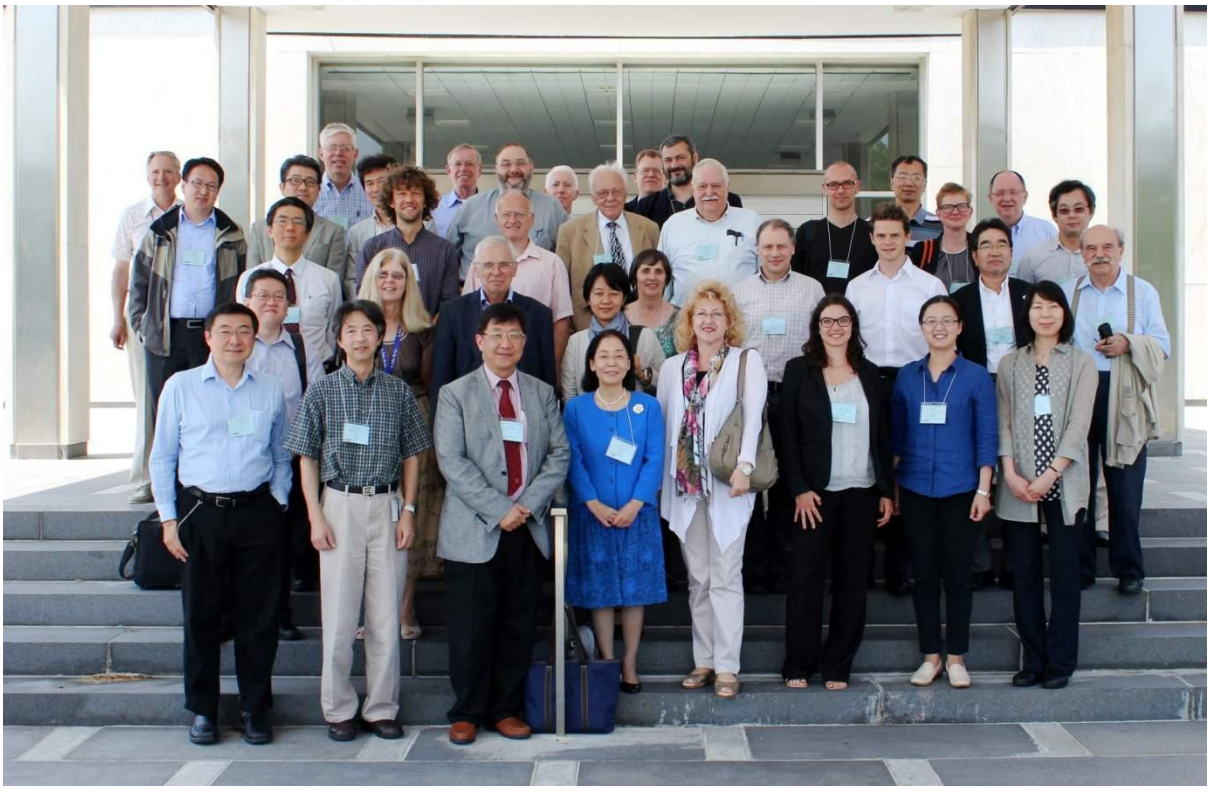
COMMISSION INTERNATIONALE DE L'ECLAIRAGE
INTERNATIONAL COMMISSION ON ILLUMINATION
INTERNATIONALE BELEUCHTUNGSKOMMISSION

DIVISION 1: VISION AND COLOUR

MINUTES of the 7th Meeting of the Luo Term

Monday 16 June 2014
Tuesday 17 June 2014

NIST, Gaithersburg, Maryland, US



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1. WELCOME

The Division Director, Ronnier Luo, welcomed all those present to NIST and thanked the hosts, including the Inter-Society Color Council, for making all of the arrangements for the meeting.

2. ATTENDENCE

Officers	Ronnier Luo	GB	DD – Director
	Miyoshi Ayama	JP	AD – Vision
	Ellen Carter	US	AD – Colour
	Phil Green	GB	DE – Editor
	Mike Pointer	GB	DS – Secretary (via Internet)

Country Representatives	Australia	Peter McGinley*	(via internet)
	Belgium	Peter Hanselaer	
	Brazil	Ana Paula D. Alvarenga	
	Canada	Sharon McFadden	
	China	Changjun Li*	
	France	Sophie Jost	
	Germany	Klaus Richter	
	Great Britain	Mike Pointer	(via internet)
	Hungary	Janos Schanda*	
	Italy	Laura Bellia	
	Japan	Miyoshi Ayama	
	Korea	Youngshin Kwak*	
	Netherlands	Esther de Beer	
	Norway	Jan Henrik Wold	
	Spain	Manuel Melgosa	(via internet)
	Sweden	Ludovic Coppel	(via internet)
	Turkey	Rengin Unver	
	USA	Paula Alessi	

*Nominated representative

In addition, Andrew Chalmers (New Zealand) nominated the Division Secretary as his voting representative.

Thus there were 19 countries represented at the meeting for official ballots.

Technical Committee Chairmen	Miyoshi Ayama	TC1-42
	Manuel Melgosa	TC1-55
	Klaus Richter	TC1-63, TC1-81, L1-05
	Sharon McFadden	TC1-64
	Hiroyasu Ujike	TC1-67
	Changjun Li	TC1-71, TC1-73, R1-42
	Janos Schanda	TC1-74, TC1-85
	Ronnier Luo	TC1-75, TC1-78, L1-04
	Jan Henrik Wold	TC1-82
	Nana Itoh	TC1-84
	Po-Chieh Hung	TC1-89
	Hirohisa Yaguchi	TC1-90, L1-07
	Kaida Xiao	TC1-92
	Robert Carter	TC1-93
Reporters	Hugh Fairman	R1-52
	Phil Green	R1-58
Liaison	Paula Alessi	L1-01
	Danny Rich	L1-06

Guests	In addition there were approximately 10 guests present.		
Apologies	Andrew Chalmers	NZ	
	Wendy Davis	AU	
	Steve Fotios		TC1-80
	Marte K Gunde	SI	
	Jishoo Hwang	KR	
	Li-Chen Ou		TC1-86
	Ken Sagawa		L1-09
	Michael Stock		L1-02
	Klara Wenzel	HU	
	Haising Xu	CN	
	Joanne Zwinkels		L1-03

Total attendance: Approximately 40 persons

3. MEMBERSHIP

The following changes in national representative to Division 1 were noted:

Italy: from Osvaldo da Pos to Laura Bellia
France: from Francoise Vienot to Sophie Bossard-Jost
Germany: Klaus Richter appointed member
Australia: from Peter McGinley to Wendy Davis

The following additional member countries have appointed a representative to Division 1:

Thailand: Sorasakdi Ungbhakorn

4. CONFIRMATION OF THE AGENDA

The Agenda, as appended to these Minutes, was agreed.

5. MINUTES

The Minutes of the 2013 meeting held in Leeds, Great Britain, were approved.

