



International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

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**PROCEEDINGS of
CIE 2016
"Lighting Quality and Energy
Efficiency"**

3 - 5 March 2016

Melbourne, Australia

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Descriptor: Lighting. Illuminating engineering
Descriptor: Photometry

THE INTERNATIONAL COMMISSION ON ILLUMINATION

The International Commission on Illumination (CIE) is an organization devoted to international co-operation and exchange of information among its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in about 40 countries.

The objectives of the CIE are:

1. To provide an international forum for the discussion of all matters relating to the science, technology and art in the fields of light and lighting and for the interchange of information in these fields between countries.
2. To develop basic standards and procedures of metrology in the fields of light and lighting.
3. To provide guidance in the application of principles and procedures in the development of international and national standards in the fields of light and lighting.
4. To prepare and publish standards, reports and other publications concerned with all matters relating to the science, technology and art in the fields of light and lighting.
5. To maintain liaison and technical interaction with other international organizations concerned with matters related to the science, technology, standardization and art in the fields of light and lighting.

The work of the CIE is carried out by Technical Committees, organized in seven Divisions. This work covers subjects ranging from fundamental matters to all types of lighting applications. The standards and technical reports developed by these international Divisions of the CIE are accepted throughout the world.

A plenary session is held every four years at which the work of the Divisions and Technical Committees is reported and reviewed. Plans are made for the future. The CIE is recognized as the authority on all aspects of light and lighting. As such it occupies an important position among international organizations.

LA COMMISSION INTERNATIONALE DE L'ECLAIRAGE

La Commission Internationale de l'Éclairage (CIE) est une organisation qui se donne pour but la coopération internationale et l'échange d'informations entre les Pays membres sur toutes les questions relatives à l'art et à la science de l'éclairage. Elle est composée de Comités Nationaux représentant environ 40 pays.

Les objectifs de la CIE sont :

1. De constituer un centre d'étude international pour toute matière relevant de la science, de la technologie et de l'art de la lumière et de l'éclairage et pour l'échange entre pays d'informations dans ces domaines.
2. D'élaborer des normes et des méthodes de base pour la métrologie dans les domaines de la lumière et de l'éclairage.
3. De donner des directives pour l'application des principes et des méthodes d'élaboration de normes internationales et nationales dans les domaines de la lumière et de l'éclairage.
4. De préparer et publier des normes, rapports et autres textes, concernant toutes matières relatives à la science, la technologie et l'art dans les domaines de la lumière et de l'éclairage.
5. De maintenir une liaison et une collaboration technique avec les autres organisations internationales concernées par des sujets relatifs à la science, la technologie, la normalisation et l'art dans les domaines de la lumière et de l'éclairage.

Les travaux de la CIE sont effectués par Comités Techniques, organisés en sept Divisions. Les sujets d'études s'étendent des questions fondamentales, à tous les types d'applications de l'éclairage. Les normes et les rapports techniques élaborés par ces Divisions Internationales de la CIE sont reconnus dans le monde entier.

Tous les quatre ans, une Session plénière passe en revue le travail des Divisions et des Comités Techniques, en fait rapport et établit les projets de travaux pour l'avenir. La CIE est reconnue comme la plus haute autorité en ce qui concerne tous les aspects de la lumière et de l'éclairage. Elle occupe comme telle une position importante parmi les organisations internationales.

DIE INTERNATIONALE BELEUCHTUNGSKOMMISSION

Die Internationale Beleuchtungskommission (CIE) ist eine Organisation, die sich der internationalen Zusammenarbeit und dem Austausch von Informationen zwischen ihren Mitgliedern bezüglich der Kunst und Wissenschaft der Lichttechnik widmet. Die Mitgliedschaft besteht aus den Nationalen Komitees in rund 40 Ländern.

Die Ziele der CIE sind:

1. Ein internationales Forum für Diskussionen aller Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik und für den Informationsaustausch auf diesen Gebieten zwischen den einzelnen Ländern zu sein.
2. Grundnormen und Verfahren der Lichttechnik auf dem Gebiet der Lichttechnik zu entwickeln.
3. Richtlinien für die Anwendung von Prinzipien und Vorgängen in der Entwicklung internationaler und nationaler Normen auf dem Gebiet der Lichttechnik zu erstellen.
4. Normen, Berichte und andere Publikationen zu erstellen und zu veröffentlichen, die alle Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik betreffen.
5. Liaison und technische Zusammenarbeit mit anderen internationalen Organisationen zu unterhalten, die mit Fragen der Wissenschaft, Technik, Normung und Kunst auf dem Gebiet der Lichttechnik zu tun haben.

