COMMISSION INTERNATIONALE DE L'ECLAIRAGE
INTERNATIONAL COMMISSION ON ILLUMINATION
INTERNATIONALE BELEUCHTUNGSKOMMISSION

ACTIVITY REPORT

DIVISION 1

VISION AND COLOUR

February 2015

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CIE Division 1 held a very successful meeting at the National Institute of Standards and Technology (NIST) Gaithersburg, Maryland, USA on 16, 17 June 2014 as part of a week long series of meetings on 'colour' including a meeting of ASTM E12 Color and Appearance.

The Division met for Technical Committee meetings on 16 June at NIST. The following TCs met:

- TC 1-63 Validity of the range of CIEDE2000
- TC 1-71 Tristimulus integration
- TC 1-73 Real colour gamut
- TC 1-75 A comprehensive model of colour appearance
- TC 1-81 Validity of formulae for predicting small colour differences
- TC 1-82 Calculation of colour matching functions as a function of age and field size
- TC 1-84 Definition of visual field for conspicuity
- TC 1-85 Update CIE Publication 15:2004 Colorimetry
- TC 1-89 Enhancement of images for colour defective observers
- TC 1-90 Colour fidelity index
- TC 1-91 New method for evaluating the colour quality of white-light sources
- TC 1-92 Skin colour database
- TC 1-93 Calculation of self-luminous neutral scale

In addition to the above, TC1-83, TC1-86, TC1-88, TC1-90 and TC1-91 met at the CIE 2014 Lighting Quality & Energy Efficiency conference held in April 2014 in Kuala Lumpur, Malaysia.

The following activities were closed at the NIST meeting:

- TC1-68 Effect of stimulus size on colour appearance
- TC1-69 Colour rendition of white light sources
- TC1-78 Evaluation of visual performance in the real lit environment
- TC1-74 Methods for re-defining CIE D illuminants
- R1-49 Above-threshold Pulsed Lights
- R1-51 Reconciling Maxwell vs Maximum Saturation Colour Matches

In addition the following TCs have been closed by email ballot since the NIST meeting

TC1-42 Colour appearance in peripheral vision

TC1-80 Research methods for psychophysical studies of brightness judgements

The following changes and new Reporters were approved in NIST:

TC1-94 Visually meaningful spectral luminous efficiency functions: change of chairman from Janos Schanda HU to Ferenc Szabó HU

R1-52 Spectral data interpolation: change of Reporter from Hugh Fairman US to Danny Rich US

R1-61 Source whiteness metric: Aurelian David US

R1-62 Typical LED spectra: Sophie Jost FR

There was discussion in NIST about two possible new activities but no progress has been made since the publication of the minutes of the NIST meeting.

The following Division 1 publications have appeared during the last year:

CIE 208:2014: *Effect of stimulus size on colour appearance*

CIE 211:2014: *Colour appearance in peripheral vision*

CIE 212:2014: *Guidance towards best practice in psychophysical procedures used when measuring relative spatial brightness*

A summary of the status of each of the Technical Committees in Division 1 is included in this report together with summaries from the Reporters and Liaisons. The reports from the Vision Section are presented first, followed by those from the Colour Section and then the Liaison reports.

VISION SECTION: TECHNICAL COMMITTEES

TC1-36 (V)	**Fundamental Chromaticity Diagram with Physiologically Significant Axes**
Established:	1991
Terms of Reference:	To establish a chromaticity diagram of which the coordinates correspond to physiologically significant axes.
Chairman:	Françoise Viénot FR
Members:	D MacLeod US, JD Mollon GB, JD Moreland GB, Y Nakano JP, J Pokorny US, LT Sharpe DE, A Stockman GB, A Valberg NO, PL Walraven NL, J Wold NO
Consultants:	H Scheibner DE, P Trezona GB, and H Yaguchi JP

Part 2 of the Technical Report is in the final stages of production.

TC1-42 (V)	**Color Appearance in Peripheral Vision**
Established:	1993
Terms of Reference:	To prepare a technical report on color appearance zones for colored lights in terms of unique hues in peripheral vision.
Chairman:	Miyoshi Ayama JP
Members:	I Abramov US, M Ayama JP, H Chan US, G Derefeldt SE, L Eriksson SE, L MacDonald GB, K Okajima JP, A Yujiri JP

CIE 211:2014: *Colour appearance in peripheral vision* is now published and this TC has been formally closed.

TC1-67 (V)	**The Effects of Dynamic and Stereo Visual Images on Human Health**
Established:	2005
Terms of Reference:	To write a technical report on the physiological and psychophysical effects of dynamic and stereo visual images in terms of photosensitive seizures, visually induced motion sickness and eyestrain.
Chairman:	H Ujike JP
Members:	Jelte Bos NL, Graham F A Harding GB, Peter A Howarth GB, Tohru Kiryu JP, Ken Sagawa JP, Richard H Y So HK, Brian Tansley CA, Arnold Wilkins GB, Makoto Yoshizawa JP

The draft of Technical Report for photo-sensitive seizures developed by the editorial group in this TC was revised in terms of CIE format of Technical Report. Then, the draft was again circulated, and some comments were obtained from the viewpoints of references, detailed expressions, and some technical matters. Based on those comments, the draft was revised as that for TC ballot. The basic information of the draft is as follows:

Title: Undesirable biomedical effects of photosensitive seizures: Effects of flash and pattern, their measurements, and countermeasures

Pages of main text and references: 15
Figures: 5
Tables: 1
References: 42
Table of contents:
Summary
1. Introduction
   1.1. General
   1.2. Broadcast material
   1.3. Video games
   1.4. Movies
   1.5. Purpose
2. Measurement and categories of PSS
   2.1. Diagnosis

2.2. Measurement
2.3. Definition of abnormalities
2.4. Susceptibility
2.5. Types of seizure
3. Prevalence and incidence
4. Patho-Mechanisms
5. Evaluation Methods
6. Visual Stimuli
6.1. General
6.2. Flash
6.3. Pattern
6.4. Electronic displays
7. Countermeasures
7.1. Reduction of stimulus
7.2. Bases of the guidelines
7.3. Guideline provided by the Epilepsy Foundation of America
7.4. Efficacy of guidelines
7.5. Preventative measures available to patients

References

TC1-80 (V)	**Research Methods for Psychophysical Studies of Brightness Judgements**
Established:	2010
Terms of Reference:	To report on research methods (both research design and statistical analysis) for psychophysical studies of spatial brightness judgements. The aim is to bring best practices from psychology into the wider awareness of people in the lighting community who wish to use such tools in their own work, to avoid errors that plague the existing literature.
Chairman:	Steve Fotios
Members:	Alan Chan HK, Ulrich Engelke NL, Peter Hanselaer BE, Kevin Houser US, Ásta Logadóttir DK, Balazs Nagy HU, Keith Niall CN, Osvaldo da Pos IT, David Simmons GB, Lou Tassinary US, Jan Vanrie BE, Minchen (Tommy) Wei US, Martijn Withouck BE

CIE 212:2014: *Guidance towards best practice in psychophysical procedures used when measuring relative spatial brightness* is now published and this TC has been formally closed.

TC1-82 (V)	**The Calculation of Colour Matching Functions as a Function of Age and Field Size**
Established:	2010
Terms of Reference:	1. Following on from CIE Technical Report 170, to recommend a procedure for calculating XYZ-like colour marching functions from cone fundamentals, as a function of age and field size. 2. To deliver a computer programme for the calculations.
Chairman:	Jan-Henrik Wold NO
Members:	C F Andersen NO, M Brill US, M Fairchild US, H Fairman US, I Farup NO, C-S Lee KR, C Li CN, K Richter DE, F Viénot FR, M Withouk BE, Y Yamuchi JP

The cone-fundamental-based V(λ)-function

The calculation of the weighting factors defining the cone-fundamental-based V(λ)-function as a linear combination of the L and M cone fundamentals has been revised (corrected). Whereas the weighting factors (as calculated on a quantum scale) are still taken as independent of field size, an age dependency is now implemented.

Limitations on age parameter

In order to evaluate the reliability of the computed cone fundamentals for the elderly people, it seems necessary to investigate all available databases, with particular regard to the scattering of the data at different ages. The decision on an upper limit for the age parameter should be made with reference to these investigations. The TC will thus make contact with labs (Rochester, Leeds and others) that have determined individual LMS cone fundamentals for different field sizes and ages. Contact will also be made with researchers at the Department of Ophthalmology, Glostrup Hospital, University of

Copenhagen, who have studied age-related changes in transmission properties of the eye lens (in vitro). No action has been taken in 2014. These matters will be further discussed at the next TC meeting (at the 28th Session of the CIE in Manchester).

Programming

COMPUTATIONAL KERNEL

The main structure of the computer program is established. In particular, the major part of the computational kernel is implemented. In addition to the age- and field-size-parameterised calculation of cone-fundamental-based XYZ colour-matching functions (CMFs), the program facilitates age- and field-size-parameterised calculation of MacLeod–Boynton (*l, s*)-diagrams and Maxwellian (equi-energy-normalised) (*l*, *m*)-diagrams. For comparison with the existing standards, plots and tabulations of the CIE 1931 and CIE 1964 colorimetric systems are also implemented.

At the TC meeting at NIST, Gaithersburg (Maryland, US), the TC agreed that for the calculation of cone-fundamental-based XYZ CMFs, the computer program should facilitate the following two options:

1. Calculation of CMF tables with values given at user-defined wavelength intervals, selected (picked) from the (standard) 1-nm tables (390–830 nm).
2. Calculation of CMF tables with values given at user-defined wavelength intervals, renormalised to give equal tristimulus values for Illuminant E (to the precision of at least five decimal places).

   A concept for the calculation of tristimulus values of the maximum-saturated purple stimuli as a function of complimentary wavelengths is developed. The coding of the relevant procedures remains.

STAND-ALONE PYTHON PROGRAM

A preliminary version of the stand-alone Python program was demonstrated at the CIE DIV 1 meeting at NIST.

WEB-APPLICATION

A preliminary version of the web-application was demonstrated at the CIE DIV 1 meeting at NIST.

MATHJAX

For the display of transformation formulae, MathJax is implemented in the stand-alone Python program. The implementation of MathJax for the web-application remains.

MATLAB APPLICATION

The work on the porting of Python code into MATLAB is started, but detailed coding will wait until the Python program is finalised.

EXCEL APPLICATION

As the Python application will facilitate data saving (tables etc.) in a variety of file formats, including Excel-format (xls-files), the TC has agreed not to provide a special Excel application (as first planned).

TC meetings

A TC meeting was held on June 16, during the CIE Division 1 Annual Meeting at NIST, Gaithersburg, Maryland, USA, June 16–17, 2014. The next TC meeting will take place during the 28th Session of the CIE in Manchester, UK, June 28 – July 4, 2015.

TC1-83 (V)	**Visual Aspects of Time-Modulated Lighting Systems**
Established:	2011
Terms of Reference:	1. To investigate and report on current research on the perception of visual artifacts of temporally modulated lighting systems, including flicker, the stroboscopic effect, and the phantom array effect. 2. Design methodology and gather data on the visibility of temporal artifacts. 3. Build a model for the visibility of temporal artifacts and their dependence on environmental, demographical and lighting parameters.

Chairman:	Dragan Sekulovski NL
Members:	Pei-Ting Chou TW, Dennis Couzin DE, Jim Dakin US, Nana Itoh JP, Chan-Su Lee KR, Tsung-Xian Lee TW, Malgorzata Perz NL, Andy Bao-Jen Pong TW, Michael Poplawski US, Lili Wang CN, Lorne Whitehead CA, Arnold Wilkins UK, Yasuki Yamauchi JP

The TC met in Kuala Lumpur in April 2014. At the meeting, a new, more general set of definitions for Temporal Light Artifacts that were discussed, voted on, and accepted by the TC. A set of methodological recommendations for experimental design and analysis of psychophysical data for the development of visibility models was proposed and accepted by the TC. Results from a number of experiments done between the meetings were presented: 1) a large set of temporal output measurements of existing luminaires was used to show the correlation between existing measures for flicker and the stroboscopic effect (NL); 2) A flicker visibility experiment that relates the perceptual severity of flicker to the prediction of four proposed measures of flicker visibility was carried out in NL; the waveforms used were taken from real world examples; 3) An experiment quantifying the effect of the light level on the visibility of the stroboscopic effect was carried away in CN. A first draft of the introduction, literature overview, definitions and methodology sections of the report has been finalized.

TC1-84 (V)	**Definition of Visual Field for Conspicuity**
Established:	2011
Terms of Reference:	To define and classify functional visual fields for universal tasks and develop guidelines for the layout of visual information to increase the visibility of visual signs, displays and markings.
Chairman:	Nana Itoh JP
Members:	Not reported

TC1-88 (V)	**Scene Brightness Estimation**
Established:	2012
Terms of Reference:	1. To investigate current research on brightness estimation methods using a calibrated luminance image of a real indoor scene 2. To compare brightness estimations of real indoor scenes with those predicted 3. To recommend a method to predict the brightness of specified regions of a scene from a luminance image of that scene
Chairman:	Yoshiki Nakamura JP
Members:	Not reported

The first TC meeting was held in Kuala Lumpur on 28th April 2014. An outline of TC activity plan was explained by the chair at the meeting, and members agreed to collect previous relevant researches and to try to carry out relevant subjective experiment. Next TC meeting will be held on Manchester in June this year.

TC1-89 (V)	**Enhancement of Images for Colour Defective Observers**
Established:	2012
Terms of Reference:	To study, evaluate and recommend image enhancing techniques for colour defective observers and to provide test procedures for the evaluation of those techniques.
Chairman:	Po-Chieh Hung JP
Members:	M Ayama JP, B Daniela BR,H Chen TW, L Fernandes BR, Y Ichihara JP, Y Kishimoto

JP, G Kuhn BR, Y Kwak KR, R Lenz SE, R Mochizuki JP, B Nagy HU, M Oliveira BR, S Otsuka JP, T Sakamoto JP, G Sharma US, F Viénot FR, Y Yoshikawa JP

We held three official TC meetings over the Internet using WebEx in February, July and November as well as an informal and physical TC meeting in conjunction with Division 1 meeting at NIST, MD, USA. We welcomed two new members from Brazil and Korea this year.

We mostly discussed the contents of our Technical Report. There are four criteria to visually evaluate enhancement techniques: distinction by Colour Defective Observers (CDOs), color name information, preservation of original colour, and preference. TC members tentatively agree that recommending a single unique enhancement method is not realistic because each technique has pros and cons. For example, as the result of colour enhancement, CDOs should be able to easily distinguish a pair of colours as Colour Normal Observers (CNOs) do. But it often contradicts the preservation of original colour, which is preferred by CNOs, in case the image is shared by both CDOs and CNOs such as a poster or a display posted in public area as opposed to the situation that the enhanced image is personally observed by a CDO.

The key output would be the categorization of enhancement techniques and recommendations depending on use-cases or applications. The current tentative organization of the report is: (1) Introduction, (2) Scope, (3) Definition, (4) Use case and requirement, (5) Enhancement technique (Re-colouring, Edge-enhancement, and Pattern-addition), (6) Test method for enhancement technique (Test image, Evaluation method), (7) Recommendation, and (8) Annex (Assessment of CDO, List of CDO Group, and Colour difference data for uniform colour space).

The progress of the committee is a bit behind the original schedule. Our work plan for 2015 is to create a working draft.

