed as the light changed, and the brain waves responded differently at this time.

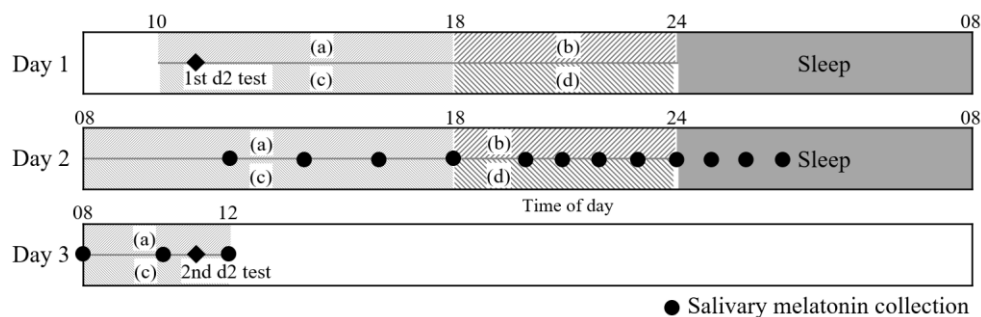


Fig. 1 Experimental schedule. The protocol above was performed twice using two types of lighting: Conventional lighting (a) 5000K with 500 lux, (b) 2200K with 190 lux, HCL lighting (c) 5000K with 500 lux, (d) 2200K with 190 lux. And EEG and the test of attention was conducted in the morning of 1st and 3rd day and always recorded HRV during clinical periods.

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FACTORS THAT INFLUENCE NIGHT LIGHTING CONDITIONS IN PATIENT ROOMS

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The conflict between the lighting needs of healthcare patients and staff has been a long-standing and contentious issue, which is most evident at night in shared spaces of hospitals like patient rooms. Dim lighting enhances the sleep quality of patients, but healthcare staff consider the light levels to be too low when conducting nursing tasks [1]. Poor lighting conditions have been associated with higher medical error rates [2] and poor health outcomes for both patients and healthcare staff [3–6], and yet this problem of inadequate lighting persists in practice. To better understand why this problem continues to exist, this study will explore which factors may have influence on how lighting is used in patient rooms at night and to what extent. A mixed-methods approach is proposed for the study and field data will be collected from a healthcare facility and the staff that work there. The quality and quantity of light (such as illuminance and luminance levels, and spectral power distribution) in patient rooms will be evaluated against lighting standards to identify design-related issues. The perceptions and experiences of healthcare staff with night lighting will be gathered using interviews and observations (using video recordings) [7] to uncover issues with social (patient–staff interactions), behavioural (nursing workflows), and environmental (facility management and policies) factors. The expected outcomes of the study will be used to develop lighting design strategies to help improve the night lighting conditions for healthcare staff as they work (but without causing adverse effects for the patients).

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ABSTRACTS

Session 4

Obtrusive Light and Sky Glow

IS CCT REALLY THE BEST SPECTRAL INDEX FOR PREDICTING SKY GLOW?

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Globally light pollution from artificial sources has grown at a rate greater than the global population growth. Some authorities attempt to address this by specifying LED road lighting luminaires with a low correlated colour temperature (CCT) e.g. 3000K. However, the CCT was not intended as a sky glow index and may not be the best index for purpose.

This study uses the spectral power distribution (SPD) from 75 LED road lighting luminaires to calculate the following indexes and relate them to the relative sky glow derived from the US Department of Energy “Sky glow comparison tool v1.0” [1],

- Correlated Colour Temperature (CCT)
- Scotopic / Photopic Ratio (S/P ratio)
- % Blue light (430 – 470 nm)
- % Blue light (400 – 500 nm)
- % Blue light (400 – 550 nm)

When plotted against the relative skyglow a good predictor index will produce low dispersion of points and a high correlation co-efficient. A series of some 25 graphs illustrate how well each of the indexes predict the relative skyglow for scenarios including air pollution, observer eye sensitivity and proximity to light sources.

Results

Figure 1 (L) shows CCT as only a moderate predictor of sky glow ($R^2=0.75$) whereas the same data in Figure 1 (R) shows the S/P ratio to be a strong predictor ($R^2=0.99$). Overall, the strongest spectral predictor of skyglow was the S/P ratio and the weakest was % Blue light (430 – 470 nm).