Die Arbeit der CIE wird durch Technische Komitees geleistet, die in sieben Divisionen organisiert sind. Diese Arbeit betrifft Gebiete mit grundlegender Bedeutung in allen Arten der Lichtanwendung. Die Normen und Technischen Berichte, die von diesen international zusammengesetzten Divisionen ausgearbeitet werden, sind auf der ganzen Welt anerkannt.

Alle vier Jahre findet eine Session statt, in der die Arbeiten der Divisionen berichtet und überprüft werden, sowie neue Pläne für die Zukunft ausgearbeitet werden. Die CIE wird als höchste Autorität für alle Aspekte des Lichtes und der Beleuchtung angesehen. Auf diese Weise unterhält sie eine bedeutende Stellung unter den internationalen Organisationen.

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Lighting Quality & Energy Efficiency

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The following table provides an overview of the oral presentations, presented posters and posters presented at the conference. The papers are published in the proceedings in consecutive order of presentation. Papers that have not been submitted are marked as such ("n.s.").

The authors are responsible for the contents of their papers.

Please note: For direct access of a paper click on the respective page number.

| Invited Presentations | | | Page |
|-----------------------|--------------|---|------|
| IT01 | Ramus, B. | The Quality of Light in our Life – Reflecting our Rhythms | n.s. |
| IT02 | Hurlbert, A. | Tuning light to see and feel better: The human visual and non-visual responses to spectral variations in light (Chair: Erkki Ikonen, FI) | 1 |
| IT03 | King, B. | Australian and New Zealand Road Lighting - Applying Advanced Energy Performance Metrics | n. |

| Oral Presentations | | | Page |
|---|--------------------------|---|------|
| PA1-1 Colour quality (1) | | | |
| OP01 | Padfield, J. et al. | OPTIMISATION OF ARTWORK ILLUMINATION SPECTRA BY MUSEUM PROFESSIONALS | 7 |
| OP02 | Chou, C.J. et al. | MUSEUM LIGHTING: DESIGN WITH COLOR BASED COLOR RENDER INDEX | 12 |
| OP03 | Abdalla, D. et al. | CUSTOMIZATION OF LIGHT SOURCE SPECTRUM TO MINIMIZE LIGHT ABSORPTION BY ARTWORK | 22 |
| OP04 | Wei, M. et al. | EFFECT OF GAMUT SHAPE ON COLOUR PREFERENCE | 32 |
| PA1-2 Interior applications - Efficiency and visual perception quality (1) | | | |
| OP05 | Jakubiec, J.A. et al. | ACCURATE MEASUREMENT OF DAYLIT INTERIOR SCENES USING HIGH DYNAMIC RANGE PHOTOGRAPHY | 42 |
| OP06 | Robinson, K. et al. | DETECTION OF LUMINANCE DIFFERENCES ACROSS ARCHITECTURAL SPACES | 53 |
| OP07 | Sullivan, J.T., Donn, M. | LIGHT DISTRIBUTION AND SPATIAL BRIGHTNESS: RELATIVE IMPORTANCE OF THE WALLS, CEILING, AND FLOOR | 59 |
| OP08 | Van de Perre, J. et al. | CONTRAST METRICS EVALUATION | 70 |
| PA1-3 Advanced Radiometry and Photometry | | | |
| OP09 | Young, P. et al. | ACCURATE ESTIMATION OF COLOUR UNCERTAINTIES USING A SIMPLIFIED MODEL | 79 |
| OP10 | Ullli, T. et al. | UNCERTAINTY EVALUATION OF SPECTRAL INTEGRALS FOR LED LAMPS | 89 |
| OP11 | Lee, D.-H. et al. | OPTICAL DETECTOR WITH DESIGNABLE SPECTRAL RESPONSIVITY | n.s. |
| OP12 | Schneider, P. et al. | LASER BASED CALIBRATED V(LAMBDA) TRAP DETECTOR | 94 |
| PA2-1 Colour quality (2) | | | |
| OP13 | Gu, H.T. et al. | COMPARING THE QUALITY OF THE LED BASED AND CONVENTIONAL CIE ILLUMINANT SIMULATORS | 103 |