TC1-93 (V)	**Calculation of self-luminous neutral scale**
Established	2013
Terms of Reference:	To recommend a formula or computational method for an achromatic, neutral or gray scale for self-luminous (i.e. non-reflective) surfaces. (This computation complements CIE Lightness, L*, which serves a similar purpose for reflective surfaces.)
Chairman:	Robert Carter US
Members:	Phil Green GB, Elizabeth Krupinski US, Robert Marcus US, Claudio Oleari IT, Kevin Smet BE

History, background, relation to other CIE TCs and organization of the TC were covered in detail in the 2013 activity report. These remain as they were.

A committee meeting was held at 9-10 AM on June 16, 2014, at the CIE Division 1 meeting at National Institute of Standards and Technology, in Gaithersburg MD. The chairman reviewed material mentioned in the previous paragraph, along with a proposed formula for self-luminous neutral scale. Paula Alessi asked about terminology, suggesting that lightness might be a more correct term than contrast brightness (offered by the author of the proposed formula, Paul Whittle, in Vision Research, 1992) to describe self-luminous gray scale of visual targets in the context of a luminous background adjoining and surrounding the targets. The point she raised is reflected in the terms of reference of this TC, which offers alternative terminology to ensure understanding. Craig Revie asked whether spectral composition affects neutral scale; a topic being addressed by the subcommittee on “the meaning of neutral.” Danny Rich commented that multi-JND differences are not meaningful in some other contexts, like detection; he wondered what is different about matching, scaling and discrimination where multi-JND differences are demonstrably meaningful.

Peter Hanselaer suggested measuring self-luminous neutral scale by direct estimation, without reference to JNDs. Also in attendance were, Nana Itoh, Klaus Richter, Hiroyasu Ujike, Hugh Fairman and Ronnier Luo.

At a subsequent Intersociety Color Council (ISCC) symposium, held at the same venue on June 18, the chairman presented a comparison of self-luminous gray scale slopes (i.e., rate of change of gray appearance as a function of changing target luminance for any fixed background luminance) 1) predicted by Whittle's formula and 2) experimentally determined in 1961 by Eric Heinemann over six log units of target luminance. This presentation included a mathematical derivation showing that the slope equals the inverse of Heinemann's experimentally determined increment threshold, at any combination of target and background luminance. The slopes so derived from Heinemann's 1961 data match the magnitudes of slopes calculated from Whittle's formula for 78 such combinations in the Heinemann data set. The two sets of numbers correlate 0.97, with a zero intercept and an approximately 45-degree positive slope; they are arguably identical. This enhances our confidence in the proposed self-luminous neutral scale formula.

During the year there were exchanges among TC participants (particularly the chairman, Danny Rich, Robert Marcus and Kevin Smet) germane to the goal of providing standardization language to codify the "meaning of neutral in self-luminous neutral scale." Related references were collected and studied. Alternate perspectives on the meaning of neutral were discussed. Although the TC plan defers completion of this task to the end of the TC, Danny Rich indicates that his goal is for completion much sooner. At the same ISCC symposium on June 18, Kevin Smet reviewed his experimental data related to this question, concluding that aggregate trends versus any individual observer's data may tell different stories about causes of neutral, or colorless, appearance.

At the close of the co-located June CIE, ISCC and ASTM meetings, Osvaldo daPos asked a helpful question related to TC 1-93: "If you have a displayed self-luminous gray-scale image, and you want to print it, how would you use the proposed self-luminous neutral scale to accomplish tone mapping from the self-luminous display to the printed image?" The chairman has written a working paper on this topic, while interacting with Maureen Stone of Tableau Software (who asks excellent Socratic questions, and suggested a sample image for this tone mapping). An early draft of the working paper has been commented on by a member and by an adviser of TC 1-93. While a successful tone mapping method has been achieved, which differs from the commonly used media-relative tone mapping, examining the implications of this novel tone mapping method remains a work in progress. At least the exercise has demonstrated that Whittle's formula and L* are compatible and that tone mapping between them is possible.

Also at the meeting, several people (e.g., Miyoshi Ayama, Klaus Richter, Ronnier Luo and others) volunteered to provide self-luminous neutral scale data, with variation of background luminance, spatial scale, and target luminance and chrominance, for subsequent testing of the self-luminous neutral scale formula in the context of color difference (where L* would be for reflective media). In follow-up, the chairman asked these data-volunteers to give their data directly to Manuel Melgosa, Rafael Huertas and Claudio Oleari for this purpose.

An example of TC 1-93 progress in 2014 is publication of:
Carter R. C., Brill M. H. Calculation of Self-luminous Neutral Scale: How Many Neutral Steps Can You See On That Display? J. Soc. for Info. Display 2014, 22.

The publication is available online, but not yet printed. This manuscript describes the formula currently proposed in response to the TC terms of reference. It shows how the low-contrast (i.e., crispening) gain of the formula increases with background luminance. It demonstrates that the

formula is consistent with the DICOM Grayscale Standard Display Function, used in medical imaging to predict minimum visible changes of luminance, at any level of background luminance. It ends with a tabular answer to the question of the title, calculating the formula under a variety of conditions of spatial scale, background luminance and display maximum and minimum luminances. The manuscript was submitted to Journal of the Society for Information Display because: 1) information display is a common application of self-luminous neutral scale, 2) Society for Information Display is primarily a practitioner group, rather than an academic group, so attention might be called to CIE TC 1-93 among people who would be most likely to be affected by any resulting standards documents, 3)members of Society for Information Display have pre-existing methods for calculating achromatic, neutral or gray scale for self-luminous surfaces, so a spirited review (which lasted nine months) and reader response might be assured, and 4) a previous publication (about effect of angular subtense on color perception) by the chairman in that journal had generated interest and response at professional gatherings, so TC 1-93 might benefit from similar interest and response in the future.

Another area of TC 1-93 activity during 2014 has been to derive (from first principles) the loss of contrast in an external image as it passes through the intraocular media on its way to becoming the retinal image. The parameter k in Whittle's formula is the proportion of contrast lost to intraocular scattering, for any particular angular subtense. Whittle used empirical values of k, from the 1966 and 1967 publications of Campbell and Gubisch. For instance, k = 0.25 and 0.49 respectively for a 4 cycle-per-degree and an 8 cpd grating. Whittle used k=0.055 for 2.1-degree subtense disk targets, in his 1992 Vision Research publication of the formula. Obviously, self-luminous neutral scale is a subjective phenomenon resulting from residual contrasts in the retinal image rather than from unattenuated contrasts in the objective external image. Furthermore, it would be nice to be able to calculate k for any visual subtense, aspect ratio and shape of contrast. To this end, the chairman has been working with Geunyoung Yoon at University of Rochester, Center for Visual Science, Advanced Physiological Optics Laboratory. Professor Yoon has derived an intraocular point spread function (PSF), taking account of pupil diameter, Rayleigh-Debye (aka random phase) scattering, chromatic aberration, and spherical and cylindrical aberrations. When this PSF is convolved with the external image contrast(s) of magnitude A, the result is the predicted retinal image contrast(s) of magnitude B. In this conceit, k = 1-B/A. During testing this computation of k to date, it has been demonstrated that values derived by Campbell and Gubisch (and published by Whittle as k in his formula) for 4 and 8 cpd are replicated by the computation. Testing of the computation continues, to validate the 2.1-degree disk result, k = 0.055. Successful completion of the project would be useful for calculation of self-luminous neutral scale and other predictions about vision. For example, Carter and Silverstein (JOSA A, 2012) showed that k is an important determinant of the discriminability of color differences, and of color appearance. Gubisch observed in his 1967 publication that limits of visual spatial resolution due to intraocular scattering are very similar to limits set by the neural infrastructure of vision. It is as if the optics of the eye and the receptor structure of the retina had co-evolved, so that there would be no advantage in one being more capable than the other with respect to modulation transfer at various spatial scales. Having k in Whittle's formula encapsulates the effects of spatial scale on retinal contrast magnitude, and hence on perceived self-luminous neutral scale.

TC 1-93 has reviewed some history associated with the TC terms of reference. Specifically, Silverstein and Merrifield in their 1985 classic book on Color Systems for Airborne Applications, pages 29-30, note that Carter and Carter (CR&A, 1983) recommend Yn in L* be set to the maximum possible luminance of the self-luminous image segments whose color differences are to be calculated. They go on to write: "*While this solution is not entirely satisfactory, it does preserve ΔE* scale invariance with respect to choice of luminance units and provides an acceptable interim recommendation. The choice of appropriate neutral reference values for color difference formulations to be used with self-luminous color displays will be a priority topic for a newly formed CIE committee on revised*

standards for self-luminous displays." This information about the CIE committee is attributed to Justin J. Rennilson in personal communication with Silverstein and Merrifield in 1984. The chairman of TC 1-93 contacted Dr. Rennilson, who indicated that these "priority" topics identified by Silverstein and Merrifield were indeed not resolved by TC 1-10. Terms of Reference of TC 1-10 were: To study colorimetric measurements, and their correlations with colour appearance, for self-luminous displays. Mike Pointer has provided copies of the TC 1-10 reports, which corroborate what Dr. Rennilson recalled. Two objectives apparent since the early days of self-luminous colorimetry remain to be attained: 1) choice of appropriate neutral reference values for color difference formulations, and 2) improvement upon the "not-entirely satisfactory" nature of using maximum image or device luminance as the normalizing factor in L*. Both of these issues are within the purview of TC 1-93. The first is being addressed by a subcommittee (Marcus, Rich and Smet) considering "the meaning of neutral in self-luminous neutral scale." The second is addressed by the proposed self-luminous neutral scale formula, which avoids the "not entirely satisfactory" use of maximum luminance of the medium as a normalizing factor.

The cited publication is Silverstein, L.D., & Merrifield, R.M. (1985, July). The development and evaluation of color systems for airborne applications (Report No. DOT/FAA/PM-85-19). Washington, D.C.: U.S. Department of Transportation. This book is a compendium of reference data and guidelines compiled based upon Boeing experience with development of the glass cockpit. It remains influential among display system designers and human factors engineers. The US Department of Defense Technical Information Center vends copies under AD-A168563, with the same title, authorship reversed and a publication date of 1986.

2015 Prospects for TC 1-93

1. Items mentioned above:
   a. Progress on standardization of the meaning of "neutral" in self-luminous neutral scale. Primary responsibility: Danny Rich, Robert Marcus and Kevin Smet.
   b. Completion of computation of k from first principles. Primary responsibility: Rob Carter and Geunyoung Yoon
   c. Progress on tone mapping using Whittle's formula. Primary responsibility: Rob Carter
2. Newly-started items
   a. Testing of Whittle's formula in the context of color difference calculations, e.g., CIEDE2000 and the Granada-Parma color difference formula, is planned in 2015. Claudio Oleari has expressed interest in comparing other alternatives to Whittle's formula such as Semmelroth's power functions and media-relative L*. Depending upon availability of data (remember those volunteers from the CIE Division 1 meeting last June?), these tests would include effects of background luminance, spatial scale, range of target luminance, and target chrominance. Testing over a wide range of color difference is desirable (see Carter and Huertas, CR&A, 2010 for example). A recent BARCO example of testing self-luminous neutral scale (the DICOM Grayscale Standard Display Function) in the context of medical color difference (i.e., CIEDE2000) was distributed by the chairman to interested participants in TC 1-93. Potential participants: Oleari, Melgosa and Huertas.
   b. Testing the assumption of additivity of Just Noticeable Difference of self-luminous gray or neutral scale is possible in 2015. A possible experiment was described in an Appendix to the Reportership Report leading to formation of TC 1-93. But a better experiment might be devised instead. Kevin Smet indicated the prospect of a student to do this work during late 2014 or 2015.
   c. Other participants in TC 1-93 have expressed interest (perhaps by motivating their students' interest) in accomplishing various tests of the limitations of the proposed self-luminous neutral scale formula.

d. Klaus Richter has expressed interest in providing bipartite field data, having background of varying luminance, for testing the use of Whittle's formula. Some preliminary testing with small samples of data has suggested successful modeling of these bipartite data with Whittle's formula. The data are in media-relative and absolute-luminance notations, with repetitions by the same observers and by different observers. Mere access to the website is not sufficient to ensure correct interpretation of the data. So progress will happen on this item when Dr. Richter can provide the chairman with tabular data 1) in absolute luminance notation, 2) clearly indicating which observations are repeats by the same observer and which are for new observers, 3) specifying the background absolute luminance and the two bipartite field absolute luminances, as well as the luminance of the far surround highlight, not adjoining the bipartite field. Dr. Richter will have the best idea of which data are most relevant to his interest in testing the Whittle formula with bipartite field data. The anticipated approach to analysis is explained in Kingdom and Whittle, Vision Research, 1996. Specifically, the discrimination is between two contrasts: left bipartite and the surround (Δ1) versus right bipartite and the surround (Δ2). Min1 is the minimum luminance in Δ1, and Min2 is the minimum luminance in Δ2. W1 = Δ1/min1, W2=Δ2/min2. Kingdom and Whittle showed that at threshold for detection of a difference between contrasts, ΔW=cWn, where n is an exponent close to 1 in Whittle's 1992 and 1996 experiments. Primary responsibility: Richter for providing tabulated data as indicated above, Carter for analyzing the data.
e. During June 28 through July 4, TC 1-93 will have a meeting at the CIE meeting in Manchester England. The agenda for this TC meeting will be to review progress on the items listed in this activity report, and any other items germane to TC 1-93 that are of interest to the attendees

TC1-94 (V)	**Visually meaningful spectral luminous efficiency functions**
Established	2013
Terms of Reference:	To propose new 2 degree and 10 degree photometric observers based on the work described in CIE Publications 086-1990 and 165:2005, as well as that of CIE TC1-36 *Fundamental chromaticity diagram*, and study their use in practical photometry.
Chairman:	Ferenc Szabó HU
Members:	To be provided

As the work inside TC1-94 has not been started in 2014, no meaningful activity report can be submitted. During the autumn 2014, I was authenticated as the new chair of this TC.

I would like to hold a statutory meeting of TC1-94 (Visually meaningful spectral luminous efficiency functions) in Manchester. I hope the real work can be started during 2015.

JTC1	**Standard on Mesopic Photometry and Guidelines for Defining Photometric Values in the Mesopic Region**
Established:	2011
Terms of Reference:	1. To investigate adaptation and viewing conditions in outdoor lighting. 2. To define lighting applications where mesopic photometry should be used. 3. To provide methods and guidelines for calculating photometric values in the mesopic region to prepare a standard on a system of mesopic photometry
Chairman:	Stuart Mucklejohn GB
Members:	

No report.

VISION SECTION: REPORTERS

There are recurrently no Reporters in the Vision Section of Division 1.

COLOUR SECTION: TECHNICAL COMMITTEES

TC1-55 (C)	**Uniform Colour Space for Industrial Colour Difference Evaluation**
Established:	1999
Terms of Reference:	To devise a new uniform color space for industrial color-difference evaluation using existing experimental data.
Chairman:	Manuel Melgosa ES
Members:	D Alman US, R Berns US, E Carter US, G Cui GB, M D Fairchild US, R Kuehni US, M R Luo GB, J Nobbs GB, C Oleari IT, M R Pointer GB, D Rich US, K Richter DE, B Rigg (GB), A R Robertson CA, J Romero ES, G Rösler DE, M Vik CZ, K Witt DE, J H Xin CN, H Yaguchi JP
Advisor:	R Huertas ES

Work is on-going to produce a Technical Report.