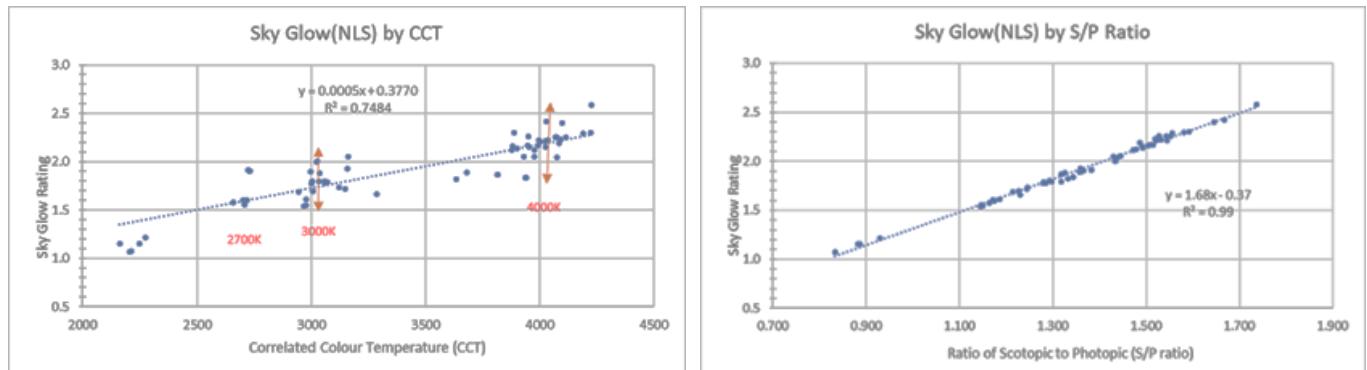


Figure 1: (L) Index CCT; (R) Index S/P ratio

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STANDARDISING ARTIFICIAL LIGHT AT NIGHT SURVEYS

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In January 2020 the Australian Federal Government released the National Light Pollution Guidelines for Wildlife¹. The guidelines are a great reference tool which helps lighting designers, governments and planners in the design of lighting installations in wildlife sensitive areas, such as turtle nesting beaches. However, the guidelines lack or are inconsistent in the specification of equipment suitable for conducting assessments of artificial light at night and does not provide a standard methodology for conducting these surveys. Measurements are affected by atmospheric and environmental conditions, such as temperature, humidity, fog, sea spray, and cloud cover distribution, height and thickness. Furthermore, these conditions may change throughout the night and throughout the year and the variability in the conditions should be taken into consideration when preparing the survey methodology.

WAVES Testing, Research and Consulting has been investigating the use of digital cameras with fisheye lenses, which have been calibrated for luminance (mcd/m^2), visual magnitude ($\text{mag}/\text{arcsec}^2$) and correlated colour temperature (K), to benchmark sky glow in locations throughout Queensland. This data allows councils and State government to quantify the effect new and refurbished lighting installations have on sky glow.

While some of these parameters can only be assessed over a long time-frame, some can be investigated over a short timeframe and have been the subject of studies aimed at developing a standard testing procedure which is repeatable and comparable. Comments on the specifications made in the guidelines regarding equipment and results of these studies will be presented.