| | | | |
|---|-----------------------------|--|------|
| OP14 | Ma, S. et al. | EVALUATION OF WHITENESS INDICES | 112 |
| OP15 | Ou, L. | A COMPARISON OF COLOUR APPEARANCE BETWEEN INDOOR AND OUTDOOR ENVIRONMENTS | 118 |
| PA2-2 Interior applications - Glare (1) | | | |
| OP16 | Safdar, M. et al. | THE HUMAN VISION MODEL TO PREDICT DISCOMFORT GLARE FROM LUMINANCE IMAGE | 125 |
| OP17 | Hansen, P. et al. | GLARE CAUSED BY CONTRAST BETWEEN TASK AND IMMEDIATE SURROUND: AN EVALUATION OF LUMINANCE DISTRIBUTION IN THE FIELD OF VIEW | 132 |
| OP18 | Donners, M. et al. | A PSYCHOPHYSICAL MODEL OF DISCOMFORT GLARE IN BOTH OUTDOOR AND INDOOR APPLICATIONS | 142 |
| PA2-3 CIE Strategy on LED based calibration standards | | | |
| OP21 | Liu, H. et al. | CHARACTERIZATION OF MODIFIED LED LAMPS FOR LUMINOUS FLUX STANDARD | 52 |
| OP20 | Zwinkels, J.C. | CCPR ACTIVITIES RELATED TO LED BASED CALIBRATION STANDARDS | 157 |
| OP19 | Poikonen | REVIEW OF CHALLENGES AND DISADVANTAGES OF POSSIBLE LED-BASED PHOTOMETRIC STANDARDS | n.s. |
| PA3-1 Colour quality (3) | | | |
| OP22 | Smet, K.A.G. et al. | ON THE IMPORTANCE OF COLOR SPACE UNIFORMITY AND SAMPLESET SPECTRAL UNIFORMITY FOR COLOR FIDELITY MEASURES | 166 |
| OP23 | Ohno, Y. | VISION EXPERIMENT FOR WHITE LIGHT CHROMATICITY FOR LIGHTING | 175 |
| OP24 | Teunissen, C. | A FRAMEWORK FOR EVALUATING THE MULTIDIMENSIONAL COLOR QUALITY PROPERTIES OF WHITE LED LIGHT SOURCES | 185 |
| PA3-2 Interior applications - Glare (2) | | | |
| OP25 | Scheir, G.H. et al. | VISUAL DISCOMFORT PREDICTION BASED ON RECEPTIVE FIELDS | 195 |
| OP58 | Goovaerts, C., Descamps, F. | STRATEGY FOR VISUAL COMFORT CONTROL THROUGH ANALYSIS OF HIGH DYNAMIC RANGE IMAGES AND ACTUATION OF VENETIAN BLINDS | 204 |
| OP27 | Hirning, M.B. et al. | DISCOMFORT GLARE IN ENERGY EFFICIENT BUILDINGS: A CASE STUDY IN THE MALAYSIAN CONTEXT | 212 |
| PA4-1 Light and vision | | | |
| OP31 | Wang, L. et al. | INFLUENCE OF CONTRAST AND COLOR ON THE VISIBILITY OF THE STROBOSCOPIC EFFECT OF TEMPORAL MODULATED LEDS | 224 |
| OP32 | Lee, C.-S. et al. | EFFECT OF COLOR AND LUMINANCE INTENSITY ON THE PHANTOM ARRAY | 232 |
| OP33 | Xu, L. et al. | THE DEVELOPMENT OF A COLOUR DISCRIMINATION INDEX | 241 |
| PA4-2 Interior applications – Efficiency and visual perception quality (2) | | | |
| OP34 | Hu, Y. et al. | ASSESSING UNIFORMITY OF ILLUMINANCE BASED ON A LED TUNABLE SYSTEM | 247 |