6. MATTERS ARISING FROM THESE MINUTES

There were no matters arising not covered by items on the agenda.

7. DIVISION OFFICER REPORTS

7.1 Director

The Director presented a report and highlighted the following points from the activities over the last year:

Terms of Reference

To study visual responses to light and to establish standards of response functions, models and procedures of specification relevant to photometry, colorimetry, colour rendering, visual performance

and visual assessment of light and lighting.

Officers

Director	Ronnier Luo (GB)
Associate Director (Colour)	Ellen Carter (US)
Associate Director (Vision):	Miyoshi Ayama (JP)
Secretary:	Michael Pointer (GB)
Editor:	Phil Green (GB)

Status

- The Division last met on 5-6 July 2013 in Leeds, Great Britain.
- There are currently 30 Technical Committees (12 Vision + 18 Colour), 1 Joint Technical Committee, 7 Reporters and 7 Liaisons to Division 1

Recent Publications: Reports

204:2013: Methods for Re-defining CIE D Illuminants
208:2014: Effect of Stimulus size on Colour Appaearance

Recent Publications: Standards

None

Close to Publication

TC1-36 Fundamental chromaticity diagram with physiological significant axes (TC ballot)
TC1-42 Colour appearance in peripheral vision (Being produced by CB)
TC1-64 Terminology for vision, colour and appearance (Technical Note)
TC1-80 Research methods for psychophysical studies of brightness judgments (Final balloting)

New Technical Committees – Leeds

TC1-93 Calculation of self-luminous neutral scale Robert Carter US
TC1-94 Visually meaningful spectral luminous efficiency functions Janos Schanda HU

New Reporters – Leeds

R1-60 Future colour difference-evaluation: Guihua Cui CN

Meetings

CIE2014 Lighting Quality and Energy Efficiency, Kuala Lumpur, 23-26 April

- D1 TCs 1-83, 1-86, 1-88, 1-90, 1-91 meetings held on 28 April 2014.
- TC1-83 and TC1-88 were holding their first meeting since being established.
- D1 organised 1 out of 7 workshops, provided 2/6 invited talks, 11/67 oral papers in 2/10 oral sessions and 12/87 poster papers.
- At a two-hour workshop on Colour Quality for Museum Lighting, Janos Schanda gave an invited talk on 'What is Colour Fidelity in Museum Lighting?'

CIE Directors and Board Meetings

Held in Kuala Lumpur in conjunction with the above conference - main items discussed included:

- Priority projects – TC1-90 Colour Fidelity Index
    - To prepare the Technical Guideline (close to finish) and the Technical Proposal (10 February 2014)
    - Purchasing samples and buying people's time to work on the data analysis – EURO 15,000
    - To deliver a technical report within a year
    - To revise the Proposal sent to GLA on 25 April

    - To wait for the response by 25 June
- CIE/ISO TC274 Light and Lighting is up and running with CIE for science and ISO for applications: technical committee members should be split approximately equally.
- A report from a Reporter will in future go through a review process and to be published either as a Technical Note or on the Division website
- New CIE officers: a call for nominations went out on 10 June 2014
- International Year of Light (2015)
    - Global open lab day
- Proposed Joint JTCs –
    - Proposed JTC (D3/D1): Discomfort caused by glare from luminaires with a non-uniform source luminance
    - Proposed JTC (D4/D1): To review the CIE 143:2001 International Recommendations for Colour Vision Requirements for Transport

Division Strategy

- To closely follow the Code of Procedure and to use the Colltool.
- To continue to cover aspects of traditional colorimetry (new colour matching functions to extend to different age observers and viewing fields; new uniform colour space to perform much better than CIELAB and CIELUV; and a more comprehensive colour appearance model than the current CIECAM02).
- New topics:
    - Glare modelling on non-uniform sources
    - New colour vision test
    - Colour tolerance for LED lights
    - Whiteness index, a new index of lighting quality, purple LED?
    - Uni-dimension colour appearance scales, or a comprehensive model?
    - New appearance scales including blackness, whiteness, depth, vividness, clarity scales?
    - Appearance model of lighting

Next CIE Division 1 Meetings

- CIE Session 28 June to 3 July 2015 in Manchester
- AIC 2017 16-20 October 17 in Jeju, Korea

7.2 Editor

- Produced the Activity Report 2013
- The following TC reports have been received by the Editor: TC1-36, TC1-42, TC1-80

7.3 Secretary

- Produced and distributed the Minutes of 2013 Leeds meeting
- Contributed to and distributed the 2014 Activity Report
- Contributed to the setting up of the 2014 NIST meeting – my thanks to Ellen Carter for her considerable help with this in the USA
- Maintained the CIE D1 website
- Sent/received approximately 1157 emails!

8. TECHNICAL REPORTS VISION: Miyoshi Ayama

TC1-36 Fundamental Chromaticity Diagram with Physiologically Significant Axes:

Françoise Viénot FR

A TC ballot of the final draft of Part II of the Technical Report has been completed, and the Report will now be submitted to the Division for onward submission to the CB.

TC1-42 Colour Appearance in Peripheral Vision: Miyoshi Ayama JP

The TR is in the final BA/DIV ballot with a deadline of 20 June 2014.
Secretary's Note: This Report has now been published as CIE 211: 2014 Colour appearance in peripheral vision.

TC1-67 The Effects of Dynamic and Stereo Visual Images on Human Health: Hiroyasu Ujike JP

The second revision of the draft TR was circulated to all the TC members and also some other CIE members in D6, in 2013. Based on the comments obtained, a third revision was provided and this has just been circulated to all the TC members and other members in D6, in June, 2014. The TCC will finalize the document, and will start the TC ballot as soon as responses are obtained.

The TCC also showed the future time schedule as indicated below:
By July 18th:
Comments and suggestions on the present third draft are being invited from all the TC members and other CIE members in D6.
On August 1st:
If TCC judges that there is approval for the third draft then a formal TC ballot will be started for one month.
By September 30th:
If no negative vote is obtained in the TC ballot, the revised draft will be prepared based on technical comments obtained during the ballot, and submitted to D1.

TC1-78 Evaluation of Visual Performance in the Real Lit Environment: Monica Billger SE

The DD took over as TCC in 2013, however, he could not find enough members who have strong interest fulfilling the Terms of Reference. A ballot to close this TC was approved.

TC1-80 Research Methods for Psychophysical Studies of Brightness Judgements: Steve Fotios GB

The final draft of the TR and the TC ballot have been completed, and the TR is in the final stage, BA/DIV voting, with a dead-line of 13 July, 2014.
Secretary's Note: This Report has now been published as CIE 212: 2014 Guidance towards best practice in psychophysical procedures used when measuring relative spatial brightness.

TC1-82 The Calculation of Colour Matching Functions as a Function of Age and Field Size:

Jan Henrik Wold NO

The TC met in Gaithersburg, on 15 June, 2014. The TCC reported on the status of the committee work. A preliminary stand-alone version of a Python computer program which can calculate cone-fundamental colour matching functions for a particular age and field size(from 1° to 10° in 0.1 step intervals) was demonstrated. New options are as follows:

- Comparisons with existing standards, CIE 1931 and CIE 1964, can be indicated,
- Wavelength domain and wavelength step can be chosen from given choices,
- Tables and plots can be saved in several different file formats.