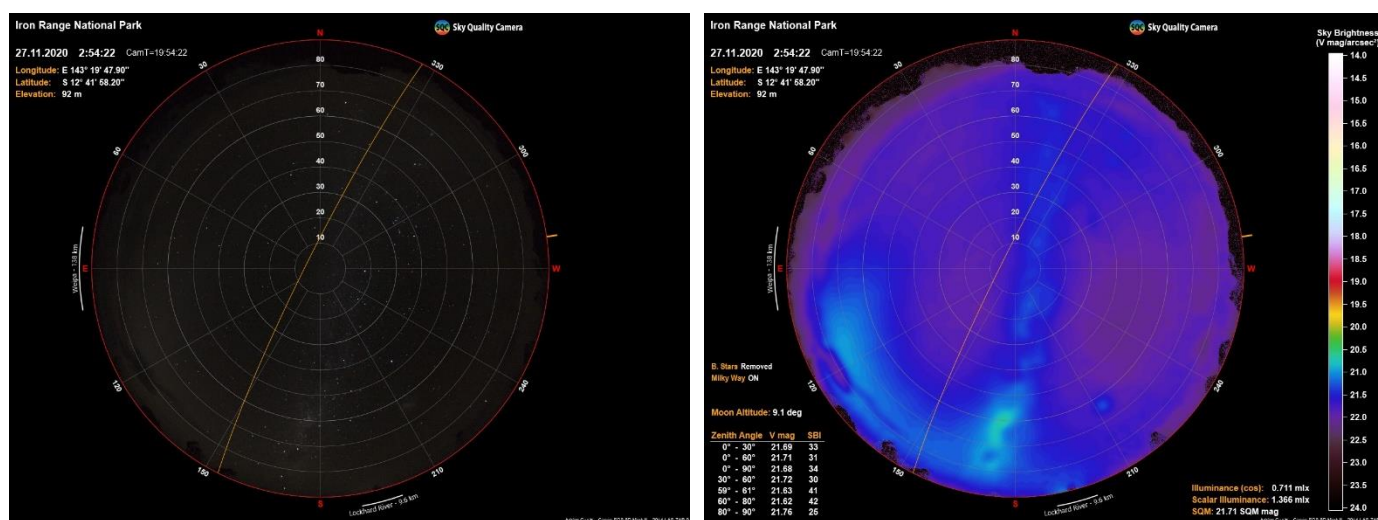


Figure 1: (L) Image from Iron Range National Park, QLD; (R) Sky brightness ($\text{V mag}/\text{arcsec}^2$)

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ABSTRACTS

Session 5

Product Performance and Measurement

MEASUREMENT OF TEMPORAL LIGHT MODULATION AND CALCULATION OF TEMPORAL LIGHT ARTIFACTS

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Temporal light modulation (TLM), the physical changes in light output on short timescales and the perceivable and imperceivable disturbances caused in observers, called temporal light artifacts (TLA) [1] are attracting attention due to the wide application of temporally modulated sources in LED lighting. TLA are suspected to cause problems with health and wellbeing [2], seemingly aggravated for sensitive individuals. To improve the situation the CIE is preparing two publications built on previous work [3], [1] and new research: A short technical note on the measurement of TLM (TC 2-89) and a more comprehensive technical report on TLA (TC 1-83).

The result of a TLM measurement is called a waveform, essentially a large series of single light measurements. The TLA measures, such as stroboscopic visibility measure (SVM) [4] and short-term light modulation (PstLM) [5] are calculated from the TLM data, so the repeatability, comparability [6] and validity of these large datasets is of crucial importance, as various regulation sets out requirements for TLA of commercial products [7], [8].

This presentation will go through highlights of the upcoming recommendations of CIE regarding measurements of TLM, the relationship to TLA as well as touch upon some of the remaining open questions, for instance:

- Uncertainty estimation for the large TLM datasets
- Effect of uncertainty in TLM datasets on the calculation of TLA

However, while measurement of TLM is a technical issue, including some novel challenges this pales in comparison to the problems of understanding the effect of TLM and TLA on the visual system and the brain.

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A MATTER OF LIFE AND STRESS: PREDICTING THE LIFETIME OF LED LIGHTING PRODUCTS

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The ability to compare the cost of ownership between competing products is an important contributing factor to procurement decisions. Parameters feeding into the cost of ownership equation for electrical appliances including LED lamps are asset price, energy usage, life of product and any labour costs associated with replacement. All except the life of the product are easily determined/estimated values. Not only is product lifetime difficult to determine, but it potentially has the greatest influence on the accuracy of the cost of ownership and, ultimately, the validity of the procurement decision.

The lifetime of a light source is the cumulative time it operates until it fails to provide a useful amount of light for its intended purpose. This failure may be in the form of either a catastrophic failure, that is no light is emitted by the lamp, or a parametric failure, where some light is emitted by the lamp but is unsatisfactory for the intended purpose. The rated lifetime of a product is defined as the median lifetime of multiple units of the same product, thereby half the units will have a lifetime shorter than this rated value and the remainder will exceed it. Due to the potentially long median lifetimes of LED light sources, testing a large sample set of a product until fifty percent have failed to operate as intended is impractical. Therefore, lifetime prediction methods must be used.

To be a complete predictor of a light source's lifetime, all the common failure modes should be assessed and included in the prediction model. Typical causes of catastrophic failure are electronic component or electrical connection failures. Typical parametric failures are deterioration of the LED die (manifested by a shift in colour and/or reduced emission of light) and LED driver performance (manifested as temporal light modulation and/or reduced light output).

Current test methods and prediction models for lifetime in international standards only consider the parametric failure mode of light loss.

This presentation will briefly describe existing endurance and lifetime tests before discussing recent investigations into test methods where products are exposed to various operating stresses while product performance data is acquired. Finally, the opportunity to formulate prediction models combining these correlations of time to end of life with the different operating stresses will be explored.

CHALLENGES IN MEASURING ULTRAVIOLET RADIATION

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Ultraviolet radiation (UVR) is optical radiation within the wavelength range 100 nm to 400 nm; further divided into the sub-wavelength ranges UV-A (315 nm to 400 nm), UV-B (280 nm to 315 nm) and UV-C (100 nm to 280 nm).