TC1-61 (C)	**Categorical Colour Identification**
Established:	2001
Terms of Reference:	To prepare a report describing a color categorization map for the photopic and mesopic illumination levels.
Chairman:	Taiichiro Ishida JP
Members:	K Okajima JP, N Johnson US, K Okajima JP, M Pointer UK, L Ronchi IT, K Sagawa JP, J Schanda HU, H Shinoda JP, O Da Pos IT, MR Luo UK, H Yaguchi JP, F Viénot FR(observer)

The 3rd draft was written and circulated to the members in June 2014. The chair is preparing the final draft in the CIE format and will proceed to the CIE publication process.

TC1-63 (C)	**Validity of the Range of CIEDE2000**
Established:	2001
Terms of Reference:	Terms of To investigate the application of the CIEDE2000 equation at threshold, and to CIELAB colour differences greater than 5 units.
Chairman:	Klaus Richter DE
Members:	P Alessi US, KR Gegenfurtner DE, MR Luo GB, M Melgosa ES, Y Nakano JP, J Nobbs GB, C Oleari IT, D Rich US, J Schanda HU, T Seim NI, MVik CZ, H Yaguchi JP

The colour difference formula CIEDE2000 is mainly based on adjacent colour pairs with colour differences between 1 and 5 CIELAB. For further tests of CIEDE2000, appropriate data near threshold (about ΔE*ab=0.2 in CIELAB) and large colour differences (ΔE*ab=10 to 30 in CIELAB) are essential.

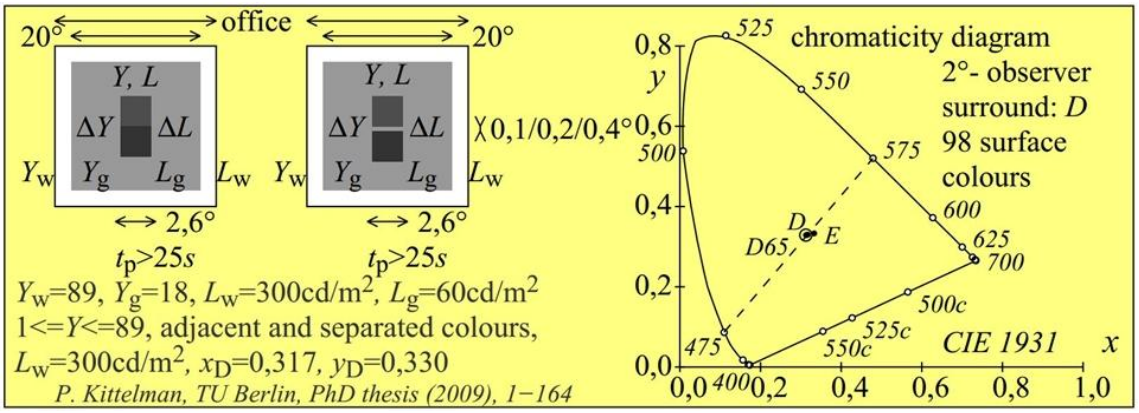


Fig. 1 (TE361-3N): Viewing situation of Kittelmann (2009)
for just noticeable colour differences (at threshold).

Fig. 1 shows as example the typical viewing situation of threshold experiments used by Kittelmann to evaluate surface colour differences. The CIE tristimulus values Y of greys are changed for a chromaticity near D65. The luminance of the grey surround is L=60 cd/m^2. This value is reached for an illumination of 1000 lux which is recommended for colour difference evaluations in offices. Kittelmann has changed 98 surface colours in different directions of the colour space. 31 Observers determined the visual difference threshold ΔY.

CIE TC1-63 uses the following CIE terms defined in the CIE eILV.

CIE terms for ΔL and L/ΔL, ΔY and Y/ΔY:
The CIE defines the “luminance difference threshold ΔL” for a visual just noticeable difference. ΔL is defined as “smallest perceptible difference in luminance of 2 adjacent fields” (eILV 17-715). The value depends on the viewing conditions including the viewing time and state of adaptation. The “contrast sensitivity L/ΔL” uses in addition the luminance L which is the average luminance of the 2 adjacent fields (eILV 17-255).

The tristimulus value Y is proportional to L and is here used instead of L in a limited luminance range (about 1,5 log units). If we can describe the threshold properties of the visual system in a large luminance range 0,1 < L < 10000 (5 log units) with the surround luminance Lu=50 cd/m^2 then we can expect a good formula in the smaller surface colour range 2,5 < Y < 90. Some experimental data for a wide range are given within the last annual activity report of CIE TC1-63 and CIE TC1-81.

The "tristimulus value difference threshold ΔY" corresponds to CIELAB colour differences in the range 0,06 < ΔE*ab < 0,48 (factor about 1 to 3 for achromatic and 1 to 8 including chromatic colours). The contrast sensitivity Y/ΔY is used in Fig. 2 and 3.

Therefore CIELAB and CIEDE2000 give different values ΔY as function of Y. The ratio (Y/ΔY) is the CIE Y contrast sensitivity. In many lighting applications the CIE luminance contrast sensitivity (L/ΔL) is used which has the same value.

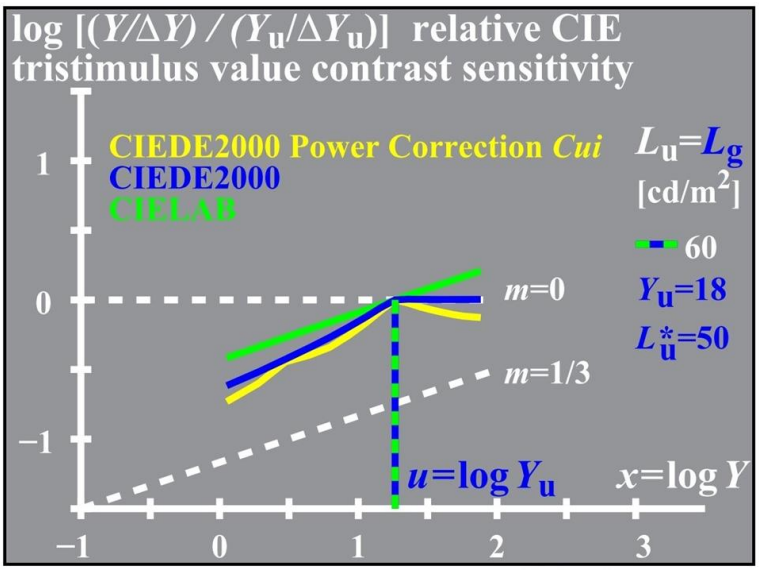


Fig. 2 (VE290-1N): Relative contrast sensitivity (Y/ΔY) as function of Y for three different formulas

Fig. 2 shows the relative CIE contrast sensitivity (Y/ΔY) as function of Y.

The predictions of three formulas are shown: CIELAB, CIEDE2000, and a similar formula with a "Power Correction of Cui (2013)". The tristimulus value of the grey surround is Yu=18 which corresponds to the CIELAB lightness L*=50. The colour difference formula CIEDE2000 corrects the CIELAB lightness L* by the difference L*-L*u = L*-50. This changes the CIELAB lightness discrimination by two different slopes below and above L*=50. The yellow curve is for the formula CIEDE2000-Cui with the Power Correction of Cui (2013). For about 5000 sample pairs which are used within TC1-63 the performance is about 20% better for CIEDE2000_Cui compared to CIEDE2000. Fig. 1 shows that the slope change compared to CIELAB is larger in both areas but seem to fail for Y>Yu (compare Fig. 3).

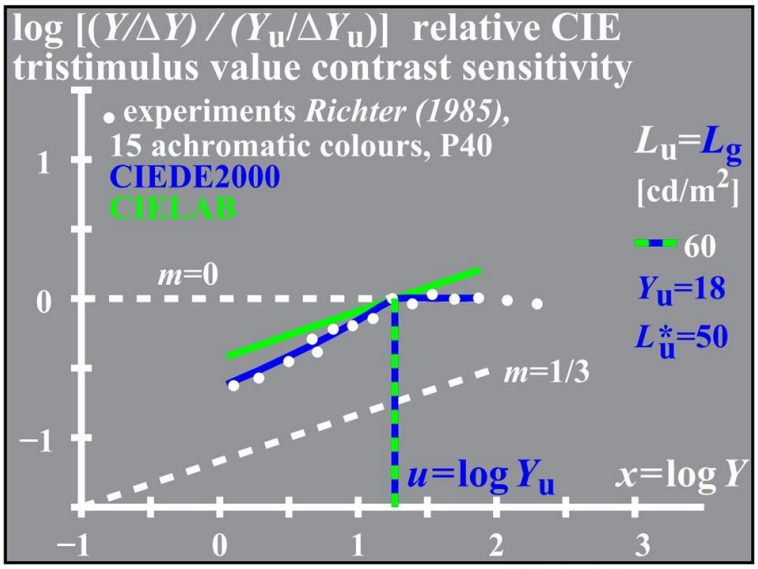


Fig. 3 (VE290-2N): CIE contrast sensitivity (Y/ΔY) as function of Y for two formulas and one experimental result.

Fig. 3 shows the CIE contrast sensitivity (Y/ΔY) as function of Y. The predictions of the two formulas

CIELAB and CIEDE2000 are compared with an example experimental result of Richter (1985). A wide Y range above Y=90 for white is used in this experiment and shows a constant CIE contrast sensitivity (Y/ΔY) above the grey surround. This constant value is expected by the Weber-Fechner law and is very different compared to the Stevens law used in CIELAB. The experimental result matches the predictions of CIEDE2000.

The over all performance of the experimental results of Richter (1985) is very similar to CIEDE2000. The experimental conditions are similar to the viewing situation given in Fig. 1 with adjacent colours, a grey background and a white border. Therefore the colour differences at least for grey colours are well described by the formula CIEDE2000 both at threshold and for all larger colour differences.

Only one example result for achromatic colours is given here. For all chromatic colours which change in the tristimulus value Y a model based on physiological responses shows a slope changes not at the tritimulus value Yu but at lower tritimulus values Yeff. More information is given in the activity report of TC1-81 "Validity of Formulae for Predicting Small Colour Differences".

Summary
For adjacent samples with Y values larger than the Yu value of the grey surround the Weber-Fechner law is valid and this law is included in CIEDE2000, see Fig. 2 and 3. The psycho-physical basis of this Weber-Fechner law is assumed to be a local adaptation to the two adjacent grey colour stimuli.

For adjacent samples with Y values smaller than the Yu value of the grey surround there are differences between CIEDE2000 and CIELAB, see Fig. 2 and 3. CIEDE2000 has been developed for colour differences ΔE*ab between 1 and 5. In addition and according to Fig. 3 CIEDE2000 describes very well the grey differences at threshold (about ΔE*ab=0,2) and above for a wide Y range.

For separate samples and for a wide Y range the Stevens law is valid and used by CIELAB with the power exponent 1/3, see Fig. 2 and 3.

For a physiological model which tries to describe these results and others for chromatic colours see the report of CIE TC1-81.

Remark: Any final conclusion depends on the members of TC1-63, and on the final data and formulas to be considered.

Workplan (Timeframe):

1. Second draft of a Technical Report (Chairman and Members): February 2015
2. Third draft which includes Comments of Committee Members: June 2015
3. Draft for voting by Committee Members of TC1-63: End of 2015
4. Draft for voting by CIE Division 1: September 2015
5. Publication: 2016

TC1-64 (C)	**Terminology for Vision, Colour and Appearance**
Established:	2003
Terms of Reference:	To monitor the terminology requirements of Division 1 including the revision of the present ILV terms and the addition of new terms.
Chairman:	Sharon McFadden CA
Members:	E Carter US, O Da Pos IT, M Pointer GB, J Schanda, HU, and M Melgosa SP

During 2014 a third draft of a Technical Note (TN) was reviewed by members. After recommendations from that review had been incorporated, the TN was sent to Division 2 for their

comments. They provided several excellent suggestions, many of which were incorporated into a fourth draft. This draft has now being reviewed by members and a ballot will be conducted shortly.

The TC continues to monitor Division reports for new terminology. It will also consider suggestions for new terms or revised definitions of Division 1 terms currently in the ILV. During the past year, it considered a definition for Illuminant E at the request of TC1-85.

TC1-70 (C)	**Metameric Samples for Indoor Daylight Evaluation**
Established:	2007
Terms of Reference:	To investigate the derivation of a set of metameric samples to enable the evaluation of indoor daylight simulators
Chairman:	B Kránicz HU
Members:	Péter Bodrogi DE, Robert Hirschler HU, Danny Rich US, Patrick Rombauts BE, Alexander Rosemann CA, János Schanda HU

No report.

TC1-71 (C)	**Tristimulus Integration**
Established:	2007
Terms of Reference:	To investigate methods for computing weighting tables for the calculation of tristimulus values from abridged data.
Chairman:	Changjun Li CN
Members:	J Campos Acosta ES, M Brill US, H Fairman US, B Jordan CA, Y Ohno US, C Oleari IT, MR Pointer UK, AR Robertson CA, J Schanda HU, R Seve FR, G Wang CN

Progress

1. The least-squares method (Li-Wang-Luo) has been revisited and shown to be connected with the optimum method (Li-Luo-Rigg). Comparisons were made between the least-squares method, the optimum method, the ASTM Table 5 method, the ASTM Table 6 method, CIE-R, the Oleari zero-order method and the second-order methods for 10 nm and 20 nm intervals. It was found that the least-squares method performed the best for 10 nm interval data and the optimum method was the best for 20 nm interval data, with the least-squares method as second best.
2. Further comparisons were also made using the above methods and with wavelength interval data sets at 2, 3, 4, 5, 6, 7 and 10 nm respectively. It was found that the least-squares method was the best in each case for six illuminants: D65, D50, A, F2, F7, and F11.

The above results have been included in a paper entitled “Testing the Accuracy of Methods for the Computation of CIE Tristimulus Values Using Weighting Tables” by the Chair and his co-authors, which has been submitted to Color Research and Application and is now in revision stage.

Time Scale

The above results will be circulated to members of the TC and hopefully agreement will be reached and a draft TR report made ready before the CIE meeting in Manchester (UK) in June 2015. It is also planned to have a TC meeting in Manchester and hopefully the final TR report completed by the end of this year when the TC can be closed.

TC1-73 (C)	**Real Colour Gamuts**
Established:	2007
Terms of	To recommend a gamut representative of real (non-fluorescent) surface colours

Reference:	and defined by associated spectral reflectance data.
Chairman:	Changjun Li CN
Members:	P Alessi US, Maeng-Sub Cho, MR Luo GB, F Martinez-Verdu ES, Jan Morovic, M R Pointer GB, Jin-Seo Kim KR, K Richter DE, Krisztián Samu HU, Pei-Li Sun TW
Observers:	Ellen C Carter US, Siu-Kei Tin

Progress

Li CJ, Luo MR, Pointer MR, Phil Green have done some research on generating colour gamuts. A paper entitled "Spectral Based Gamut for Object Colours" was submitted to Color Research and Application and it is in the revision stage. The paper presents a new gamut in terms of L*, C* and h under a fixed illuminant/observer and in terms of reflectance functions.

An MSc student at the University of Science and Technology Liaoning (China) is evaluating the new gamut developed in the above paper. His task is to find out if new this gamut is reasonable and, if not, develop a new methodology to improve it and finally produce a new gamut. Results will be reported to TC members in due course.