A preliminary web-application for the CIE web-site was also demonstrated. A MATLAB version is being developed by TC member, Dr. C-H Lee. Investigation of the data for elderly people is still needed to determine the cut off with respect to the age range. The TCC will contact members of D6 on this issue.

TCC and attendees at the meeting agreed that the application is not just the common property of the CIE members, but should be in the public domain. It was proposed that the way to open the application, i.e., the way to give permission to access the application, should be seriously discussed in the TC, Division, and BA, to avoid undesirable usage.

TC1-83 Visual Aspects of Time-Modulated Lighting Systems: Dragan Sekulovski NL

A TC meeting was held at the CIE Kuala Lumpur conference, on 28 April, 2014. The agenda and memo of the TC meeting are as follows,

1. Introduction
2. Recent studies; the TCC showed the experiments and measurements carried out done at Philips EH and China on items 1 and 2 of the ToR.
3. Definition revisited; Definitions of “Flicker”, “Stroboscopic effect”, and “Ghost effect” were discussed. The TCC proposed the definitions which were approved in the TC.
4. Methodology.

The TCC described the activity following the previous TC meeting:

- In Eindhoven, a large measurement overview of the temporal properties of both traditional and LED lamps was carried out and correlations between measures computed.
- Also in Eindhoven, a flicker measurement experiment was carried out.
- In South East University, an experiment on the influence of light level on the visibility of the stroboscopic effect was carried out.
- A setup able to measure the sensitivity to the stroboscopic effect was built at NTUST (needs confirmation).

At the Kuala Lumpur meeting, the following items were accepted unanimously:

- A more general set of definitions of temporal properties of visual perception.
- A draft proposal on methodologies for experiments.

The next meeting will be held on WebEx, and the TCC will show the draft of a TR.

TC1-84 Definition of the Visual Field for Conspicuity: Nana Itoh JP

A TC meeting was held in the Division 1 Meeting, on 16 June, 2014, at NIST. The agenda of the Meeting was as follows:

1. Report from Chair
   Review of last meeting.
   Purpose of the 3nd Meeting of TC1-84 2014
2. Discussion
   “Guideline of how to consider visual fields function to increase the visibility of visual information”
3. Schedule and tasks assignment

The TCC proposed the format of “General guidelines of considering functional visual field,” shown below:
Example:

- Sufficient contrast between signs and its surroundings is …
  Increase the luminance contrast of target and background is needed for elderly people.
  see reference XX: Effect of luminance contrast for detectability

Above style was accepted.

Minutes of TC meeting, 2014;

- The framework of guideline and the examples of how to use the data of visual field were explained in TC meeting.
- All attendees agreed to continue efforts to make guideline.
- TCC will collect more references about the performing tasks, e.g., vection.
- TCC will check the ILV definition of the term "visual field", and reconsider an alternative term if necessary.
- Complete the first draft by the next meeting of D1 in Manchester, 2015.

TC1-88 Scene Brightness Estimation: Yoshiki Nakamura JP

A TC meeting was held at the CIE Kuala Lumpur conference, on 28 April, 2014.
The CB has just accepted this TC in March 2014, and thus the meeting was the start-up meeting.

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.

The Working Program is as follows:
In 2013, 2014, members investigated current research on brightness estimation methods using a calibrated luminance image of a real indoor scene, and will make a list of them and will give explanatory descriptions of them.
In 2015, several members in different laboratories will carry out experiments to compare brightness estimations of real indoor scenes with those predicted by different estimation methods.
In 2016, the TC will finalize the activity and recommend a method to predict the brightness of specified regions of a scene from a luminance image of that scene.
The TCC showed his study using contrast profile technique.
The next meeting will be held in the CIE 2015 or via WebEx.

TC1-89 Enhancement of Images for Colour Defective Observes : Po-Chieh Hung JP

An informal physical TC Meeting was held in the D1 Meeting, on 16 June, 2014.

Technical presentations in TC meetings from the beginning are listed below.
1st meeting, December 2012:
Exact Compensation of Color-Weakness with Discrimination Threshold Matching (Rika Mochizuki)

2nd meeting, February 2013:
An efficient naturalness-preserving image-recoloring method for dichromats (Giovane Kuhn, Manuel M. Oliveira, and Leandro Fernandes)
Real-time temporal-coherent color contrast enhancement for dichromats (Gustavo M. Machado and Manuel M. Oliveira)
Proposal on hypothetic model for color defective observers (Yasunari Kishimoto)
3rd meeting, May 2013:

Proposal of real-time and bi-directional color simulator for dichromacy and trichromacy on smart phones (Sakuichi Ohtsuka)
A colour conversion method which allows colour blind and normal-vision people share documents with colour content (Po-Chieh Hung)

4th meeting, July 2013:
An analytical strategy for color vision deficiency using a digital color vision test plate (Hung-Shing Chen)

5th meeting, August 2013:
Classification of enhancement methods by measures against color confusion: Introduction of image enhancement methods based on color separation, p/d-safe color palette, and related problems (Takashi Sakamoto)
Adaptive color visualization for dichromats using a customized hierarchical palette (Gaurav Sharma)

6th meeting, September 2013:
Inherited color vision deficiency diagnostics with special focus on monitor based tests and their correlation with genetic analysis (Balázs Vince Nagy)
Preference for color enhanced images assessed by color deficiencies (Miyoshi Ayama)

7th meeting, November 2013:
Color universal design - Analysis of color category dependency on color vision type (4) – (Yasuyo G. Ichihara)

8th meeting, February 2014:
Feeling edgy about color blindness (Alessandro Rizzi – invited)

The TCC showed the planned structure of the TR as indicted below, and it was basically agreed in this informal meeting, but will be discussed in the formal meetings through WebEx.

0. Introduction
1. Scope
2. Definition
3. Use-case and requirement
   - 3.1 Use-case
   - 3.2 Requirement
     - 3.2.1 Distinction
     - 3.2.2 Color name information
     - 3.2.3 Preservation of original color
     - 3.2.4 Preference
4. Enhancement technique
   - 4.1 Recoloring
     - 4.1.1 Classification
     - 4.1.2 Recoloring
     - 4.1.3 Lookup-Table-based Techniques
     - 4.1.4 Optimization-based Techniques
     - 4.1.5 Projection-based Techniques
   - 4.2 Pattern based (texturing)
   - 4.3 Edge enhancement (spatial processing)
   - 4.4 4.4 Comparison of techniques
5. Test method for enhancement technique

5.1 Abstract
5.2 Test image
5.2.1 Natural image (Photographic image)
5.2.2 C/G (SciVis, color gradation)
5.2.3 Text & graph (office docs, map)
5.3 Evaluation method
5.3.1 By CDO
5.3.2 By Simulator + Normal vision
6. Recommendation
7. Appendix
7.1 Detection of CDO
7.1.2 visual test
7.1.3 gene test
7.2 List of group of color deficiency people
7.3 Color difference data for uniform color space

Purpose of the physical informal meeting is to introduce the TC activity to non-members and to obtain comments from them.
Comments obtained:
General

- These techniques can solve small field Tritanopia (about 20' in diameter) issue. At least, a note should be added in TR.
- Unique hue of CDOs is being obtained. Preliminary data (unpublished) can be provided.