The use of UVR, and in particular germicidal ultraviolet radiation (GUV) in the UV-C region, for purposes of disinfection has become of greater interest since the advent of the SARS-COV-2 virus which carries the COVID-19 coronavirus disease [1]. However, although it may be useful to use GUV for disinfection it is also important to know how much radiation is being used, i.e. accurate measurement methods. Accurate measurements need accurate and appropriate calibration of the radiometers used to measure the UVR.

However, calibration and use of UV radiometers and spectroradiometers is complicated, and it is very easy to end up with large errors. Factors such as spectral mismatch; directional response; and the respective positions of the reference planes of the source and detector become critical in performing accurate measurements. For wavelengths below 250 nm, aspects such as metrological traceability; reliable calibration sources; detector responsivity stability; and atmospheric absorption become important. Although guidance is available for characterisation and calibration of UV radiometers [2], many people who use UV radiometers remain unaware of the care that needs to be taken to properly match the calibration and use of the instrument.

In this presentation these challenges will be highlighted, as well as progress in research the author is undertaking into atmospheric absorption of the UV-C radiation and the difficulty this creates in passing on metrological traceability between sources and instruments at short wavelengths.

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ESTIMATING ILLUMINANCE WHEN VIEWING A VIRTUAL REALITY SCENE ON THE OCULUS QUEST USING THE UNREAL ENGINE

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Virtual Reality (VR) headsets create immersive worlds. VR may be used to assess vision-guided mobility, which is an increasingly important outcome measure to assess the efficacy of treatments e.g. bionic prostheses and gene therapies for conditions such as macular degeneration and retinitis pigmentosa [1,2]. VR measures for vision-guided motion can be used to assess a wide range of scenarios without needing space to build physical obstacle courses and minimal safety concerns. It is essential that vision-guided motion is assessed at a range of light levels for many vision conditions: e.g. one RP study assesses 1-256 lux [3] and the Multi-Luminance Mobility Test assesses 1-400 lux [4]. In this study we investigated illuminance generated using the UNREAL engine and the Oculus Quest headset for one VR scenario.

Methods and Results: A method was developed to estimate illuminance. Unreal Engine was used to create a single grey VR room illuminated from above by a single light. VR candelas were input to the engine and illuminance estimated for a 12 mm viewing vertex distance, based on illuminance measurements using the International Light Technologies 1700 illuminance meter at a known distance (see Figure 1).

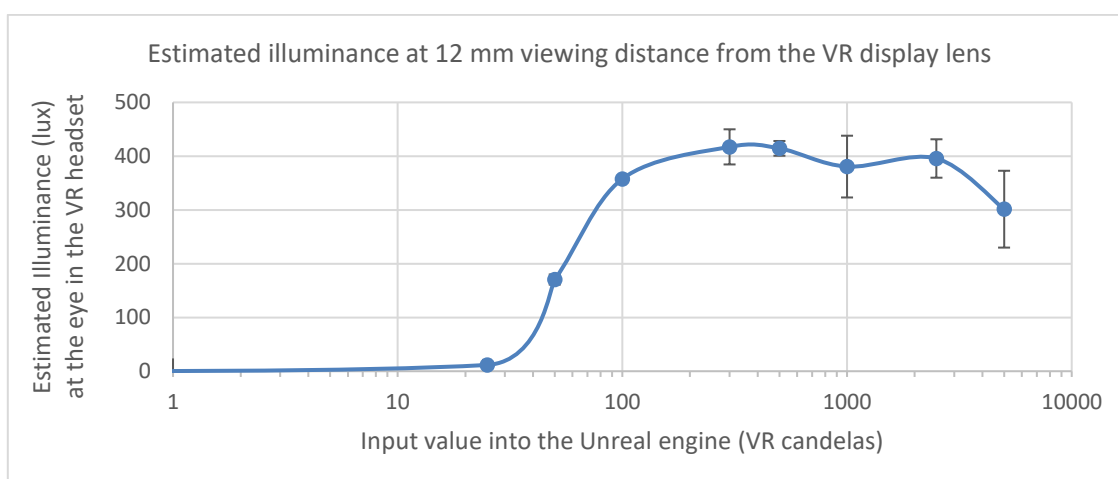


Figure 2: Relationship between virtual candelas and average illuminance viewed. Error bars are +/- 1 standard deviation.

Conclusion: With a single VR light, VR wall illumination levels were similar to the range of physically constructed vision-guided mobility tests. For values >300 VR candelas (cd) a ceiling was reached, and values <15 VR cd were subject to unknown error due to calibration limits. Future work will investigate multiple light configurations, filters, alternative scenarios and test additional values.

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