Gamut development has proved much more complicated than we first thought. Hopefully some earlier results from the MSc project can be reported during the CIE meeting in Manchester in June 2015.

TC1-75 (C)	**A Comprehensive Model of Colour Appearance**
Established:	2009
Terms of Reference:	To derive colour appearance models that include prediction of the appearance of coloured stimuli viewed in typical laboratory conditions that 1) appear as unrelated colours, 2) are viewed under illumination down to scotopic levels and 3) include consideration of varying size of stimulus.
Chairman:	Ronnier Luo UK
Members:	R. W. G. Hunt GB, M. Fairchild US, N. Morony US, C. Y. Fu CN, C. Li CN, K. D. Xiao CN, Y. S. Kwak SK, S. Y. Choi SK, H. Yaguchi JP

The formulation of a comprehensive model of appearance is nearing completion.

TC1-76 (C)	**Unique Hue Data**
Established:	2009
Terms of Reference:	To study and report on unique hue data, including an analysis of the scatter of those data: this to include practical viewing conditions.
Chairman:	Sophie Wuerger GB
Members:	Miyoshi Ayama JP, Rolf Kuehni US, Katsurnori Okajima JP, Galina Paramei GB, Renzo Shamey US, Vicki Volbrecht US, Michael Webster US, Kaida Xiao GB

No report.

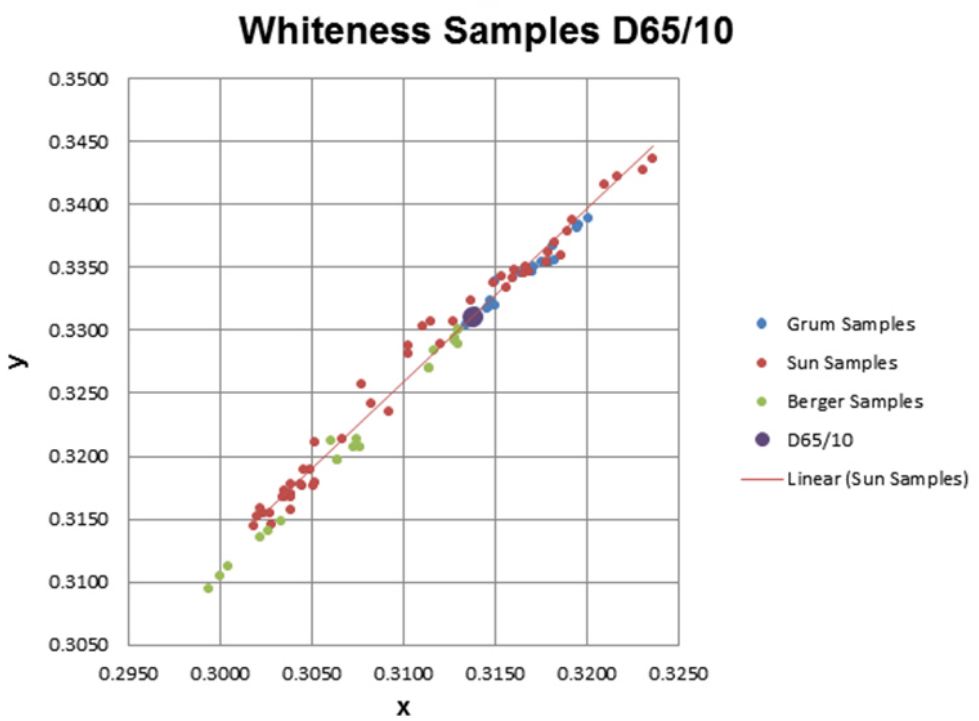
TC1-77 (C)	**Improvement of the CIE Whiteness and Tint Equations**
Established:	2009
Terms of Reference:	To recommend improvements or modifications to the existing CIE Equations for Whiteness and Tint to extend their scope of application to a wider range of instrument conditions and white materials; e.g. various tints and levels of fluorescence.

Chairman:	Robert Hirschler HU
Members:	Alexandre Azevedo BR, Miyoshi Ayama JP, Michael Brill US, Ellen Carter US, David Chen CN, Roland Connelly US, Ludovic Coppel, DE, Dan Fleming US, Phil Green GB, Peter Hubner DE, Kenji Imura JP, Byron Jordan CA, Ichiro Katayama, JP, Ronnier Luo GB, Danielle Oliveira BR, M Todd Popson US, Claudio Puebla DE, Danny Rich US, Pat Robertson US, Wolfgang Schlenker DE, Robert Sève FR, Tarja Shakespeare FI, Renzo Shamey US, C Silva BR, Art Springsteen US, Klaus Wobser DE, David Wyble US, Zhiling Xu CN, Joanne Zwinkels CA
Advisors:	Seyed Hossein Amirshahi IR, Mark Cipollone US, Aurelien David US, Richard Harold US, Razieh Jafari IR

There was very little activity in 2014. Two interesting papers on whiteness perception under arbitrary light sources:
Houser et al. http://dx.doi.org/10.1080/15502724.2014.902750
David et al. http://www.soraa.com/public/docs/Whiteness-for-sources-of-arbitrary-CCT-David-Opt-Expr-21-2013.pdf

Both were circulated among TC members, but raised only moderate interest. Three papers by TC members are being submitted for the CIE 2015 session. One of these papers reports on important research work conducted by Danny Rich, a brief description follows – thanks Danny.

Sun Chemical has completed a study of 30 white papers, 15 with some level of OBA and 15 without any OBA. The papers were ranked for whiteness following a similar method used by Bonnie Swenholt of Kodak (B Swenholt, F. Grum, R. Witzel, Color Research & Appl., v3, p141, 1978). The specimens were measured with a KonicaMinolta FD-7 for illuminant conditions D65/10 and for D50/2 and the specimens were ranked in a GTI lighting cabinet equipped with the latest ISO 3664 compliant D50 simulators. The chart below shows the measurement data for the Sun papers compared to the plastics and textiles reported by Grum (F. Grum, R. F. Witzel, and P. Stensby, J. Opt. Soc. Am. v64, p210, 1974).and by Berger (A. Berger, Die Farbe v22, p213, 1973). Data points laying above and to the right of the D65 point are non-fluorescent while points laying below and to the left of D65 exhibit increasing amounts of fluorescence. While the Sun Chemical dataset is larger and encompasses both the Grum and Berger data which were used by Ganz in the validation of the whiteness equations that were eventually adopted by the CIE, The Sun measurements agree better with Berger's dataset than with Grum's. Comparison of the visual scaling of whiteness under D50 to predictions of the CIE whiteness equation, adjusted for the change in chromaticity of the source as described in ASTM E313, resulted in rather poor correlations. Numerical modelling of the parameters of the whiteness equation is underway and a final report will be given at the CIE quadrennial meeting in Manchester.



TC1-81 (C)	**Validity of Formulae for Predicting Small Colour Differences**
Established:	2010
Terms of Reference:	1. To evaluate available formulae for small colour differences (<~2.0 CIELAB). 2. To define a visual threshold colour difference.
Chairman:	Klaus Richter DE
Members:	S Bracko SI, MR Luo GB, M Melgosa ES, T Seim NO

This committee was very busy and has discussed results at monthly CIE Webex meetings since November 2014. About 80 documents are now at the server of CIE COLLTOOL. In addition many experimental results for small colour differences are shown at the two URL's
http://130.149.60.45/~farbmetrik/UE.HTM
http://130.149.60.45/~farbmetrik/VE.HTM

TC1-81 was established because both CIELAB and CIEDE2000 seem to fail to describe colour differences near threshold.

According to the separate report of CIE TC1-63 which looks at a wide ΔE*ab range the performance of the colour difference formula CIEDE2000 is better compared to CIELAB. CIEDE2000 is appropriate for all achromatic colour pairs in a wide Y application range. The bipartite viewing field and the standard grey surround with Yu=18 (CIELAB L*u=50) is used in experiments.

However, for chromatic colour series of constant chromaticity which change in Y still CIEDE2000 seem to fail according to the following model in this report, and based on physiological responses.

For achromatic colours the CIELAB standard defines the CIE lightness L* in the application range (1 < Y < 100) by the formula $L^* = 116\,(Y/100)^{(1/3)} - 16$

For the grey discrimination we get $dL^*/dY = (1/3)\,(Y/100)^{(-2/3)}$

and for dL*=1 we can write $dY = 3\,(Y/100)^{(2/3)}$

or $\log(dY) = \log(3) + (2/3)\log(Y/100)$

Therefore in a log-log plot the slope is 2/3. For the ratio log (Y/dY) the slope is (1/3), see Fig. 2 and 3 of the TC1-63 report.

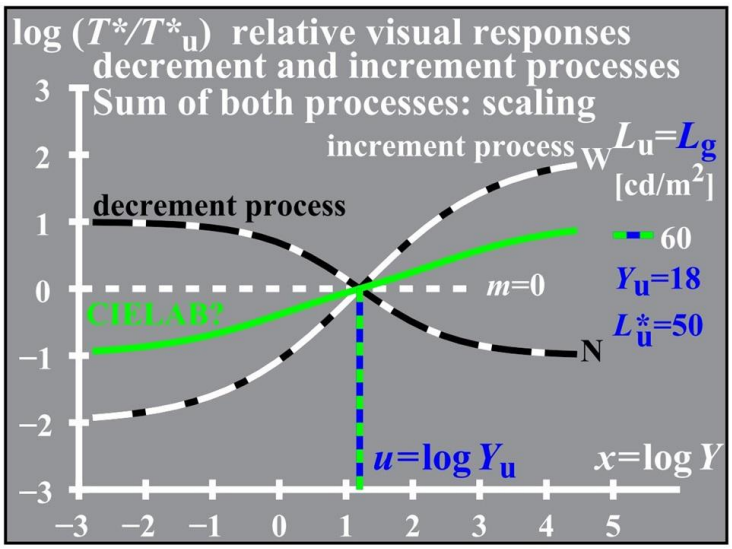


Fig. 1 (VE290-3N): Relation between different visual response curves

Fig. 1 shows the model relation between different visual response curves. Two response curves in black and white describe a decrement and an increment visual process. The slopes at the tristimulus value Yu of the surround are -2/3 and 1. If both are added the slope (1/3) is created which is the slope of CIELAB in the log-log plot.

As a result the slope (1/3) of the response of the green line is identical to the slope of CIELAB L*. The slope 1 of the increment process is the expected slope defined by the Weber-Fechner law. CIEDE2000 is in agreement with this law for all grey colours with the tristimulus values Y larger than Yu=18 (or L*u=50). The slope -2/3 of the decrement process is the negative slope used in CIEDE2000 for all grey colours with tristimulus values Y smaller than Yu=18.

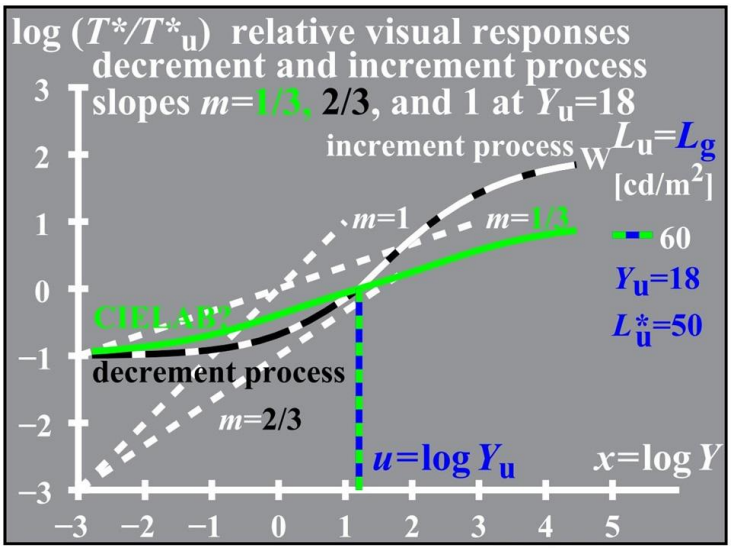


Fig. 2 (VE290-4N): Slopes of the different visual responses

Fig. 2 shows the slopes of the three different responses by numbers in the different Y ranges. For Y near Yu the slope is 1 for the increment process, the slope is (2/3) for the decrement process, and the slope is (1/3) for the sum of the two processes. The slope (1/3) of the sum is identical to the slope (1/3) of CIELAB L* which may be called a response curve or a line element for achromatic colours.

The response curves of both the decrement and the increment processes have both larger slopes (2/3) and 1 compared to the slope (1/3) of CIELAB L*. This indicates a higher discrimination of both threshold processes T*. This is known as "crispening effect". Therefore at least for small colour differences near the threshold (ΔE*ab=0,2) either the decrement or the increment process determines the visual just noticeable difference. At present the transition between small and large colour differences is under study using the many experimental data and least square technology. According to Kittelmann (2009) a linear visual relation is valid between the threshold colour difference (ΔE*ab=0,2) and the 10 times larger difference (ΔE*ab=2) to be studied in TC1-81.

Kittelmann (2009) and Avramopolous (1985) made experiments with colour series of constant chromaticity which change in Y. Then the cut point of the three response curves shifts to Yeff values lower compared to the tristimulus value Yu of the surround. This can be described by the formula

$$\log(Yeff) = \log(Yu) - pco\ [\log(Yu)-\log(Yo)]$$

The value pco is the relative CIE colorimetric purity compared to the Ostwald (o) colours and has the value 1 for these colours. With a=x/y and b=-0.4(z/y) (chromaticities in luminance units) it is valid

$$pco = [(a-an)^2 + (b-bn)^2]^{(1/2)} / [(ao-an)^2 + (bo-bn)**2]^{(1/2)}$$

In this formula (xn, yn) or (an, bn) are the chromaticities of the surround, for example D65. All Ostwald colours have the chromaticity (xo, yo) or (ao, bo) and a tristimulus value Yo, compare CIE R1-57 "Border between blackish and luminous colours".

Therefore the shift from Yu to Yeff of the three response curves in Fig. 1 towards lower values Yeff is known for any colour series of any chromaticity.

CIE R1-57 includes the CIE values (xo, yo, Yo) of the Ostwald colours for 16 hue angles. Intermediate values can be interpolated from this table.

The URL http://130.149.60.45/~farbmetrik/VE40/VE400-7T.TXT includes a table of the data (xo, yo, Yo) of the Ostwald colours for 360 hue angles, and for the CIE 2 degree observer and the CIE standard illuminant D65. In addition tables for the CIE standard illuminant D50 and the CIE 10 degree observer are at similar URLs. In applications for any colour with the CIE data (x, y, Y) the 360 hue angles can be used as an index for a fast calculation of the values (xo, yo, Yo) of the Ostwald colours.

Summary

The slopes (2/3) and 1 in plots log(ΔY) as function of log(Y) of both CIEDE2000 and a visual model agree well for all CIE values Y. This result is valid for grey colours in a grey surround with the value Yu=18 (CIELAB L*u=50). CIELAB fails especially for colours with Y values larger compared to the surround.

Richter (1996) has published a visual response model for achromatic and chromatic colours, see the pictures in the book "Computergrafic and colorimetry" (pages 117 to 127) at the URL http://130.149.60.45/~farbmetrik/buche.html. This model makes useful predictions for similar slope

changes for chromatic colours of constant chromaticity. For any chromatic colour series which changes in Y it is valid Yeff < Yu.

Remark: Any final conclusion depends on the members of TC1-81, and on the final data and formulas to be tested.