Categorization of recoloring

- Original color is kept or not
- Discrete or continuous
- Non-technical categorization is appreciated

TC1-93 Calculation of Self-luminous Neutral Scale: Robert Carter US

The TCC showed the timeline of the TC indicated below:

- Approved unanimously by 23 national delegates to CIE Division 1, June 2013.
- Approved by CIE Central Bureau August 28, 2013.
- Completion expected by August 2017. Milestones:
  - Specify a calculation of self-luminous neutral scale, 2014
  - Integrate self-luminous neutral scale with CIE color difference calculations, 2015
  - Standardize the meaning of “neutral”, 2016
  - Complete CIE Paperwork, 2017
  -

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.)

Tasks are going to be done by the subcommittees below:

1. Specify a calculation of self-luminous neutral scale (Robert Carter, Michael Brill, Geunyoung Yoon)
2. Define the meaning of “neutral” in neutral scale (Robert Marcus, Kevin Smet, Danny Rich)
3. Integrate the neutral scale calculation with color space and color difference calculations (Claudio Oleari, Manuel Melgosa, Rafael Huertas)
4. Consider the specified calculation and alternatives in various contexts (Phil Green, Miyoshi Ayama, Schanda, Elizabeth Krupinski, your name here?)

Task of the subcommittee 1;

- Start with “simplest and most precise” neutral scale formula from Whittle, Vis. Res., 1992.
- Show that the slope of crispening (b) increases with background luminance (Whittle footnote in Gilchrist: Lightness, Brightness and Transparency, 1994). Carter, Brill.
- Calculate formula’s k: proportion of retinal contrast lost to intraocular scattering. Use convolution of PSF with image, taking account of pupil size (as affected by image luminances). Yoon, Brill, Carter.

Task of the subcommittee 2;

- In Whittle calculation, background luminance is zero of neutral scale, between positive & negative contrasts.
- In commercial contexts, customers prefer a bluish hue in “neutral” scale. Marcus and Rich have ideas about how to standardize this. Note, TC1-82: luminance has 0 blue cone weight, depending exclusively on R&G cones.
- Arend & Spehar (P&P, 1993) found that neutral scale is most stable when the entire range of the scale is simultaneously visible, particularly the maximum and minimum luminances which anchor the neutral scale.
- Smet has applied for funding to do research.

Task of the subcommittee 3;

- Oleari is writing a book on color difference. He intends to try Whittle’s logarithmic formula and Semmelroth’s formulas for self-luminous neutral scale, during 2015.
- Melgosa and Huertas have individually applied for funding to research the topic.
- The minimum objective is to generalize CIE color difference formulae to self-luminous applications.

Task of the subcommittee 4;

- Phil Green and a PhD student have computed stress for fit of Whittle and DICOM GSDF formulae with self-luminous data. Both fit.
- Elizabeth Krupinski has compared the concepts of Whittle’s formula and the DICOM GSDF. They are compatible. While the GSDF fulfills a specialized purpose, Whittle’s is more general.
- Schanda, Ayama intend related student projects.
- We would welcome your participation to show the limitations of computing self-luminous neutral scale.

The TCC demonstrated uses of Whittle’s formula in the literature. The TCC also showed the calculation of JNDs in various backgrounds and far surround luminance conditions.

The following are further issues to be solved, and the TCC asked for help from the attendees:

- Calculate the Intraocular Point Spread Function convolutions with image segments to estimate Whittle’s k parameter.
- Identify self-luminous data (wide range of background luminances) for evaluation of color difference with self-luminous neutral scale.
- Model the effect (on neutral scale) of far surround highlight. Independent variables of Whittle’s formula are target’s and adjoining background’s luminances, not far surround luminance highlight.

TC1-94 Visually Meaningful Spectral Luminous Efficiency Functions: Janos Schanda HU

This TC was proposed and accepted by the Division, and established officially in 2013. According to

the email from the TCC, it is agreed at the meeting that the work of the TC will start after completion of the updating of CIE 15 Colorimetry, scheduled for the 2015 CIE Session. It was agreed unanimously at this meeting to change the TC Chairman from Janos Schanda (HU) to Ferenc Szabó (HU).

JTC-1 Implementation of CIE 191: Mesopic Photometry in Outdoor Lighting: Liisa Halonen FI

Both the TCC and TCS have resigned from the JTC. A JTC Meeting was held at the CIE Kuala Lumpur Conference, on 28 April, 2014, chaired by Ron Gibbons from D4. The TC has been divided into two sub-TCs, one for Task 1 (investigation of adaptation and viewing conditions, definition of visual adaptation fields), and the other for Task 2 (lighting applications of mesopic photometry) and Task 3 (provision of guidelines for implementation). The chairmen of the TC and sub-TCs are as follows:

- Sub-TC on Task 1: Tatsukiyo Uchida JP
- Sub-TC on Task 2 and 3: Stuart Mucklejohn GB
- The new TCC is Stuart Mucklejohn GB

R1-49 Above-threshold Pulsed Lights: Malcolm Nicholson UK & Dennis Couzin US

Malcolm Nicholson submitted a report written by Dr. Peter Rhodes (University of Leeds) entitled "Apparent Intensity of Flashing Light." This report is appended to these Minutes. The report was written independently from Dennis Couzin, and his comments will be sent to Malcolm Nicholson and the Division officers. It was agreed to close this Reportership.

R1-51 Reconciling Maxwell vs Maximum Saturation Colour Matches: Mike Brill US

The Reporter informed the meeting that he cannot continue the reportership. The DD asked the audience whether anyone could volunteer to continue this work, but no one responded. It was therefore agreed to close this Reportership.

9. TECHNICAL REPORTS COLOUR: Ellen Carter

TC1-55 Uniform colour space for Industrial Colour-Difference Evaluation: Manuel Melgosa ES

TC Meetings in Leeds (UK), 2013

On July 5th, 2013 a TC meeting was held in Leeds (UK), with participation of 26 people (7 TC members included). The main conclusions of this meeting were as follow:

1. Besides advances made after the development of the CIEDE2000 color-difference formula and the proposal of new color spaces, currently CIE TC 1-55 cannot recommend a new Euclidean color space significantly improving CIEDE2000 from existing experimental datasets;
2. A Technical Report (TR) with tentative title "Method for evaluation of the performance of color-difference formulas" and tentative contents including performance of new color spaces and color-difference formulas will be prepared. After approval of this TR, TC 1-55 will be disbanded;
3. To encourage and follow-up future research on color-difference evaluation. At CIE D1 meeting in Leeds (UK), Dr. Guihua Cui (CN) accepted this responsibility, and was appointed as CIE reporter.