| | | | |
|---|----------------------------|--|-----|
| OP37 | Hu, W., Davis, W. | LUMINANCE RESOLUTION OF LIGHTING CONTROL SYSTEMS: USABILITY AND ENERGY CONSERVATION | 253 |
| OP52 | Gasparovsky, D. et al. | PROPOSAL OF A METHOD FOR ASSESSMENT OF ENERGY PERFORMANCE OF LIGHTING IN RESIDENTIAL BUILDINGS | 264 |
| PA4-3 Exterior applications – Efficiency and visual perception quality | | | |
| OP38 | Fotios, S. et al. | VARYING FACIAL EXPRESSIONS IN STUDIES OF INTERPERSONAL JUDGEMENTS AND PEDESTRIAN LIGHTING | 275 |
| OP39 | Chen, Y.C. et al. | LUMINANCE CONTRAST STUDY OF LED TRAFFIC SIGNS | 283 |
| OP50 | Van Heur, R.J. et al. | MAINTENANCE FACTOR FOR STREET LIGHTING | 287 |
| PA5-1 Photobiological effects and their measurement | | | |
| OP41 | Wang, M.L. and Luo, M.R. | EFFECTS OF LIGHTING PARAMETERS ON WORK PERFORMANCE USING COMPREHENSIVE METHODS | 294 |
| OP42 | Zheng, S.Q. et al. | THE EFFECT OF CCT-CHANGING DYNAMIC LIGHT ON HUMAN ALERTNESS | 300 |
| OP43 | Shitomi, H. and Suzuki, K. | CONSIDERATION ON SAFETY FACTORS APPLIED TO A SIMPLIFIED APPROACH TO EVALUATE THE LIGHT HAZARD OF GENERAL LIGHT SOURCE BY MEANS OF PHOTOMETRY | 305 |
| PA5-2 Characterization of LEDs and OLEDs | | | |
| OP30 | Leise, N. et al. | HIGH SPEED MEASUREMENT METHODS FOR LARGE AREA OLEDs | 311 |
| OP56 | Poppe, A. et al. | MULTI-DOMAIN MODELING OF POWER LEDs BASED ON MEASURED ISOTHERMAL I-V-L CHARACTERISTICS | 318 |
| OP57 | Miller, C.C. et al. | SOLID-STATE LIGHTING MEASUREMENT ASSURANCE PROGRAM SUMMARY WITH ANALYSIS OF METADATA | 328 |
| PA5-3 Road lighting | | | |
| OP47 | Rossi, G. et al. | ON SITE ROAD SURFACE CHARACTERIZATION | 334 |
| OP48 | Donners, M.A.H et al. | ROAD LIGHTING FOR AGEING DRIVERS – A USERS' PERSPECTIVE | 345 |
| OP49 | Buyukkinaci, B. et al. | ANALYSIS OF ROAD LIGHTING AUTOMATION SCENARIOS ACCORDING TO VISIBILITY PERFORMANCE | 355 |
| PA6-1 Interior applications - Visual comfort | | | |
| OP45 | Iwata, T. et al. | MEASUREMENT OF LUMINANCE DISTRIBUTION OF SPORTS LIGHTING -TOWARD DEVELOPMENT OF EVALUATION METHOD FOR LED SPORTS LIGHTING 'GLARE' | 365 |
| OP44 | Surey Khanie, M. et al. | GAZE RESPONSIVE VISUAL COMFORT: NEW FINDINGS ON GAZE BEHAVIOUR IN A DAYLIT OFFICE SPACE IN RELATION TO GLARE | 373 |
| OP46 | Amirkhani, M. et al. | REDUCING LUMINANCE CONTRAST ON THE WINDOW WALL AND USERS' INTERVENTIONS IN AN OFFICE ROOM | 385 |

| PA6-3 Mesopic photometry | | | |
|---------------------------------|----------------------|--|-----|
| OP53 | Winter, J. et al. | GAZE BEHAVIOUR WHEN DRIVING AFTER DARK ON MAIN AND RESIDENTIAL ROADS | 395 |
| OP54 | Uchida, T., Ohno, Y. | M/P RATIO METHOD FOR MESOPIC LUMINANCE MEASUREMENT | 402 |
| OP55 | Lau, S. et al. | A NEW MEASUREMENT SOLUTION FOR MESOPIC PHOTOMETRY OF ROAD LIGHTING | 410 |