Workplan (Timeframe):

1. Third draft of a Technical Report (Chairman and Members): February 2015
2. Fourth draft which includes Comments of Committee Members: June 2015
3. Draft for voting by Committee Members of TC1-81: November 2015
4. Draft for voting by CIE Division 1: April 2016
5. Publication: 2016?

TC1-85 (C)	**Update CIE Publication 15:2004 Colorimetry**
Established:	2011
Terms of Reference:	To update CIE Publication 15:2004 taking into consideration the current CIE/ISO standards on colorimetry and the work of TC1-36 Fundamental Chromaticity Diagram with Physiologically Significant Axes
Chairman:	Janos Schanda HU
Members:	Francoise Viénot FR, Alan Robertson CA, Mike Pointer GB, Hirohisa Yaguchi GB, Ellen Carter US

Draft 8 of the revision is currently being discussed in the TC.

TC1-86 (C)	**Models of Colour Emotion and Harmony**
Established:	2011
Terms of Reference:	To recommend models of colour emotion and harmony based on existing psychophysical data obtained by different research groups or networks for applications in the colour design area.
Chairman:	Li-Chen Ou TW
Members:	Osvaldo Da Pos IT, Shing-Sheng Guan TW, Rafael Huertas ES, John Hutchings GB, Hossein Izadan IR, Tien-Rein Lee TW, Wen-Yuan Lee TW, M. Ronnier Luo GB, Forough Mahyar IR, Tetsuya Sato JP, Ferenc Szabó HU, Suchitra Sueeprasan TH, Tsung-Hsun Yang TW, Yinqiu Yuan TW
Advisor:	Mike Pointer GB

- TC members have submitted existing psychophysical data of colour emotion and colour harmony. All submitted data can be accessed using the CollTool.
- Colour emotion models based on the submitted data has been developed, as summarised in last year's annual report.
- The first version of colour harmony model based on the submitted data has been developed, as summarised in this report.

Existing psychophysical data of colour harmony have been submitted, including:

- Li-Chen Ou (TW) – two sets of colour harmony data, one based on Chinese data obtained in the UK and the other obtained from Argentina, Iran, Spain and Taiwan.
- Wen-Yuan Lee (TW) – a set of colour harmony data collected in Taiwan.
- Suchitra Sueeprasan (TH) – two sets of colour harmony data, both collected in Thailand.
- Ferenc Szabó (HU) – four sets of colour harmony data: monochromatic 2-colour combinations,

dichromatic 2-colour combinations, monochromatic 3-colour combinations and trichromatic 3-colour combinations. All data were collected in Hungary.

Recent development in colour harmony research took advantage of technologies in the CIE colorimetry and psychophysical scaling methods (such as categorical judgement) for measuring and modelling harmony in terms of visual response to combinations of colour patches. A basic assumption for such an approach is that the harmony response is consistent, predictable and can be quantified as a function of colour appearance values. On the basis of psychophysical findings, predictive models of colour harmony have been developed, such as Ou and Luo (2006), Nayatani and Sakai (2009) and Szabó et al. (2009). According to these models, a number of common principles were identified:

- Hue similarity: Colours similar in hue tend to appear harmonious.
- Chroma similarity: Colours similar in chroma tend to appear harmonious.
- Lightness difference: Small lightness variations between the constituent colours in a colour pair may reduce the harmony of that pair.
- High lightness: The higher the lightness value of each constituent colour in a colour pair, the more likely it is that this pair will appear harmonious.

Based on these common principles, the first version of colour harmony model $(CH_{U,draft\,1})$ was developed to fit the psychophysical data collected. The model is described as follows.

$$CH_{U,draft\,1} = CH_C + CH_L + CH_H$$

in which

$$CH_C = CH_{\Delta C} + CH_{C_{sum}}$$

where

$$CH_{\Delta C} = -0.3\tanh(-1.5 + 0.05\Delta C^*_{ab})$$

$$CH_{C_{sum}} = 0.2 - 0.4\tanh\left[-1.0 + 0.029\left(C^*_{ab,1} + C^*_{ab,2}\right)\right]$$

$$CH_L = CH_{\Delta L} + CH_{L_{sum}}$$

where

$$CH_{\Delta L} = 0.04 + 0.5\tanh(-1.5 + 0.05\Delta L^*)$$

$$CH_{L_{sum}} = 0.28 + 0.54\tanh[-3.88 + 0.029(L^*_1 + L^*_2)]$$

$$CH_H = -0.8\tanh(-1.0 + 0.03\Delta H^*_{ab})$$

Here, ΔC^*_{ab}, ΔL^* and ΔH^*_{ab} mean the difference in chroma, lightness and hue of the CIELAB system between the two component colours; C^*_{ab} and L^* mean the chroma and lightness in CIELAB.

This new "universal" model $(CH_{U,draft\,1})$ performed slightly better than the Ou-Luo model (2006) in terms of colour harmony prediction, the former having a mean correlation coefficient of 0.68, and the latter 0.61. While there seems to be some improvement here, the predictive performance of the new model is disappointing and is far from satisfactory. Why is it so difficult to develop a universal model of colour harmony? Is colour harmony response a consistent, universal aesthetic reaction to

colour combination? We will need to look into the data further and to investigate how the effect of individual difference in each dataset influences the colour harmony response.

Table 1 Predictive performance of the new universal model of colour harmony for different countries, in terms of correlation coefficient.

Model	Chinese	Spain	Iran	Argentina	Thai	Hungary	**Mean**
Ou-Luo (2006)	0.85	0.64	0.56	0.50	0.60	0.53	**0.61**
$CH_{U,draft\,1}$	0.71	0.68	0.64	0.66	0.60	0.80	**0.68**

TC1-90 (C)	**Colour Fidelity Index**
Established:	2013
Terms of Reference:	To evaluate available indices based on colour fidelity for assessing the colour quality of white- light sources with a goal of recommending a single colour fidelity index for industrial use.
Chairman:	Hirohisa Yaguchi JP
Members:	Peter van der Burgt NL, Jeff Zawada US, Esther de Beer NL, Peter Bodrogi DE, Kevin Smet BE, Lorne Whitehead CA, Ferenc Szabó HU, Günther Heidel DE, Janos Schanda HU, Werner Jordan DE, Richard Young DE, Ronnier Luo GB, Sophie Jost FR, Kenjiro Hashimoto JP, Ayako Tsukitani JP, Tadashi Yano JP, Osvaldo da Pos IT, Yoko Mizokami JP, Wendy Davis AU, Shinji Kobayashi JP, Yoshi Ohno US, Françoise Vienot FR, Klaus Richter DE, Takayoshi Fuchida JP, Po-Chieh Hung JP, Tomoko Kotani JP, Josep Carreras ES, Aurelien David US, Minchen Wei US, Pedro Pardo ES, Pedro Pardo ES, Hyensou Pak KR, Michael Shur US, Kees Teunissen NL
Observers	Yandan Lin CN, Andreas Kraushaar DE, Peter Karp DE

TC1-90 had two meetings during 2014. The first meeting was held on April 28 in Kuala Lumpur.
Prof. Yaguchi summarized the data analyzing correlation between Ra and CRI2012 conducted by different groups.

- CRI2012 with HL17 and Real 210 set give lower scores for sources with CCT ≤ 4000 K, 80 ≤ Ra ≤ 90 and for tri-band fluorescent lamps. (K Smet, L Whitehead, J Shanda and R Luo, Leeds Mtg., 2013)
- Low scores of CRI2012 for tri-band fluorescent lamps could be caused by the selection of deep red test color samples, HL15, 16, 17. (A Tsukitani, Leeds Mtg., 2013)
- Scores of color fidelity index depend on the choice of test color samples rather than color difference formula. (Y Mizokami, D Tagawa and H Yaguchi, Leeds Mtg., 2013)
- In correlation between Ra and CRI2012 for current LEDs on the market in Japan, many LEDs show nCRI > Ra. Any LED with Ra ≧ 80 is never below 80 in nCRI and any LED with Ra ≧ 90 is never below 90 in nCRI. (K Mukai, JCIE TC1-90 Committee, 2014)
- Fidelity predictions are strongly influenced by the sample set. (A David, CIE Conference 2014)

Dr. Whitehead presented update on CRI2012, which is a collaborative work with K Smet, R Luo, J Schanda and A David.
First, he emphasized that key issue regarding colour rendering samples is that general CRI index must uniformly sample wavelength space, not just colour space. Uniformly sampling colour space is not sufficient and it may not even be necessary. Overall goal is realizing smooth spectral sensitivity of CRI to SPD perturbations, subject only to the human eye. SPD of samples largely influences the chromaticity and CRI.
Then he explained that a few small issues with CRI2012 now resolved.

- HL1000 set was wavelength-shifted real, but it now guides choice of real samples
- Concerns about colour difference for extreme spectra. We can choose samples uniformly in a

smaller zone – more like CQS

- HL17 samples needed very low reflectance "floor" and increased peak with wavelength. With extreme spectra out, both of these factors have gone away.
- Problem of overly complex scaling formula is solved by adopting the CQS formula.
- Samples were uniform in CIELAB, not CAM02UCS. We now use CAM02UCS for this as well.
- HL8 set lacked purple, but now we have HL8 with purple.

Now we have complete set of samples. For uniform selection (distribution) in UCS color space. Sphere is ok, but the shape maybe better using "Munsell-like volume" or NCS instead of sphere. Real samples are relatively good correlation with HL1000. Revised HL-8 set has reasonably good spectral uniformities and colours.

There were some discussions. Scores are largely depending on samples. CRI2012 need samples with broader spectra. Samples should include wide range of samples with various spectral reflectance, and be carefully chosen by taking into account various light sources since CRI2012 has a big impact to the development of light sources.

Prof. Yaguchi explained the guidelines about light sauces, test samples, viewing conditions, scaling techniques. Color samples (made by Japan Color Research Institute) will be hand over to people who join the experiments. Members or observers joining the experiment had been asked to give their experiment plans to Prof. Yaguchi. A few of them are introduced. Others who have not submitted their plan are expected to prepare it.

Dr. Sekulovski (for Dr. de Beer) presented a perception experiment conducted in Philips. They propose that the samples should include reflection sample sets of both CRI and new-CRI, both individual color patches and compositions of color patches, and both color patches and real objects. They used a paired comparison method. Lamp spectra were 8 Lamp spectra @2850K, and 4 lamp spectra @6500K. Samples were 8 Munsell samples corresponding to CRI and 8 LH17 samples, under the conditions with 2 fixed arrangements of color patches (1 per color set), and 2 'real scenes' with familiar objects of various hues.

Prof. Luo explained update since Leeds meeting; Update on the application of CIE priority project, Update on the technical guideline, test sample preparation, an example of the lighting setup. Then, he introduced experimental settings that they are planning in Hangzhou and Taipei. They use illuminance about 500 lx (200 lx in the guideline may be too low). They use double cabinet covered with black paper to improve the color difference judgment.

In terms of visual experiments, we are still revising the guideline. Experiments should follow the guideline. People joining the experiment are M R Luo (Zhejiang Univ., NTUST), H Yagucih & Y Mizokami, E de Beer, J Shanda, S Jost, O da Pos, P Pardo, Y Ono, Y Lin, Group of JCIE, JCRI.

There were comments and discussions on following issues.

- Should you use smaller samples (for 2-degree observer)?
- Will you match the color of Incandescent lamp with LED visually or instrumentally (same appearance or same chromaticities)?
- How do you control the distribution of light to equate FL and LED (with diffuser)?
- Gray background is better to avoid change in color appearance mode, state of adaptation, and the lack of reference in the environment, etc.

Another important issue is the selection of samples. We will continue the discussion.

The second meeting was held on June 16 at NIST during the Division 1 meeting.

Dr. Ohno presented the analysis of CRI2012 test samples and visual observation at NIST. CRI2012 represents the whole range of objects existing in the world. CRI2012 scores did not seem to correlate well with fidelity of typical objects used in offices and homes, which had smaller gamut. CRI2012 requires broader-band spectra, which are usually not necessary except for special high-chroma objects (usually not found in offices and homes.) It would impact energy efficiency of lighting since broader-band spectra requires more energy. His suggestions are to go back to Munsell and/or NCS samples and to restrict the color gamut of the samples by cutting very high chroma and very dark samples.

(It was pointed out that HL1000 and HL17 are no longer the part of the proposed CRI. It was also informed that “Cadbury” (color of chocolate package) is an example of the most saturated color.)

Dr. Whitehead presented the update on CRI2012. Key issue is what are right samples to use in experiment and calculation. Therefore, sample selection and reflectance are important. Producing the set mathematically is easy, but the problem is the experimental part. Small number of samples to evaluate accurately is required. Dr. Rich has helped to make HL8 samples. (Dr. Rich briefly explained the techniques to make samples.) The spectral reflectances of samples are similar to the ideal ones. He also brought and showed actual HL8 samples including purple.

Currently, we have eleven experimental sites. We hope to have results by the end of the year.

Experimental designs (and data) in the following labs were introduced.

- Dr. Luo explained an experiment which his student had started after KL meeting. Visual matching using 3 cabinets and gray scale method were used. It was shown that small color difference was judged less accurately, lightness correction was able to further improve the data quality, CRI2012-30 correlated with visual results better than other CRIs, and so on.
- Dr. Mizokami introduced experimental plan at Chiba University using corresponding color and gray scale method.
- Dr. Jost introduced two experiments (plan): one was on the color appearance of painting and color chart under museum lighting, the other was on a color difference.
- Dr. da Pos introduced the valuation method of colour shifts under different light sources following Hering's natural colour system. It can be applied to all surface colors in complete adaptation state and color similarity that is the relevant dimension of the color rendering index can be calculated.

Discussions

- Dr. Whitehead explained FAQs about CRI Improvement quickly. The FAQ had been distributed through ML beforehand. One of important issue would be a tradeoff between energy efficiency and accuracy (what’s the most valuable light for use). There was no time for discussion. The discussion or question will be continued on ML.
- Prof. Michael Shur (Rensselaer Polytechnic Institute) introduced a research “Statistical Color Rendering Metrics” by their smart lighting team as a guest presenter. He has proposed new color rendition metrics based on statistical analysis. There are many applications, such as medical field, preferred lighting, restoring damaged artwork. (There are two units in RPI (Dr. Rea’s group and Dr. Shur’s groups) and they are very active.)

Our future plan is as follows.

1. To carry out visual experiments
2. To make minute investigations of CFIs

3. To analyze visual experiment data
4. To write a technical report.

The future meetings are tentatively scheduled as follows,

- WebEx meeting(s), by the end of 2014
- AIC2015, 19-22 May, 2015, Tokyo, Japan
- The 28th SESSION of the CIE, July 2015, Manchester, United Kingdom

TC1-91 (C)	**New Methods for Evaluating the Colour Quality of White-Light Sources**
Established:	2012
Terms of Reference:	To evaluate available new methods for evaluating the colour quality of white-light sources with a goal of recommending methods for industrial use. (Methods based on colour fidelity shall not be included: see TC1-90).
Chairman:	Yandan Lin CN
Members:	Esther de Beer, Laura Bellia, Peter Bodrogi, Takayoshi Fuchida, Yoshie Imai, Sophie Jost, Ming Ronnier Luo, Yoshi Ohno, Janos Schanda, Kevin Smet, Ferenc Szabó, Ayako Tsukitani, Minchen Wei, Tsung-Hsun Yang, Tadashi Yano
Observers:	Peter Karp, Jeff Zawada, Hirohisa Yaguchi

The 3rd meeting of TC1-91 was hold in in Kuala Lumpur, Malaysia (28 April 2014), 21 participants at field and 6 participants via Webex. The 4th meeting of TC 1-91 was hold in NIST.