Advances after TC Meetings in Leeds (UK) and Future

The TC chair apologized for the current delay in the preparation of the first draft of the intended TR. He proposed to finish this first draft before the end of the current year 2014. During the past months two tasks were accomplished:

1. We analyzed the paper from E. Kirchner, N. Dekker, J. Opt. Soc. Am. A 9, 1841-1848 (2011) criticizing the STRESS index as an appropriate measurement for evaluating color-difference equations, and proposing as alternative the use of Pearson's linear correlation coefficient in

combination with graphical and diagnostics analyses. We consider that this publication is compatible with the proposal of the STRESS index intended in our TR.

2. Dong-Ho Kim (Korea) published a new color space named ULAB (see Color Res. Appl. Early View, DOI: 10.1002/col.21854) which will be added to the analyses presented in the intended TR.

TC1-61 Categorical Colour Identification: Taiichiro Ishida JP

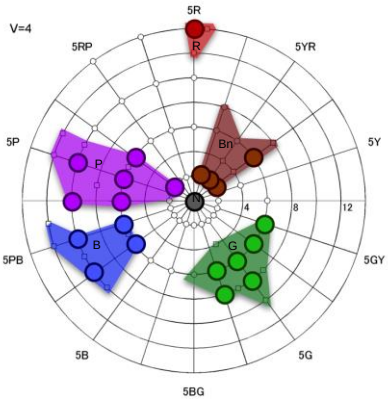
A review of the activities of this TC show the first draft of the TR was written in June 2010, a second draft in October 2011. Then the TC met in Taipei in 2012, and Leeds in 2013. At the 2013 meeting it was agreed to add a chapter to the 3rd draft of the report and circulate the draft to TC members and CIE officers at the same time. Then if the report was acceptable proceed to CIE Publication. The draft with the added chapter was sent to TC members in June 2014.

TC1-61
Recommendation

- preparing the colour categorization maps on the Munsell colour space to show the colours categorized with high consistency.

- small circle: ishida
- small square: Sturges&Whitfield

- Coloured areas: more than 90% agreement at 1000 lx.
- Colour circles with the thick outline: more than 90% agreement both at 1000 and 10 lx.



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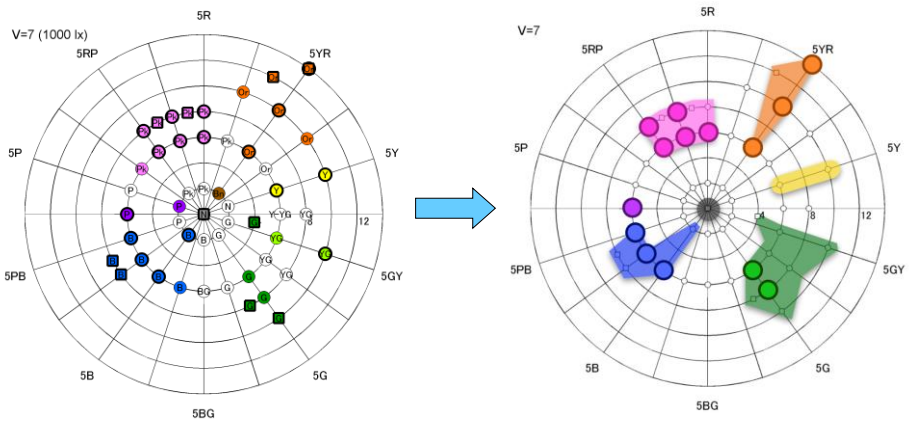
If Yellow-Green and Blue-Green responses were not allowed in Ishida's study, many of the colours named as Yellow-Green or Blue-Green must be named as Green instead. If the Yellow-Green and Blue-Green responses in Ishida's study were integrated to the Green response based on the following criteria:

1. The colour was identified only by "Yellow-Green", "Green" and "Blue-Green" in all trials. None of the other colour terms were used for this colour.
2. The colour was identified as "Green" in more than 50% of all trials.

If the responses of the colour satisfied (1) and (2), the category of the colour was regarded as Green.

TC1-61
Deciding the colour category area



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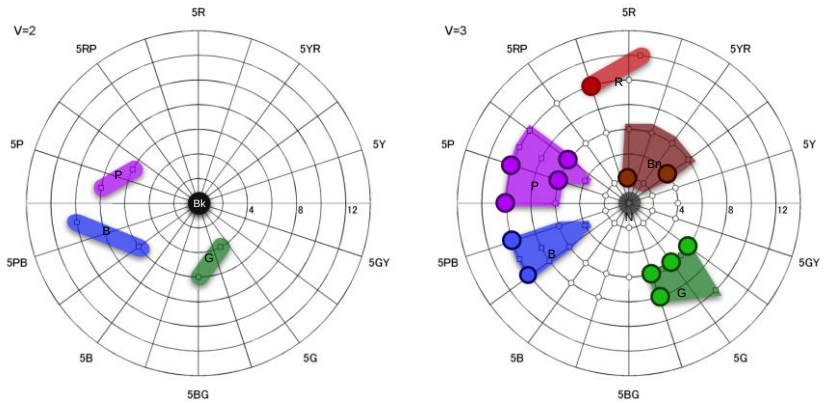
TC1-61
colour categorization map (V=2,3)



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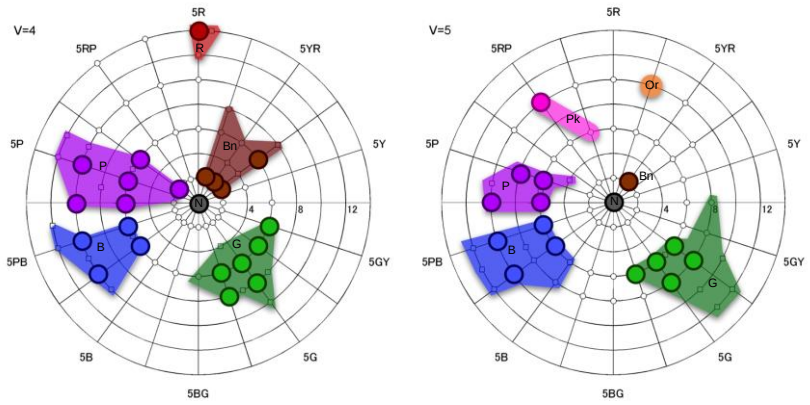
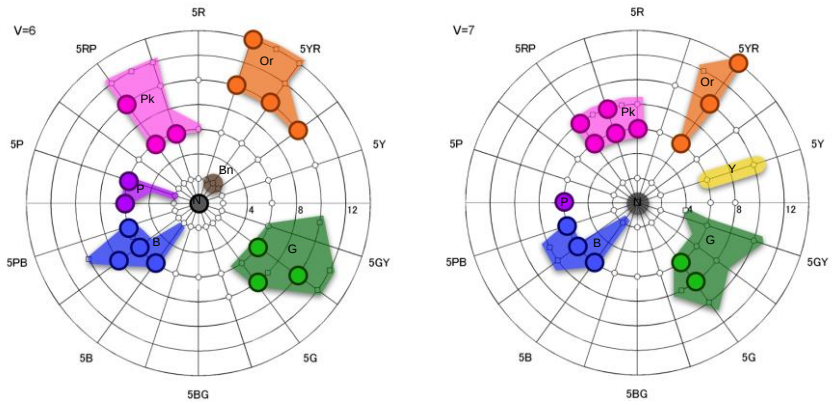
TC1-61
colour categorization map (V=4,5)