| Presented Posters | | | Page |
|---|------------------------------------|--|-------------|
| PS1 Lighting and Lighting Quality | | | |
| PP01 | Chien, S.-C. et al. | AN INTEGRATED CYBER-PHYSICAL MODEL TOWARDS HIGH-PERFORMANCE LIGHTING SYSTEMS OPERATION | 417 |
| PP02 | Luo, T. et al. | A NEW SIMULATION METHOD FOR PREDICTING LIGHTING ENERGY CONSUMPTION OF OPEN-PLAN OFFICES | 427 |
| PP03 | Kobav, M.B., Bizjak, G. | SPATIAL DISTRIBUTION OF SKY LUMINANCE AND CCT | 437 |
| PP04 | Wang, Y.Z. et al. | SKIN LIGHTING STUDY BASED ON MULTISPECTRAL IMAGES | 446 |
| PP06 | Yang, Y. et al. | GLARE MODEL FOR NON-UNIFORM WHITE LED LUMINAIRES | 451 |
| PP08 | Nilsson Tengelin, M., Källberg, S. | EVALUATION OF LIGHTING AND VISUAL COMFORT IN SWEDISH CLASSROOMS | 457 |
| PP09 | Yuan, Y. et al. | EFFECTS OF AGE AND GENDER ON VISUAL COMFORT FOR READING USING WHITE LED LIGHTS | 463 |
| PP10 | Sekulovski, D. | MEASURING TEMPORAL LIGHT QUALITY | n.s. |
| PP26 | Koga, Y. et al. | TOWARDS THE NEW GENERATION OF LIGHTING DESIGN FOR ADVANCED CONTAINER TERMINALS | 468 |
| PP27 | Shen, H. et al. | FAST MEASUREMENT METHOD FOR SKY PERCENTAGE IN TUNNEL LIGHTING | 477 |
| PS2 Colour Quality / Photobiology / Measurements | | | |
| PP11 | Yang, T.H., et al. | SUBJECT COLOUR DIFFERENCE ARISING FROM LIGHT SOURCES WITH VARIOUS CCT | 483 |
| PP12 | Wang, M. et al. | SKIN COLOUR MEASUREMENT BY USING NON-CONTACT METHODS | 487 |
| PP13 | Chalmers, A.N., Soltic, S. | EXPERIMENTS IN COLOUR RENDERING ASSESSMENT | 493 |
| PP14 | Oh, S. et al. | COLOR APPEARANCE OF LED LIGHTS | 500 |
| PP15 | Wen, C.H. et al. | INVESTIGATION OF FLICKER METRICS FOR LIGHTING ON HIGH SPEED ROADS | 505 |
| PP16 | Dubnička, R., Gasparovsky, D. | ANALYSIS OF VISUAL FIELD OF OBSERVER IN CONNECTION WITH THE ADAPTATION LUMINANCE DETERMINATION IN MESOPIC PHOTOMETRY | 513 |
| PP17 | Donners, M.A.H. et al. | EXPERIMENTAL EVALUATION OF LONG-TERM ECOSYSTEM EFFECTS OF ARTIFICIAL LIGHTING ON A FORREST EDGE | 523 |

| | | | |
|------|-----------------------|---|-----|
| PP19 | Liu, G. et al. | RESEARCH ON QUANTITATIVE RELATIONSHIP BETWEEN SWIFTS' OUT OF THE NEST AND HOMING AND NATURAL LIGHT IRRADIANCE | 533 |
| PP20 | Stefani, O. et al. | EFFECTS OF DISCERNIBLE ILLUMINANCE CHANGES ON PERFORMANCE AND CONDITION | 540 |
| PP21 | Thorseth, A. et al. | A COMPARISON OF GONIOPHOTOMETRIC MEASUREMENT FACILITIES | 547 |
| PP24 | Konjhodzic D., Ma, X. | APPLICATION OF STRAY LIGHT CORRECTED ARRAY-SPECTRORADIOMETERS | 555 |
| PP18 | Nel-Sakharova, N. | AN ASSESSMENT OF THE PHOTOBIOLOGICAL SAFETY OF TYPICAL LED PRODUCTS USED IN SOUTH AFRICA | 561 |