Based on the data collection it has been decided that 5 indexes will be included in the technical report, CQS, FCI, MCRI, HRI and PS. Index without enough validation was not suggested to be included in this report. Many members already contributed to the current draft report (V3.0) and it is now being discussed and still with more contribution to it. Another possible index of CRV suggested from Esther de Beer need to be discussed about its possibility with current available data to be included into the current report. Before Manchester meeting it will be discussed by a webex meeting and hopefully that there can be a draft with not so much disagreement before the meeting in Manchester. If so, the technical report is expected to be finished this year.

TC1-92 (C)	**Skin Colour Database**
Established:	2013
Terms of Reference:	1. To investigate the uncertainty in skin colour measurement and to recommend protocols for good measurement practice. 2. To tabulate skin colour measurements that accord with these protocols covering different ethnicity, gender, age and body location.
Chairman:	Kaida Xiao CN
Members:	Paula Alessi US, Peter Bodrogi DE, Francisco Imai US, Esther Perales ES, Peili Sun TW, Suchitra Sueeprasan TH, Wen Luo UK

Progress in 2014

1. Skin Colour Measurements

Liverpool-Leeds Data: Skin colours for 200 subjects (mainly Caucasians and Chinese) were measured in Liverpool using a spectrophotometer, a telespectroradiometer and a digital camera.
Chula Data: Skin colours for more than 426 Thai subjects were measured in Bangkok using a spectrophotometer.

2. Uncertainty of skin colour measurement
   - Spectrophotometer

Repeatability, Effect of pressure, Effect of Size

- Spectroradiometer
  Repeatability, Effect of measurement
  Agreement between skin colour measurement
  Spectrophotometer vs. Spectroradiometer measurement

To be presented in the CIE Session 2015

3. Skin spectral reflectance re-construction model for digital camera
   - Effect of skin colour chart for training colours
   - Effect of mathematic model
   - Effect of applied spectral skin colour database

4. Work Plan 2015
   - To develop measurement protocols for different applications.
   - To collect skin colour data for elderly.
   - To investigate skin colour appearance and variations.
   - To develop new method for skin reflectance reconstruction.

5. Further meeting
   - CIE Session 2015, Manchester

COLOUR SECTION: REPORTERS

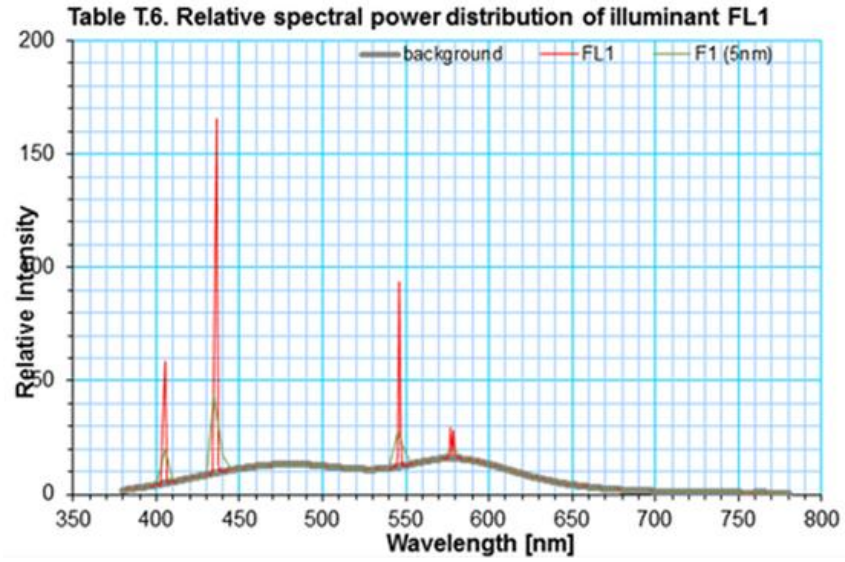
R1-42 (C)	Extension of CIECAM02
Established:	2007
Terms of Reference:	To evaluate potential additions to CIECAM02 in liaison with Division 8 and to include: Those published in the literature; Extension to include unrelated colours; Extension of the range down to scotopic levels
Reporter:	Changjun Li CN

Brill MH [Color Res Appl 2006; 31: 142-145] and Brill and Süsstrunk [Color Res Appl 2008; 33: 424-426] found that CIECAM02 has yellow-blue and purple problems and gave partial solutions to them. Recently Li CJ and his co-authors have given a full solution to the yellow-blue and purple problem. Their results also show that the yellow-blue and purple problems are solved, but the updated CIECAM02 performs worse in predicting the visual results. This is indeed to be expected since more constraints were added to satisfy the nesting rule. These results also tell us that if we want to repair the CIECAM02 problems and also want to keep the prediction accuracy as good as the original, if not better, we have to consider the problem from a different direction such as changing the structure of the CIECAM02. Research in this direction is underway.

Relevant publication:
Jun Jiang, Zhifeng Wang, M. Ronnier Luo, Manuel Melgosa, Michael H. Brill and Changjun Li, An Optimum Solution to the CIECAM02 Yellow-Blue and Purple Problems, Color Research and Applications , Article first published online: 7 OCT 2014, DOI: 10.1002/col.21921

R1-52 (C)	**Spectral Data Interpolation**
Established:	2010
Terms of Reference:	To review the methods, and make a recommendation for the interpolation of existing, highly structured source spectra, including the FL illuminants, for colorimetric calculations.
Reporter:	Danny Rich US

Wolfgang Schlenker and myself have been corresponding on methods for interpolating illuminant spectral data. We are testing some new ideas on dealing with emission spikes versus the continuum radiations. We have no final conclusions yet, but for many lamps, the method seems to work well. In the Figure below, the 1 nm bandwidth curve will produce the same tristimulus values as the 5 nm curve as the interpolation is constrained to make it so. Fairman commented, “Whatever method you are using to do your spline-interpolation seems to be deconvolving the data. The 5 nm data has about a 5 nm half-bandpass. Your 1 nm data seems to have about a 1.5 nm bandpass. If this is true, that means that we don’t need to bandpass correct the 5 nm data before interpolation. The less messing we do with the data the better. We go back to chromaticity coordinates as given by the CIE instead of the slightly altered coordinates of my last communication. That is good.”

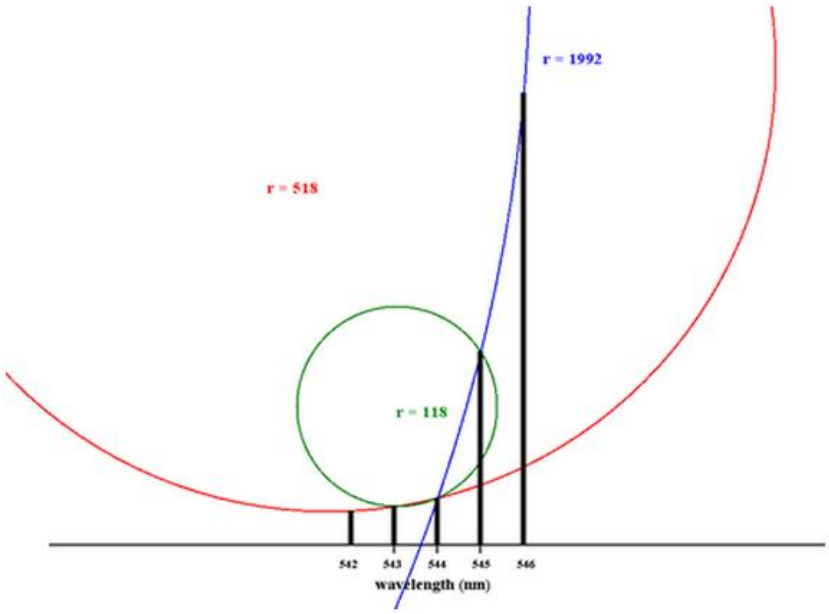


Hugh Fairman also submitted a comment to us on his circles method. Why the circle method works
The equation for the circle is

$$(x-\alpha)^2+(y-\beta)^2=r^2$$

where the symbols are as previously defined, is a quadratic. Therefore, it takes three parameters to fulfil the equation. Three values of points on the circle are sufficient to describe the circle fully. That means that any three points in a 2-space are on some circle or other. Certainly, these same points could be on a parabola, an ellipse, or a hyperbola as well, but the circle does something for us; whereas, it is not clear that the other curves do anything for us.

As we scan a 1 nm spectrum, taking three 1 nm intervals at a time and calculating the radius of the circle on which the three adjacent terminal points lie, the radius of these circles goes to a minimum at the point where the inflection of the chord between the first and middle wavelength is at minimum acute angle to the chord between the middle and third wavelength. This is likely the point where the power from the line-element begins in the data. This occurs regardless of the angle of the first chord. The radial minimum is true for the point where it ends on the other side of the hump.
I have taken your 1 nm spline-interpolated data for D65 at 542-546 nm to create the figure below.



R1-53 (C)	Gloss Perception and Measurement
Established:	2011
Terms of Reference:	1. To establish a database of key research articles and terminology related to gloss perception and to gloss measurement. 2. To investigate if, from this database, improved measurement methods could be suggested in order to achieve a better correlation between gloss perception and measurement.
Reporter:	Frédéric Leloup BE

There is nothing significant to report.

R1-58 (C)	Liaison with ISO TC130 *Graphic Technology*
Established:	2012
Terms of Reference:	To investigate and respond to ISO TC130 *Graphic Technology* on matters concerned with colorimetric calculations.
Reporter:	Phil Green GB

Progress in addressing issues raised by the D1-TC130 liaison were addressed was made in 2013. Remaining issues still to be clarified in D1, are:

a) Over-range L* values for fluorescing materials
b) Assessment of LED-based sources used to simulate D50 illuminants in viewing booths

A report is in preparation.

R1-60 (C)	Future colour-difference evaluation
Established:	2013
Terms of Reference:	To report on publications that relate to colour-difference evaluation and uniform colour spaces.
Reporter:	Guihua Cui CN

Sources of Publications

The publications those relate colour difference and colour spaces in this report are published in 2014 and come from the following resources by searching 'colour space' AND 'colour difference' in abstracts:

1. Wiley Online Library: 24 papers or book chapters;
2. OSA OpticsInfoBase: 37 papers;
3. Imaging.org Digital Library: 5 papers;
4. IEEE Xplore Digital Library: 56 papers.

Most above publications relate the applications of colour difference or colour spaces. However, there are 11 publications[1-11] that relate to research on colour-difference evaluation or uniform colour spaces.

New Uniform Colour Spaces

1. DLAB

CIELAB is based on the CIE 1931 colour matching functions. If we are given a new set of colour matching functions, how do we define a CIELAB-like uniform colour space for the new functions? This problem arises because the CIE recommended its physiological cone fundamentals in 2006 and is considering a new set of colour matching functions based on them. In fact, the same problem exists for many practical applications in digital imaging. Typical solutions involve using illuminant-dependent colour correction matrices to transform the device-dependent colour space

into the CIE XYZ colour space. This conversion process suffers information loss unless the two sets of colour matching functions are linear combinations of each other. Li and Lee[3] proposed a design process that allows us to develop a CIELAB-like colour space using the native sensor fundamentals. The basic idea was to choose the daylight locus as the yellow–blue opponent colour process. They named this class of colour space DLAB and described the design procedures and compared the resulting Munsell colour uniformity under CIELAB (L∗,a∗,b∗) and DLAB (L+,a+,b+).

2. Hyperbolic Geometry

It is well established from both colour difference and colour order perspectives that the colour space cannot be Euclidean. In spite of this, most colour spaces still in use today are Euclidean, and the best Euclidean colour metrics are performing comparably to state-of-the-art non-Euclidean metrics. Ivar Farup[4] showed that a transformation from Euclidean to hyperbolic geometry (i.e., constant negative curvature) for the chromatic plane can significantly improve the performance of Euclidean colour metrics to the point where they are statistically significantly better than state-of-the-art non-Euclidean metrics on standard data sets. The resulting hyperbolic geometry nicely models both qualitatively and quantitatively the hue super-importance phenomenon observed in colour order systems.

3. WLab

Derhak and Berns[5] derived a set of invertible non-linear transforms that adjusts Wpt (Waypoint) coordinates (based on Wpt normalization) to and from a perceptually more uniform coordinate system (WLab or Waypoint-Lab) than that provided by Wpt that allows for the advantageous features of Wpt to be directly applied to situations where other standard color spaces are typically used. The proposed transformations were found by optimizing for perceptual uniformity over both large and small color difference scales. The Munsell color order system was used as a representation for optimizing large-scale perceptual uniformity. Correlations with Munsell value, chroma and hue along with comparisons with CIELAB and CAM02-UCS were used to correct and assess overall large-scale uniformity. The ΔE*94 color difference formula was used for optimization purposes for small-scale uniformity. A STRESS analysis was applied to compare color differences based on Euclidean WLab distances with color differences based upon ΔE*ab, ΔE^{*94}, ΔE^{00}, DIN99o, CIECAM02, and CAM02-UCS. It was found that WLab is a reasonably uniform material color equivalency space with small Euclidean WLab distances not being statistically different from ΔE^{*94}, ΔE^{00}, and Euclidean distances of DIN99o and CAM02-UCS under reference observing conditions.

New Colour-difference Formula – AUDI2000

Manuel *et al*[6] selected 28 low-chroma colour pairs with relatively small colour differences predominantly in lightness from a set of gonioapparent automotive samples from different manufacturers. These colour pairs were visually assessed with a gray scale, at six different viewing angles, by a panel of 10 observers. Using the Standardized Residual Sum of Squares (STRESS) index, the results of their visual experiment were tested against predictions made by 12 modern colour-difference formulas. From a weighted STRESS index accounting for the uncertainty in visual assessments, the best prediction of their whole experiment was achieved using AUDI2000, CAM02-SCD, CAM02-UCS and OSA-GP-Euclidean colour-difference formulas, which were no statistically significant different among them. A two-step optimization of the original AUDI2000 colour-difference formula resulted in a modified AUDI2000 formula which performed both, significantly better than the original formula and below the experimental inter-observer variability.

New Colour-difference Datasets

1. Blue Dataset

Shamey *et al* [7,8,9] reported a new colour difference dataset. The main objective of their work was to test the performance of major formulas for assessment of small suprathreshold colour differences in

the blue region. The models examined include CIELAB colour space based equations, including CIELAB, CIE94, CIEDE2000, CMC (l:c), BFD (l:c), and formulas based on more uniform colour spaces, such as DIN99d, CAM02-SCD, CAM02-UCS, OSA-GP, and OSA-Eu in comparison against data obtained via visual assessments. For this purpose, a dataset around the CIE high-chroma blue colour center, hereafter called NCSU-B2, was developed. The NCSU-B2 dataset comprised 65 textile substrates and a standard, with a mean ΔE∗ab color difference of 2.72, ranging from 0.54–5.72. Samples were visually assessed by 26 subjects against the reference gray scale in three separate trials with at least 24 hours between assessments. A total of 5070 assessments were obtained. The standardized residual sum of squares (STRESS) index was used to examine the performance of various formulas for this dataset, as well as a previously developed NCSU-B1 low-chroma blue dataset [Color Res. Appl. 36, 27, 2011], and blue centers from other established visual datasets. Results show that formulas based on more recent uniform colour spaces provide better agreement with perceptual data compared with models based on CIELAB space.