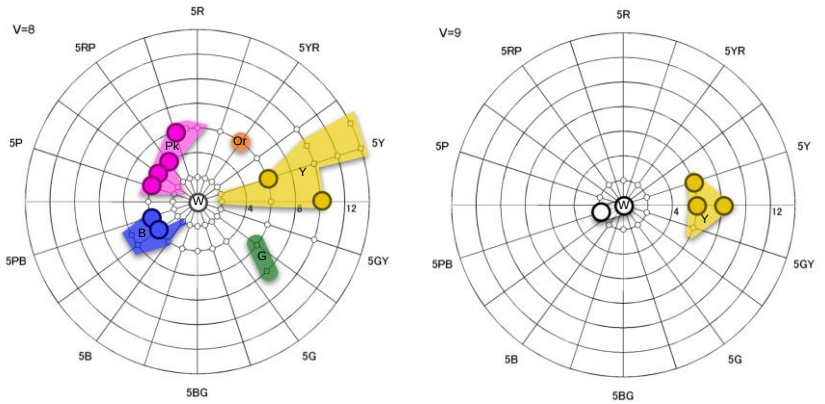
13

TC1-61
colour categorization map (V=6,7)



14

TC1-61
colour categorization map (V=8,9)



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TC1-63 Validity of the Range of CIEDE2000: Klaus Richter DE

The TC1-63 met 16 June 2014 at NIST. A first working draft WD01 was discussed. The first working draft includes the following chapters:

1. Terms of reference
2. Test charts and CIELAB data for the study of large colour differences
3. Results from different countries (CZ, DE, ES, GB)
4. Comparison and standard deviation
5. Colour threshold formula and experimental colour threshold data
6. Results for colour differences at threshold
7. Comparison and standard deviation at threshold
8. Discussion of the results
9. Summary
10. References

Experimental results for large colour differences with the test charts of TC1-63 have been available since some years. Many experimental results produced in four countries (CZ, DE, ES, GB) have been published. The results seem to show that CIEDE2000 and CIELAB may be more equivalent for the description of large colour differences $\Delta E^*_{ab} > 10$. There is some tendency that CIELAB is better, but other researchers have reported the reverse.

Different colour threshold data are now available and are described. The following Table 1 shows the colour threshold formula LABJND 1985 (JND=Just Noticeable Difference). The colour threshold is described by linear functions of the tristimulus value Y and the red-green and yellow-blue chromaticities a=x/y and b=-0,4z/y in luminance units.

Table 1 (UE130-3): Colour threshold formula LABJND 1985

Color threshold formula LABJNDS 1985 (JND=just noticeable difference)

$\Delta E^*_{JND} = Y_0 [(\Delta Y)^2 + (a_0 \Delta a'' \cdot Y)^2 + (b_0 \Delta b'' \cdot Y)^2]^{1/2} / (s + q \cdot Y)^t$

$a = x / y \; a_n = x_n / y_n \; b = -0{,}4 \, z / y \; b_n = -0{,}4 \, z_n / y_n$

$a'' = a_n + (a - a_n) / (1 + 0{,}5 \, |a - a_n|)$

$b'' = b_n + (b - b_n) / (1 + 0{,}5 \, |b - b_n|)$

where n = D65 or A (surround)

$Y = (Y_1 + Y_2) / 2 \; \Delta Y = Y_1 - Y_2 \; \Delta a'' = a''_1 - a''_2 \; \Delta b'' = b''_1 - b''_2$

s = 0,0170 q = 0,0058 t = 1,0

$a_0 = 1{,}0 \; b_0 = 1{,}8 \; Y_0 = 1{,}5$ surround D65

$a_0 = 1{,}0 \; b_0 = 1{,}7 \; Y_0 = 1{,}0$ surround A

Just noticeable difference (JND) in four colour directions

$\Delta Y = \text{const} (s + q \cdot Y)^t / Y_0$ in luminance direction *WN*

$\Delta a'' . Y = \text{const} (s + q \cdot Y)^t / (Y_0 . a_0)$ in chromaticity direction *RG*

$\Delta b'' . Y = \text{const} (s + q \cdot Y)^t / (Y_0 . b_0)$ in chromaticity direction *YB*

$\Delta c_{ab}'' \cdot Y = \text{const} (s + q \cdot Y)^t / (Y_0 \cdot [a_0^2 + b_0^2]^{1/2})$ in any chromaticity direction c_{ab}

The colour difference ΔE^*_{JND} at threshold can be calculated by three terms in white-black, red-green, and blue-yellow direction.

At threshold for example the CIE luminance sensitivity threshold L/dL = Y/dY is constant over a wide range of tristimulus values (6 < Y < 90) for a grey surround field of Y = 18. The constant ratio Y/dY is called the Weber-Fechner law. This law produces different results compared to the Stevens law (cube root function) which is used in CIELAB for the lightness L*.

Preliminary results show that the formula LABJND 1985 (JND=just noticeable colour difference) seems better or equal at threshold compared to CIEDE2000. However, the performance is worse by a factor 2, if the available industrial data above threshold in the range up to 1 CIELAB or up to 2 CIELAB are used.

Therefore CIE DE2000 may be used for the whole range above threshold and up to large colour differences.

TC1-64 Terminology for Vision, Colour and Appearance: Sharon McFadden CA

This TC has been collecting terms that were suggested to be added to the ILV. Progress that has been made in the past year includes:

1. In early 2014, approval in principle was given to a third draft of a Technical Note (TN).
2. The draft includes the terms and definitions that have been accepted by TC members.
3. Members recommended that D2 be requested to review some of the terms prior to sending the TN for Division review.
4. The report was sent to D2 in mid April with a request for feedback.
5. A summary of D2 comments is expected shortly.

Once the comments from D2 have been incorporated, a formal TC ballot will be held. The approved TN will be submitted to the Editor.

The TC continues to work on: 1) achieving consensus on the few terms still under discussion; 2) locating additional expertise in vision and 3) monitoring new D1 reports for new terms that should be added to the ILV.

TC1-68 Effect of Stimulus Size on Colour Appearance: Peter Bodrogi HU

The technical committee has finished its work with the publication of Technical Report CIE 208:2014 Effect of Stimulus Size on Colour Appearance. A vote to disband the TC was held at the D1 meeting and passed with unanimous approval.

TC1-69 Colour Rendition of White Light Sources: Wendy Davis US

While this had been a very active TC that generated numerous proposals for improving the calculations of the colour rendition of white light sources, the committee could not agree on recommendations. Two new TCs were formed to carry on aspects of the work and the materials from this TC were passed on to TC1-90 and TC1-91 for their use. No progress toward a final report from this TC has been made since the meeting in 2012. Thus at this year's meeting a motion to disband the TC passed unanimously.