| Posters | | | Page |
|---------|-------------------------------|--|------|
| P01 | Lorphèvre, R. et al. | NEW METHOD FOR ANALYSIS OF ANNUAL TUNNEL APPROACH DAYLIGHT | 564 |
| P02 | Lorphèvre, R. et al. | PUBLIC LIGHTING, PROFIT OR COST TO SOCIETY? A STUDY THROUGH ACCIDENT RISKS | 571 |
| P03 | Dubnička, R. et al. | COMPARISON OF THE MEASUREMENT METHODS OF TUNNEL LIGHTING IN RESPECT OF CIE 19:2011 | n.s. |
| P04 | Dubnička, R. et al. | FIELD MEASUREMENT OF THE FOOTBALL STADIUM'S LIGHTING | 577 |
| P05 | Forberg, L.-F. et al. | DIFFERENCES IN PERCEIVED BRIGHTNESS BETWEEN HIGH PRESSURE SODIUM AND LED LIGHT SOURCES | 584 |
| P06 | Davoudian, N., Mansouri, A.A. | DOES STREET LIGHTING AFFECT PEDESTRIAN BEHAVIOUR AT NIGHT? | 588 |
| P07 | Preciado, O.U., Manzano, E.R. | THE EFFECT OF ROAD LIGHTING LUMINAIRE SPECTRAL POWER DISTRIBUTION OVER LUMINANCE PERCEPTION CONSIDERING ROAD REFLECTANCE AND HUMAN EYE TRANSMITTANCE | 596 |
| P08 | Lee, M. et al. | A COMPARATIVE ANALYSIS OF LED ROAD LIGHTING LUMINAIRE PERFORMANCE AND A SUGGESTION FOR A SELECTION PROCEDURE | 606 |
| P09 | Wang, S., Zhao, Y. | INTRODUCTION ON TECHNICAL STANDARDIZATION PROGRESS OF LED ROADWAY LIGHTING IN CHINA | 614 |
| P10 | Yoo, S. et al. | THE SURVEY AND THE LIMIT METHOD OF LIGHT POLLUTION BY DECORATIVE LIGHTING | 618 |
| P11 | Miyamoto, M. et al. | ACTUAL CONDITION OF RESIDENTIAL LIGHTING IN JAPAN AND THE UNITED STATES | 626 |
| P12 | Hong, B.J. et al. | IMPACTS STUDY OF THE BACKGROUND LUMINANCE AND ILLUMINATION LEVEL ON MEASURING OF LED BILLBOARDS IN TAIWAN | 632 |
| P13 | Li, N. et al. | RESEARCH ON THE LIGHT INTRUSION CAUSED BY LED ADVERTISING SCREENS IN THE BEIJING-TIANJIN REGION | 642 |
| P14 | Van Heur, R.J., Deswert, J.M. | UNIVERSAL INTELLIGENT STREET LIGHTING PLATFORMS | 654 |

| | | | |
|-----|--------------------------|---|------|
| P15 | Pak, H. et al. | EFFECTS OF COLOUR TEMPERATURE OF IN-VEHICLE LED LIGHTING ON PASSENGER'S PHYSIOLOGICAL RESPONSES AND PREFERENCE | 660 |
| P16 | Maki Ichihara, JP | RELATIONSHIP BETWEEN SPATIAL BRIGHTNESS PERCEPTION AND LUMINANCE BALANCE IN WINDOWED ROOMS | n.s. |
| P17 | Kato, M. et al. | EVALUATION METHOD OF SPATIAL BRIGHTNESS BY DIRECTIONAL DIFFUSIVITY AND MEAN LUMINANCE | 664 |
| P18 | Suzuki, N. et al. | A STUDY ON THE EFFECT OF NON-UNIFORM LIGHTING ENVIRONMENT TO OCCUPANTS IN A WIDE OPEN-PLAN WORKPLACE | 669 |
| P19 | Kunishima, M. et al. | FACIAL ILLUMINANCE, WORKING SURFACE ILLUMINANCE AND SPACE EVALUATION AT VARIOUS ACTS IN JAPANESE RESIDENTIAL LIGHTING | 670 |
| P20 | Kirsch, R., Durmus, D. | DESIGN OF A LABORATORY TO MEASURE PSYCHOLOGICAL EFFECTS IN OFFICE LIGHTING | 686 |
| P21 | Mochizuki, E., Iwata, T. | SUBJECTIVE EXPERIMENT ON OBTRUSIVE GLARE IN GYMNASIUM | 691 |
| P22 | Chen, M.K. et al. | ASSESSMENT OF GLARE RATING FOR NON-UNIFORM LIGHT SOURCES | 697 |
| P23 | Hara, N. | VISUAL CHARACTERISTICS FOR EVALUATING THE DISCOMFORT GLARE - RELATIONSHIP BETWEEN THE POSITION, SIZE, ARRAY OF THE LED CHIPS, AND BCD ON THE DISCOMFORT GLARE - | 704 |
| P24 | Zhao, J. et al. | THE INFLUENCE OF COLOUR RENDERING CHARACTERISTICS ON THE TELEVISION PICTURE COLOR REPRODUCTION | 708 |
| P25 | Ishida, T. et al. | EVALUATION OF PSYCHOLOGICAL IMPRESSIONS OF TWO-COLOR GRADATION LIGHTING | 715 |
| P26 | Georgoula M. et al. | SPECIFICATION FOR THE CHROMATICITY OF WHITE AND COLOURED LIGHT SOURCES | 721 |
| P27 | Iacomussi, P. et al. | INFLUENCE OF LED LIGHTING ON COLOUR EVALUATION | 727 |
| P28 | Kozaki, T. et al. | EFFECTS OF DIFFERENT WAVELENGTH COMPOSITION OF MORNING LIGHT ON LIGHT-INDUCED MELATONIN SUPPRESSION AT NIGHTTIME. | 734 |
| P29 | Bartsev, A.A. et al. | METROLOGICAL INSURANCE OF SPECTRAL-RADIOMETRY APPROACH IN VNISI TESTING CENTRE | 738 |
| P30 | Bartsev, A.A. et al. | COMPARISON OF DETECTOR BASED AND SPECTRORADIOMETRIC MEASUREMENT APPROACHES IN PHOTOMETRY AND COLORIMETRY OF SSL LIGHTING | 743 |
| P31 | Velasquez, C. et al. | STRAY LIGHT MEASUREMENT WITH SOLID STATE LIGHT LUMINAIRE IN A C-TYPE GONIOPHOTOMETER WITH ROTATING MIRROR | 753 |
| P32 | Roman Dubnicka, SK | METHOD OF VALIDATION OF NEAR-FIELD GONIOPHOTOMETERS BASED ON IMAGE PHOTOMETERS | n.s. |