2. Saturation Dataset

Cao *et al*[10] presented a perceived saturation dataset. Two psychophysical experiments were conducted at North Carolina State University (NCSU) and Rochester Institute of Technology (RIT) to obtain replicated perceived saturation data from color normal observers on the order of one unit of saturation. The same 37 Munsell sample sheets, including up to four references that had similar perceived saturation but different hue, were used in both experiments. Different assessment methods included presenting either four references simultaneously or only one reference at a time to observers and obtaining judged saturation magnitudes for the given Munsell samples. Four saturation models comprising S*ab, S*uv, CIECAM02, as well as Richter/Lübbe, were tested. CIECAM02 gave the best prediction of saturation for data obtained at NCSU while S*ab outperformed other models for the RIT data. For the combined dataset, S*ab, the Richter/Lübbe, and CIECAM02-based saturation models exhibited comparable performances. The Standardized Residual Sum of Squares index was used to measure the inter- and intra-observer variability and goodness of fit. Inter- and intra-observer variability of assessments was smaller than or comparable to those reported for the typical colour-difference evaluation experiments.

3. Wang Dataset

Wang *et al*[11] conducted a psychophysical experiment under constant stimuli on a CRT display to measure the visual suprathreshold colour differences for five colour centers recommended by CIE under the same five background colors. The performances of four CIELAB-based, three CIECAM02-based, and two OSA-UCS-based formulas are tested. Detailed analysis results indicate the existence of chromatic crispening effect. CIEDE2000 performs best for the gray center and gray background, whereas CAM02-LCD and CAM02-UCS have the best performance for non-neutral backgrounds. CAM02-LCD significantly outperforms all other formulas for all colour centers under all background colours.

References

1. Hastings GD & Rubin A. Multivariate methods to visualise colour-space and colour discrimination data. Ophthalmic Physiol Opt 2015; 35: 97–105. doi: 10.1111/opo.12172
2. Luo, L., Tsang, K. M., Shen, H.-L., Shao, S.-J. and Xin, J. H. (2014), An investigation of how the texture surface of a fabric influences its instrumental color. Color Res. Appl.. doi: 10.1002/col.21923
3. Ying-Yi Li and Hsien-Che Lee, DLAB: a class of daylight-based uniform color space, J. Opt. Soc. Am. A 31, 1876-1885 (2014)
4. Ivar Farup, Hyperbolic geometry for colour metrics, Opt. Express 22, 12369-12378 (2014)
5. Derhak, M. W. and Berns, R. S. (2014), Introducing WLab—Going from Wpt (Waypoint) to a uniform material color equivalency space. Color Res. Appl.. doi: 10.1002/col.21933

6. Manuel Melgosa, Juan Martínez-García, Luis Gómez-Robledo, Esther Perales, Francisco M. Martínez-Verdú, and Thomas Dauser, Measuring color differences in automotive samples with lightness flop: A test of the AUDI2000 color-difference formula, Opt. Express 22, 3458-3467 (2014)
7. R. Shamey, R. Cao, T. Tomasino, S. S. H. Zaidy, K. Iqbal, J. Lin, and S. G. Lee, Performance of select color-difference formulas in the blue region, J. Opt. Soc. Am. A 31, 1328-1336 (2014)
8. Shamey, Renzo; Cao, Renbo; Sawatwarakul, Weethima; Lin, Juan; Performance of various color difference models in challenging regions of CIELAB color space, Color and Imaging Conference, 22nd Color and Imaging Conference Final Program and Proceedings, pp. 200-206(7)
9. Shamey, R., Lin, J., Sawatwarakul, W. and Cao, R. (2014), Evaluation of performance of various color-difference formulae using an experimental black dataset. Color Res. Appl., 39: 589–598. doi: 10.1002/col.21844
10. R. Cao, M. Castle, W. Sawatwarakul, M. Fairchild, R. Kuehni, and R. Shamey, Scaling perceived saturation, J. Opt. Soc. Am. A 31, 1773-1781 (2014)
11. Zhehong Wang and Haisong Xu, Evaluation of small suprathreshold color differences under different background colors, Chin. Opt. Lett. 12, 023301- (2014)

R1-61 (C)	**Source whiteness metric**
Established:	2014
Terms of Reference:	1. To review the literature on the impact of white objects containing Fluorescent Whitening Agents. 2. To report on the activity of the IES (Illuminating Engineering Society of North America) Whiteness Group which will propose a metric for the whiteness-rendering capability of light sources.
Reporter:	Aurelian David US

No report.

R1-62 (C)	**Typical LED spectra**
Established:	2014
Terms of Reference:	1. To collect available LED spectra. 2. To analyse the difference among the spectra with the aim of finding possible typical spectra for various classes, e.g. cool white, warm white.
Reporter:	Sophie Jost FR

No report.

LIAISONS

L1-1	AIC (Association International de la Couleur)

Liaison: Paula Alessi

The Auditors of the AIC, Paula Alessi (USA) and Frank Rochow (Germany) have completed their audit of the AIC finances. Their Auditor Reports were published in the AIC 2014 Annual Report.

The 2015 AIC Deane B. Judd Award will be given to our own Dr. Françoise Viénot during the 2015 AIC Midterm Meeting in Tokyo, Japan.

The AIC 2014 Interim Meeting was held in Oaxaca, Mexico from October 21-October 24. It was hosted by Asociación Mexicana de Investigadores del Color. The theme was Colors, Culture, and Identity: Past, Present and Future. Conference topics were Folklore expressions about colour, History of colour, Local stories about colour, Ancient pigments and natural local dyes, Colour as an identity means, Anthropology, Visual semiotic and psychology, Art and crafts, and Restoration.

The AIC 2015 Midterm Meeting will be held in Tokyo, Japan from May 19-22. It will be hosted by The Color Science Association of Japan. The theme will be Color and Image. Please see www.aic2015.org or office@color-science.jp for more details.

The AIC 2016 Interim Meeting will be held in Santiago, Chile from October 18-22. It will be hosted by The Chilean Color Association. The theme will be Color in Urban Life: Usability in Images, Objects, and Space. Please see www.aic2015.org or diffusion@asociaciondelcolour.cl for more details.

The AIC 2017 13th Congress will be held in Jeju, Korea from October 16-20. It will be hosted by The Korea Society of Color Studies. The venue will be the International Convention Center Jeju. Please see www.color.or.kr for more details.

Please visit the website, www.aic-colour.org , for all the latest news in the international color world.

Respectfully submitted,
Paula J. Alessi

L1-2	CCPR (Comite Consultatif de Photometrie et Radiometrie), BIPM

Liaison: Michael Stock

The CCPR meets about every two years at the BIPM in Sèvres, France, bringing together some 30-40 experts from its member NMIs (National Metrology Institutes). The last meeting took place on 17-18 September 2014. The CCPR working groups met during the two days before. It is planned to hold the next meetings of the CCPR working groups in October 2015, at NIM, China. The next meeting of the CCPR will take place around September 2016. General information on the work of the CCPR can be found on www.bipm.org/en/committees/cc/ccpr.

The CCPR Key Comparison Working Group (WG-KC) has set up a schedule for the second round of key comparisons, which are the technical basis for the CIPM Arrangement on Mutual Recognition of National Measurement Standards and of Calibration and Measurement Certificates issued by National Measurement Institutes. The key comparisons demonstrate the technical capabilities of the participating NMIs. A new comparison on luminous intensity has been started. Comparisons on regular spectral transmittance, luminous flux, spectral responsivity (300 nm – 1000 nm), spectral responsivity (900 nm – 1600 nm) and spectral irradiance (250 nm – 2500 nm) are being prepared.

The results of the completed key comparisons can be found in the Key Comparison Data Base, held at the BIPM (kcdb.bipm.org/appendixB). They cover the fields of spectral irradiance, spectral responsivity, luminous intensity, luminous flux, spectral diffuse reflectance and spectral regular transmittance. It is foreseen that a number of NMIs will carry out a supplementary comparison of solar irradiance measurements as part of the IPC 2015 (International Pyrheliometer Comparison), organized by the PMOD, Davos. The WG-KC has formed a new task group to study the use of white LED sources as transfer standards for comparisons. A pilot study of spectral responsivity measurements in the terahertz range is being prepared.

The CMC working group (WG-CMC) maintains and updates the list of recognized calibrations services, for which so-called CMCs can be submitted by the member NMIs. These are the NMIs' internationally recognized calibration and measurement capabilities. The recognition of these calibration and measurement capabilities is based on the participation in key comparisons. At the meeting of WG-CMC in 2014 the impact of key comparison results on already published CMCs was discussed.

It is expected that in the near future four of the seven base units of the SI system will be redefined: the kilogram, the ampere, the kelvin and the mole. Each of these units will be based on a fixed numerical value of a fundamental constant: the Planck constant, the elementary charge, the Boltzmann constant and the Avogadro constant. The impact of these changes on the candela will be insignificant. To give guidance on how the units can be realized in practice, a so-called mise en pratique (French for "practical realization") will be published for each base unit. The candela will not be redefined, but it is planned to change the wording of its definition. An important development in the field of photometry is the introduction of the spectral luminous efficiency functions for mesopic vision. A mise en pratique for the definition of the candela has been written by a task group of the CCPR Strategic Planning Working Group (WG-SP). This document has been recently submitted to the CCPR and the CIE for review and comments. The final document shall be available in March 2015 and will then be published on the BIPM web site. A more extensive document "Principles Governing Photometry" has been prepared by a joint CCPR-CIE task group, CIE JTC-2. This document is close to finalization. The WG-SP has created a new task group on single-photon radiometry.

At the plenary CCPR meeting the outcome of the working group meetings was discussed. Dr. Walter Bich from INRIM, Italy, presented the plans for the revision of the GUM (Guide to the Expression of Uncertainty in Measurement). The present GUM and its Supplements are not consistent. The new version of the GUM will be based on Bayesian statistics. Publication is planned for late 2015 or early 2016. The work of the CCPR was presented by the CCPR President, Dr. Takashi Usuda, in written and oral reports to the General Conference on Weights and Measures (CGPM) in November 2014. Both reports can be found on the BIPM web site:
http://www.bipm.org/en/cgpm-2014/reports-presidents.html.

The theme for World Metrology Day, 20 May 2015, will be related to light-based technologies, in line with the International Year of Light.

L1-3	**ISO/TC6/W3: Paper, Board and Pulp -Optical Properties**

Liaison: Joanne Zwinkels

The following recent activities of ISO TC6 WG3 (Optical properties), may be of interest to CIE D1:

- ISO 11476 Paper and board – Determination of CIE whiteness, C/2° (indoor illumination conditions) and ISO 11475 Paper and board – Determination of CIE whiteness, D65/10° (outdoor daylight) – both of these Standards were amended to update Annex A, Section A.2 to allow for calculations using ASTM E308 for instruments that have bandpass correction and still maintain

the non-bandpass correction procedure (Tables 5 and 6, respectively), in order to provide the ability to measure CIE whiteness on a wider range of instruments. The DIS ballot of ISO 11476 (3rd edition) began on 2014-10-22 and closes on 2015-01-22.

- ISO 5631-1 Paper and board – Determination of colour by diffuse reflectance – Part 1: Indoor daylight conditions (C/2 degrees), ISO 5631-2 Paper and board – Determination of colour by diffuse reflectance – Part 2: Outdoor daylight conditions (D65/10 degrees) and ISO 5631-3 Paper and board – Determination of colour by diffuse reflectance – Part 3: Indoor illumination conditions (D50/2 degrees) – all three of these Standards were also revised to cancel and replace the previous editions (ISO 5631:2009, ISO 5631-2:2014 and ISO 5631-3:2014); the major change is to allow for calculations using ASTM E309 for instruments that have bandpass correction and still maintain the procedure for instruments without bandpass correction. The DIS ballots for all three of these Standards close on 2014-04-19.

- ISO 2469 Paper, board and pulps – Measurement of diffuse radiance factor (diffuse reflectance factor) – the FDIS ballot of this Standard terminated on 2014-06-03. This 5th edition is a technical revision of the 4th edition where the substantive technical changes were described in the previous ISO TC6 liaison report to D1 in June 2014. There are also some editorial changes from the previous edition to update the terminology and nomenclature to be consistent with current CIE recommendations and with recommendations of ISO TR 10688, currently being balloted by WG3 as a DTR.

- ISO 2470-1:2009 Paper, board and pulps – Measurement of diffuse blue reflectance factor – Part 1: Indoor daylight conditions (ISO brightness) recently completed the ballot for systematic review (closing date: 2014-12-15). Although a majority of P members voted to confirm this standard, in light of the comments received from Canada, no decision was taken at this time and the convenor of WG3 plans to discuss these comments at the upcoming meeting of the working group in Atlanta in April 2015. These comments from Canada are largely editorial in nature– requesting that this standard be updated with regard to normative and bibliographic references, the terminology revised so that is consistent with current CIE recommendations and those of ISO TR 10688 (currently being balloted as DTR), eliminate references to ISO TC6 authorized labs and revise definitions of IR1, IR2 and IR3 so that they are in accordance with WG3 decisions regarding the revision of ISO 4094 (to address concerns from CASCO).

- ISO 4094 Paper, board and pulps – International calibration of testing apparatus – Nomination and appointment of standardizing and authorized laboratories had a systematic review in October 2013 and there was a Resolution at the ISO TC6 plenary in Delft in April 2014 to propose a new work item to revise 4094 to take into account CASCO requirements; in particular, to allow the text to follow conformity assessment guidelines given in ISO/IEC Directives, Part 2, Clause 6.7. This new work item proposal was balloted, approved and registered in the work programme of ISO TC6/WG3 as WD 4094 on 2014-09-07 with Joanne Zwinkels as the Project Leader. It is proposed to change the title and limit the scope to the requirements for laboratories authorized for optical property measurements only. The importance of this Standard to the integrity of the calibration system within ISO for optical property measurements is attested to by the following comments from the vote on this new work item (NWI):
    - This Standard is critical to conformity assessment requirements for the calibration system and procedures defined in ISO 2469, ISO 2470-1, etc.
    - This International Standard is of importance for the harmonization of calibration standards and procedures. It is used by laboratories in developing their management system for quality, administrative and technical operations. Laboratory customers, regulatory authorities and accreditation bodies can also use it in confirming or recognizing the

competence of laboratories.

- Optical properties are some of the most important from a commercial perspective, since for many grades they form a basis by which the papers are graded and sold. Therefore, it is imperative that instrumentation to measure colour and other optical properties should be maintained with reference to calibrated and certified paper samples. For this to happen, the laboratories that can maintain and supply these samples need to be certified according to a standard – hence the importance of this NWI.