TC1-70 Metameric Samples for Indoor Daylight Evaluation: Balázs Kranicz HU

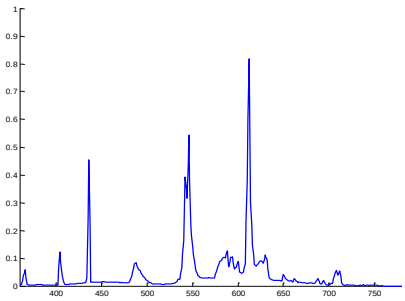
Balázs Kranicz did not submit a report for this TC. However, during discussions at the Division meeting it was commented that the work for this TC was really completed a couple of years ago, just that the TR needs to be written. Janos Schanda said he would try to get a report started by September 2014. It was also noted that on the TC membership list the country affiliation for P Bodrogi should be Germany, and P Rombauts should be Belgium.

TC1-71 Tristimulus Integration: Changjun Li CN

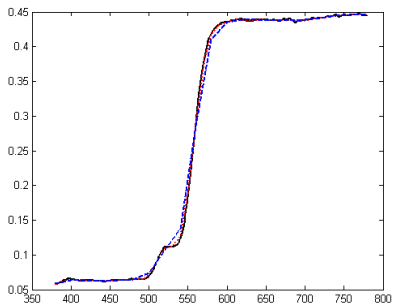
During the past 7 years, the TC has identified the problems in computing tristimulus values (TSVs) when the measured reflectance is at larger intervals such as 10 or 20nm since there is no a single unified method recommended by CIE, which can result in large differences among TSVs obtained from different methods.

Yesterday a meeting of this TC was held and the work was discussed: a summary is shown below.

TC1-71
Tristimulus Integration



3-band fluorescent lamp



Standard 1nm interval (full black curve), measured 10nm (red dotted curve), and measured 20nm (blue dashed curve) reflectance curves:

Table 1: Tristimulus values calculated using 1nm (Standard (S)), 10nm and 20nm T5, OP, LS, and DS weighting tables under a 3 band fluorescent illuminant.

	X10	Y10	Z10	X20	Y20	Z20
S	**38.91**	**28.66**	**2.37**	**38.91**	**28.66**	**2.37**
T5	38.94	28.72	2.37	39.16	29.25	2.38
OP	38.92	28.68	2.37	39.01	28.86	2.37
LS	38.92	28.68	2.37	39.02	28.86	2.37
DS	44.81	31.05	1.33	32.76	27.59	1.40

Table 2: Colour differences between each pair of the tristimulus values of standard, T5, OP, LS, DS. The bold values are under 20nm interval, and normal values are under 10nm interval.

	S	T5	OP	LS	DS
S	0	0.21	0.08	0.09	19.58
T5	**1.76**	0	0.13	0.12	19.56
OP	**0.58**	**1.19**	0	0.01	19.56
LS	**0.57**	**1.20**	**0.01**	0	19.57
DS	**19.37**	**17.75**	**18.83**	**18.84**	0

Hence it is really desired if we can have a unified method for computing TSVs. Here we quote the remarks from Fred W. Billmeyer, Jr. and Hugh S. Fairman, Color Research and Application, 1987:
"There should be no reason for the introduction of significant errors in this calculation process, even though other errors, such as those of specimen preparation or measurement, may be large in comparison."
Several methods have been identified, including:

1. Direct Selection (DS)
2. CIE-R method (interpolating measured reflectance into 1nm data and then use the 1nm summation formula)
3. ASTM Table 5 (T5)
4. ASTM Table 6 (T6)
5. Optimum Method (Li-Luo-Rigg, LLR);
6. Least Square Method (Li-Wang-Luo, LWL)
7. Zero-Order method(based on Oleari's work, OWT(0))

Second-Order method(based on Oleari's work, OWT(2))

	Median	Maximum	Average	80-percentile	95-percentile	Standard deviation
T5	0.0084	0.0490	0.0102	0.0155	0.0251	0.0075
T6	0.0033	**0.0171**	0.0036	0.0047	0.0076	0.0021
LWL	**0.0013**	0.0224	**0.0016**	**0.0021**	**0.0032**	**0.0013**
LLR	0.0038	0.0235	0.0044	0.0069	0.0099	0.0029
DS	0.0265	0.1300	0.0349	0.0619	0.0807	0.0251
CIE-R	0.0105	0.0472	0.0117	0.0175	0.0258	0.0075
OWT(0)	0.0083	0.0373	0.0092	0.0130	0.0202	0.0055
OWT(2)	0.0197	0.0985	0.0224	0.0344	0.0521	0.0154

Table 3: The performance of each method at 10 nm intervals using the combination of three continuous CIE illuminants (D65, A, and D50) and the two CIE standard observers (CIE 1931 and CIE 1964), in terms of the median, the maximum, the average, the 80-percentile, the 95-percentile and the standard deviation of the values of CIELAB color difference. The values in bold/shade indicate the best/second-best method using each of the six statistical measures.

	Median	Maximum	Average	80-percentile	95-percentile	Standard deviation
T5	0.0409	0.3283	0.0500	0.0722	0.1217	0.0362
T6	0.0408	0.3402	0.0488	0.0674	0.1167	0.0348
LWL	**0.0095**	**0.0629**	**0.0116**	**0.0173**	**0.0298**	**0.0089**
LLR	0.0107	0.0713	0.0130	0.0199	0.0322	0.0096
DS	7.3870	17.1542	7.7364	11.0629	13.5658	3.3612
CIE-R	0.0406	0.3295	0.0481	0.0667	0.1137	0.0340
OWT(0)	1.3656	2.9979	1.4373	2.0301	2.4793	0.5988
OWT(2)	0.5928	1.4730	0.6295	0.8841	1.0852	0.2622

Table 4: The performance of each method at 10 nm intervals using the combination of three fluorescent CIE illuminants (FL2, FL7 and FL1 and the two CIE standard observers (CIE 1931 and CIE 1964), in terms of the median, the maximum, the average, the 80-percentile, the 95-percentile and the standard deviation of the values of CIELAB color difference. The values in bold/shade indicate the best/second-best method using each of the six statistical measures.