TUNING LIGHT TO SEE AND FEEL BETTER: THE HUMAN VISUAL AND NON-VISUAL RESPONSES TO SPECTRAL VARIATIONS IN LIGHT

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Abstract

The advent of tuneable, multi-channel LED light source technology enables vision scientists to probe better the human response to light, yielding greater understanding of how human physiology has adapted to natural environmental illuminations. At the same time, novel lighting technology allows designers to tune lighting to shape human behaviour in different environments. In this talk, I will discuss the effects of spectral tuning of light in terms of both the visual and non-visual systems, and their possible interactions.

Keywords: Colour constancy, LED illumination, non-visual pathway

1 The optimisation of human colour constancy for daylight chromaticities: laboratory experiments

Colour constancy is the perceptual phenomenon by which object colour remains constant despite changes in the illumination spectrum – a yellow banana appears yellow whether illuminated by tungsten light or morning daylight. Colour constancy depends on multiple mechanisms in the human visual system (Hurlbert, 2007, Foster, 2011), and, although a textbook example of a perceptual constancy, it is not universally perfect for all surfaces and all illuminations – a fact captured by colour appearance models.

To examine the dependence of colour constancy on illumination, we have developed an illumination discrimination task which measures colour constancy by determining discrimination thresholds for illumination changes in particular chromatic directions (parametrised by unit distances in a perceptually uniform space (Lu^*v^*)) (Pearce et al., 2014). Using tuneable multi-channel LED light sources to generate changing illuminations in real time, we find that thresholds for discriminating illumination changes are highest – i.e. colour constancy is best - for “blue-ish” daylight illuminations. Conversely, colour constancy is worst for atypical illuminations (Pearce et al., 2014). That is, thresholds (in ΔE_{uv}) for discriminating illumination changes in ‘red’, ‘green’ or ‘yellow’ chromatic directions are significantly lower than for changes in the ‘blue’ direction.

These results suggest that colour constancy is optimised for naturally encountered illuminations, and that stability of object colour may be achieved even under changing illuminations, provided these changes occur for cooler temperatures along the daylight locus.

1.1 Illumination discrimination at non-neutral adaptation points

The “blue bias” in illumination discrimination, and colour constancy, has been shown for scenes with neutral mean chromaticity, when the participant is adapted to a neutral (D67) illumination (Pearce et al., 2014). In further experiments, we have shown that the relative thresholds for the four chromatic directions depend on the scene surface ensemble, and specifically, on the mean scene chromaticity, as demonstrated with simulated scenes on a computer display (Krieger et al., 2015).

We have further investigated the extent to which the “blue bias” also holds for adaptation points biased away from a neutral chromaticity point (Aston et al., 2015), as described in the following sections.