- ISO TR 10688 Paper, board and pulps – Basic terms and equations for optical properties. This draft technical report (informative only) is currently being balloted as DTR 10688 with closing date of: 2015-02-01.
- The new Task Group (TG1) on Cellulosic Nanomaterials (CNC), which was established at the ISO TC6 Plenary in Delft, 11 April 2014 (Resolutions 17 and 19) under the chairmanship of Dr. Jean Bouchard of FPInnovations (Canada) with Secretary, Colleen Walker of TAPPI, has had two Web-Ex meetings: 19 June 2014 and 22 Oct. 2014. To-date the members of the group have largely discussed the standardization and R&D activities on CNC in their respective countries. At the next meeting, it is planned to form subgroups to begin developing an operational work plan for the Task Group.
- As CIE liaison to ISO TC6, on 15 Jan. 2015, I distributed to members of WG3, the recent CIE Press Release regarding the publication of CIE 214:2014 on “Effect of Instrumental Bandpass Function and Measurement Interval on Spectral Quantities”.
- The next Working Group meetings and Plenary meeting of ISO TC6 will be hosted by ANSI and take place in Atlanta, Georgia, April 21-25, 2015 in conjunction with the 100th anniversary of TAPPI. This will be preceded by a two-day meeting of the representatives of the optical properties authorized laboratories (Opal Group).

Respectfully submitted, Joanne Zwinkels. National Research Council of Canada

L1-4	**ISO/TC38/SC1: Textiles: Colour Fastness & Measurement**

Liaison: M Ronnier Luo

Nothing to report.

L1-5	**ISO/TC42: Photography**

Liaison: Klaus Richter

The Scope of ISO/TC 42 is defined as "Standardization primarily in the field of still picture imaging - chemical and electronic". This includes

- definitions for still imaging systems.
- specifications and recommendations of logical and physical characteristics, practices, interfaces and formats for still imaging capture, processing, and output systems.
- methods, measurements, specifications, and recommended practices for storage, permanence, integrity and security of imaging media and materials, and imaging materials disposition.

Excluded is work defined in the scope of

- graphic technology (ISO/TC 130),
- document imaging applications (ISO/TC 171),
- office equipment (ISO/IEC JTC 1/SC 28).

However, there are some Joint Working Groups (JWG) with these committees.

According to the "TC42 Bussiness plan 2015", the objectives of TC42 are the development of new and updated standards for the capture, storage, sharing and preservation of photographic images in all forms.

In order to reach these objectives, ISO/TC 42 has adopted the following strategies for technical efforts:

- Develop standards required to assess the image quality of photographic capture devices, including mobile camera devices.
- Develop standards required for the digitization, storage and permanence of images by museums and other cultural institutions.
- Develop image permanence standards for photo books, and for specialty applications including wide format display, outdoor usage and security printing.
- Develop and update standards for exchange and interoperability of image data, such as photographic metadata, file formats and data transfer protocols.
- Update standards developed for film-based photographic systems, to address the requirements of digital photography when appropriate, or to indicate if the standard shall not be used for digital photography devices and systems.
- Cooperate with ISO/TC 130 (Graphic technologies) in areas of particular interest related to image quality, image permanence, and physical durability.

The current work programme of ISO/TC 42 is available at:
http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=48420&development=on

Especially the following working groups (WG) are dealing with colour:

- WG 18 Electronic still picture imaging
- JWG 20 Joint ISO/TC 42-IEC; Digital still cameras
- JWG 22 Joint IEC/TC 100-ISO/TC 42-TC 130; Colour management
- WG 23 Joint TC 42-TC 130-CIE; Extended colour encodings for digital image storage, manipulation and interchange
- WG 24 Joint TC 42-TC 130; Revision of ISO 3664 (viewing conditions)
- JWG 26 Joint ISO/TC 42-TC 46/SC 11-TC 171; Imaging system capability qualification for archival recording and approval

For example the following topics are under work

- ISO 17850 Geometric distortion measurements – DIS approved
- ISO 19084 Lateral chromatic displacement – CD approved
- ISO 19567 Low contrast detail
- ISO 18844 Image flare measurement
- ISO 19093 Low light performance
- ISO 22028-1 Extended colour encodings
- ISO TR 217321-3 Workflow, user controls and readouts

Members of the CIE and ISO SC42 often ask the question, if it is possible to "measure" the colours of a colour test chart or of a colour scene by photographic or scanner equipment. This question is for example important for the archival recordings. CIE colorimetry can specify the accuracy of this measuring equipment. In this field ISO TR 17321 "Graphic technology and photography -- Colour characterisation of digital still cameras (DSCs) – Part 3: Workflow, user controls and readouts" has started. The scope this ISO TR "defines an environment where typical users referring to the specification can achieve improved results in terms of color and exposure (tonal) accuracy for scene referred imaging. This document provides definitions for a workflow and recommended user

controls and readouts".

CIE members may interpret the goal of this statements to "measure" the colours and to produce appropriate rgb coordinates with a defined relation to the CIELAB LCh* measuring data. In this area, and at the last meetings in Copenhagen and Cologne, methods for output and input linearization have been presented and discussed.

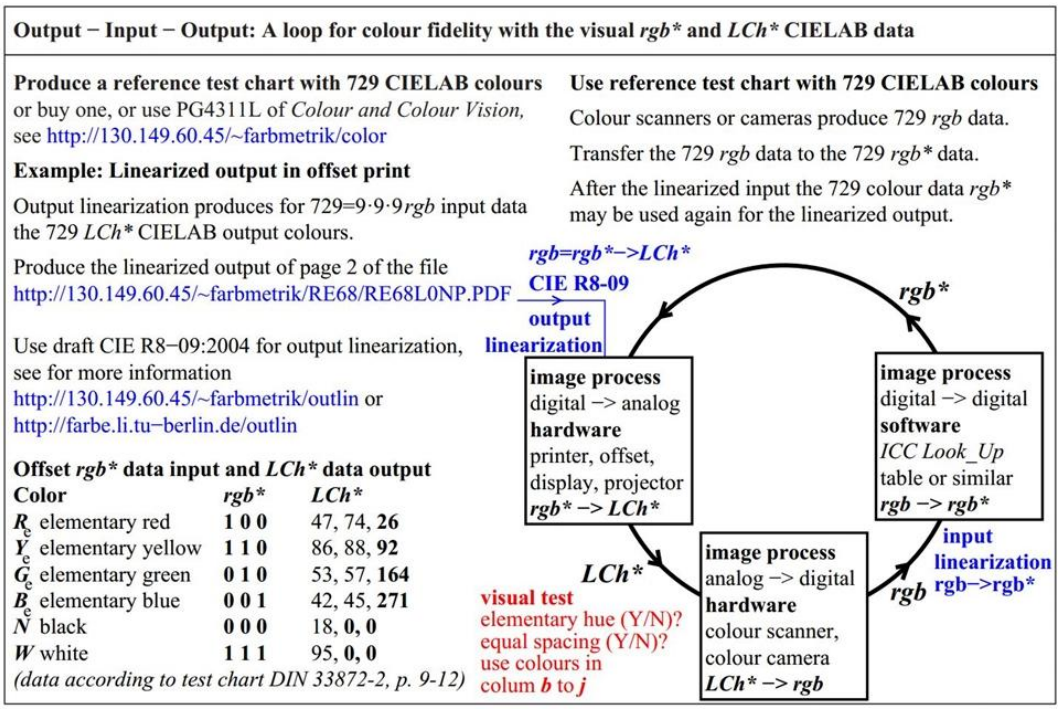


Fig. 1 (UE201-7N): Output - Input - Output: A loop for colour fidelity with rgb* and LCh* CIELAB data.

Fig. 1 shows an example Output - Input - Output loop which is based on CIE colorimetry. CIE colorimetry is included by a linear relation between rgb* and LCh* CIELAB data. The output loop is specified in draft CIE R8-09:2014.

Fig. 1 shows the URL of a test chart with 729 colours. An example linearized output in offset (PG4311L) is in the German version of an available booklet. The 9 step colour series are equally spaced both in LCh* of CIELAB and in rgb* data.

If this colour test chart is scanned or taken by photographic equipment, then usually this input process produces continues rgb data between 0 and 1. The rgb data are usually not equally spaced. However the intended rgb* data are known. Therefore a continuous transfer of the rgb scanner or camera data to this intended rgb* data is always possible, for example by a Lookup table.

The rgb* data of any pixel have a linear relation to the LCh* CIELAB data. Therefore the LCh* CIELAB data are known for any pixel. The further study of the loop Output - Input - Output shows: The original test chart file is produced again, if the 729 equally spaced rgb* data produce the linearized output in offset, and if the rgb data of the scanner or the camera are linearized to the rgb* data. In CIE terms the loop of Fig. 1 produces colour fidelity.

Linearization of the rgb data of the scanner or the camera to the rgb* data is in this case a device calibration for colour offset material. In addition the device is then able to "measure" other colour material in any colour scene with this calibration. With a material or scene dependent calibration the accuracy can be improved.

The next Plenary of ISO TC42 will be in Sapporo/Japan, June 2-5, 2015.

L1-6	ISO/TC130: Graphic Technology

Liaison: Danny Rich

ISO TC 130 held its spring meeting in conjunction with IPEX at the ExCeL Center in London, 23-28 March 2014 and the fall meeting at the Beijing Landmark Hotel, Beijing, China 14-20 November 2014.
The fall meeting included a plenary session and I have included relevant actions and advances from ISO TC 130 in this report.

ISO 12640-5, Graphic technology — Prepress digital data exchange — Part 5: Scene-referred standard colour image data (RIMM/SCID)
DIS ballot closed 2012-12-04 and was approved with no negative votes. Comments from USA, UK and Japan were resolved and the document has been forwarded to ISOCS for publication. A proof is promised by the end of October 2013.

ISO 16760, Graphic technology — Prepress data exchange — Preparation and visualization of RGB images to be used in RGB-based graphics arts workflows
Has been submitted to ISO/CS for publication

ISO 17972-1 Graphic technology — Colour data exchange format (CxFx) Part 1: Relationship to CxF3
Is in final preparation for submission to ISO/CS for publication

ISO 17972-2, Graphic technology — Colour data exchange format (CxF/x) — Part 2: Scanner target data
This document is in NWI/CD ballot which closed December 11, 2014.
ISO 17972-3, Graphic technology — Colour data exchange format (CxF/x) — Part 3: Output target data
This document is in NWI ballot which closed December 11, 2014.

ISO 17972-4, Graphic technology — Colour data exchange format (CxF/x) — Part 4: Spot colour characterization data (CxF/X-4)
The DIS ballot was approved on November 13, 2014 with no negative votes. The comments were reviewed in the Beijing Meeting and the document will be prepared for publication and forwarded to ISOCS.

The X-Rite developed CxF color exchange format based on XML is becoming very popular in color imaging.

ISO/DIS 12646, Graphic technology — Displays for colour proofing — Characteristics and viewing conditions
ISO 12646 published 2008-06, Amendment published 2010-08. The DIS ballot has been approved. After resolving a US comment (Action Item) to ISO/CS for final publication.

ISO/DIS 14861, Graphic technology — Colour Proofing using electronic displays
The DIS ballot has been approved. After resolving a US comment (Action Item) to ISO/CS for final publication.

These two documents form a pair of standards one for the manufacturer of color displays and one for the users of color displays.

ISO/DIS 18619 was approved with no negative votes. The result of voting was distributed as JWG7N098 and the resolution of comments as JWG7N099. A publication draft (N100) with the comments incorporated was distributed to both JWG7 and the ICC for a 30-day review with a deadline of 11/10/14. No comments have been received. The US delegation to submit ISO 18619 to the TC130 Secretariat with a request to send to ISO/CS for publication

ISO 15076 Mr. William Li provided a presentation on the new ICC file format "iccMAX" which has recently been announced to the public. He explained that the original ICC specification, first published as ISO 15076 in 2005 is now widely used.
Key areas that iccMAX differs from v4:

- Connection space extensions
- multiProcessingElements
- Hierarchical tag types
- Other Extensions
  - Color space encoding profiles
  - Gamut boundary description encoding
  - Color measurement (CxF) tag encoding
  - UTF8 text & UTF16 encoding
  - Additional numeric array types

There is a lot of excitement about this new standard. It represents a major step forward in graphic reproduction and a method to adopt more CIE defined color technology into the reproduction workflow.

ISO 16761-1 Graphic Technology — Printing workflow definition, requirements and testing conditions — Part 1: Commercial Printing (project editor, Mr. Elie Khoury)
Status: NWI and WD passed; proposed RoC discussed at the 8th meeting Next step: To provide an updated version of ISO 16761-1 for distribution for a 2-month CD ballot by January 31, 2015

ISO 16761-2 Conformity testing conditions – Package printing workflow (project editor, Mr. Steve Smiley)
Status: NWI and WD passed; proposed RoC discussed at the 8th meeting
Next step: To provide an updated version of ISO 16761-2 for distribution for a 2-month CD ballot by January 31, 2015

ISO 16761-3 Graphic Technology — Printing workflows definition, requirements and testing conditions – Colour quality management certification scheme (project editor,
Mr. Paul Sherfield)
Status: NWI and WD ballot (closed on January 3, 2015)
Next step: To change the project number from ISO 16761-3 to ISO 1930x and to provide an updated version of current ISO 16761-3 based on RoC on the NWI ballot

Harmonization activities
Led by Mr. Erwin Widmer, WG13 harmonization task force conducted a panel discussion on —Opportunities or barriers that certification bodies or printing companies face" at the London meeting, and a workshop on —How to increase and harmonize printing certification worldwide in the Beijing meeting. These events provide a platform for communicating certification status, ideas and experiences among WG13 members.

These 3 standards and the harmonization activity are focused on making graphic reproduction a global engineering process, much like the production of bolts or screws. For this to be fully realized there needs to be a clear definition of object color colorimetry and how to produce color/appearance measurements that agree with a user's normal experience. Many of CIE D1's activities have made this goal realizable but we have not yet reached top of the mountain yet.

TS 29112 Test charts and methods for measuring monochrome printer resolution
TS 29112 final printing experiment started: Sixteen pages in final printing set: objective and subjective. Five countries are providing print sets for round-robin measurement evaluation (China, Japan, Netherlands, USA and Korea). A very wide range of resolution capabilities are captured in the print sets produced by these printing experiments. Sets of objective prints for round-robin measurement evaluation will be distributed to four countries. Analysis of measurements of objective prints to be completed for the January 2015 WG4 meeting in San Jose, California. Parallel subjective scaling experiments (using subjective prints) to provide a ratio scale for perceptual verification of TS 29112 measurement methods. Pilot scaling experiments (RIT – September 2015). Additional scaling experiments (USA, Japan, Netherlands – November 2015). TS 29112 should be ready for DIS ballot in late 2015.

JWG14 Activity Established plan and timetable for creating test samples and investigating extensions of TS 24790 for the evaluation of mottle, graininess, streaking and banding in commercial colour hardcopy prints Established plan and timetable for investigating extensions of TS 29112 for the evaluation of resolution of commercial colour hardcopy prints. Participation in evaluation of the proposed methods for colour gamut description (Phil Green – CIE) and for hardcopy print uniformity (Andreas Kraushaar – FOGRA).

The JWG14 activity involves the mapping of psychophysical judgments of image quality onto objective measurements of image quality. This has been a major challenge as issues like gamut and uniformity as well as surface appearance all impact the quality of a reproduction. CIE D1 can be of further assistance as the process requires a thorough understanding of the perception of the spatial distribution of image elements and when can a surface defect in an image be overlooked or assumed to small or too widely separated to be visually detectable.

Respectfully submitted,

Danny C. Rich

Dr. Danny C. Rich

L1-7	**ISO/IEC JTC1/SC28 Office Equipment**

Liaison: Yaguchi

No report.

L1-8	**IALA (International Association of Lighthouse Authorities)**

Liaison: Malcolm Nicholson

No report.

L1-9	**ISO/TC159: Ergonomics**

Liaison: Ken Sagawa

No report.