TC1-71
Tristimulus Integration

	Median	Maximum	Average	80-percentile	95-percentile	Standard deviation
T5	0.1580	0.7437	0.1794	0.2734	0.3916	0.1151
T6	0.0287	0.1454	0.0333	0.0541	0.0777	0.0235
LWL	0.0243	**0.1420**	0.0293	0.0468	0.0687	**0.0208**
LLR	**0.0216**	0.1514	**0.0272**	**0.0444**	**0.0684**	0.0212
DS	0.3250	1.0626	0.4063	0.6339	0.8649	0.2354
CIE-R	0.1581	0.7387	0.1787	0.2726	0.3900	0.1147
OWT(0)	0.1433	0.5601	0.1574	0.2323	0.3347	0.0924
OWT(2)	0.2967	1.4076	0.3380	0.5181	0.7360	0.2180

Table 5: Continuous illuminants/20nm measurements/two CIE standard observers

TC1-71
Tristimulus Integration

	Median	Maximum	Average	80-percentile	95-percentile	Standard deviation
T5	0.3385	2.2159	0.3903	0.5915	0.8528	0.2651
T6	0.2199	2.9731	0.2802	0.3477	0.8319	0.2732
LWL	0.1263	**1.9107**	0.1710	0.2095	**0.5256**	**0.1787**
LLR	**0.1238**	1.9265	**0.1700**	**0.2085**	0.5290	0.1792
DS	4.6344	40.4857	10.0631	21.328	31.6365	10.2927
CIE-R	0.3386	2.2164	0.3901	0.5910	0.8535	0.2651
OWT(0)	0.8812	6.8315	1.7395	3.5294	5.4574	1.7334
OWT(2)	0.9454	4.0219	1.1390	1.8213	2.7572	0.8098

Table 6: Fluorescent illuminants/20nm measurements/two CIE standard observers

For 20 nm interval measurements, test results show LLR and LWL methods are competitive and are better than all other methods though LLR is slightly better than LWL. For 10nm interval measurements, test results show LLR is better than all other methods. Overall, the LWL method is better than the others. Further tests are needed before any recommendation can be made. How to carry out these tests and the likely outcome from this TC will be discussed in the TC meeting and amongst members of the TC.

For measurement interval smaller than 10 nm, further tests will be given and it is hoped the LWL method proves to be better than the others. It seems that the LWL method is the choice if a single method is to be recommended. However, further tests might be needed before any recommendation can be made.

TC1-73: Real Colour Gamut: Changjun Li CN

Since the formation of this TC, some of the members made some studies: Changjun Li, Ronnier Luo and Mike Pointer, together with Phil Green [Li CJ, Luo MR, Pointer M and Green P, Comparison of real colour gamuts using a new reflectance database, Colour Research and Application, 2013(accepted). Firstly, more reflectance data were accumulated, which are the basis for comparing the available gamuts and deriving a new gamut.

Table 1: Description of each reflectance data set

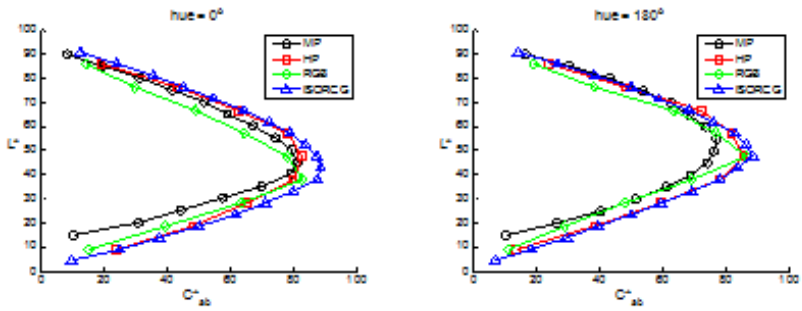
Data set	No. of samples	Surface	Measurement
Group 1			
Sun Chemical	26784	Ink on paper	Sun Chemical
Munsell (Glossy version)	1560	Paint	Leeds
NCS	1749	Paint	Leeds
DIN	981	Paint	Leeds
Munsell Limit Colour Cascade	720	Paint	Leeds
Du Pont Spectra-Master	672	Paint	Leeds
Group 2			
ISO SOCS(Calibration Data)	136	Colour Patches	SOCS data
ISO SOCS (Skin)	8570	Skin	SOCS data
ISO SOCS(Flowers)	148	Natural	SOCS data
ISO SOCS(Graphics)	30624	CMYK Printed	SOCS data
ISO SOCS(Krinov)	346	Outdoor scenes	SOCS data
ISO SOCS(Leaves)	92	Leaves	SOCS data
ISO SOCS(Paint)	505	Painted Objects	SOCS data
ISO SOCS(Photos)	2304	Colour Patches	SOCS data
ISO SOCS(Printer)	7856	Colour Patch Images	SOCS data
ISO SOCS(Textile)	2832	Textiles	SOCS data
Total	85879		

Table 2: Basic information for each of the five 3D colour gamuts: MP, ISOGSC, HP, RGB and ISORCG

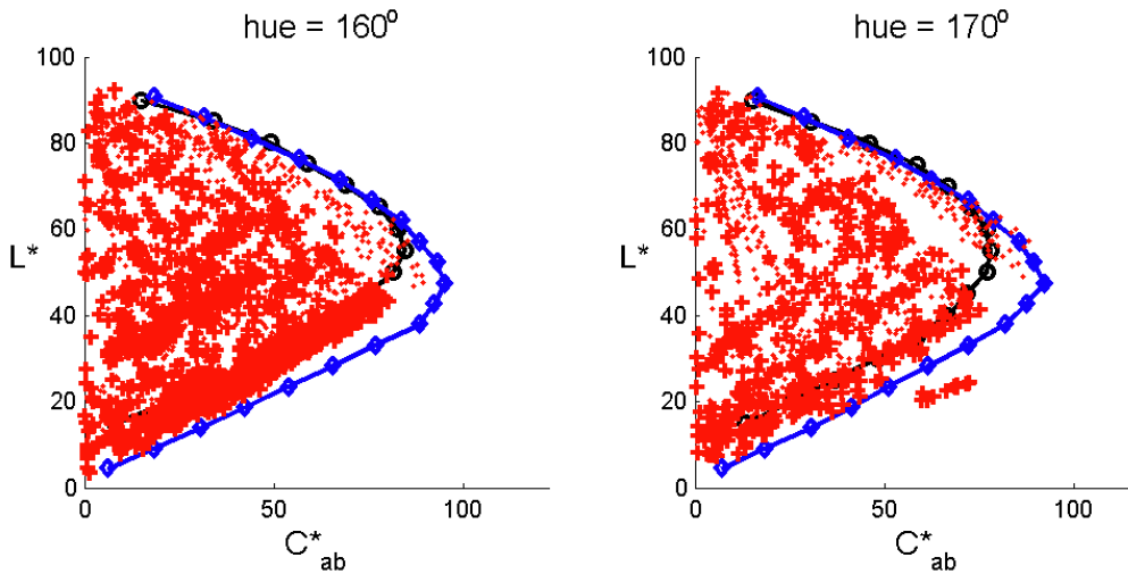
Gamut	CIE LAB Coordinates	Sampling points	LOI	Illuminant	R or A
MP (Pointer)	Hue angle (degrees)	0, 10, …, 350	10°	C	Absolute
	Lightness	15,20,…90	5		
ISOGSC	Hue angle (degrees)	0, 10 ,…, 350	10°	D50	Unknown
	Lightness	5,10,…,95	5		
HP (Printer)	Hue angle (degrees)	0, 22.5, …, 337.5	22.5°	D50	Relative
	Lightness	10,20,…,90	10		
RGB	Hue angle (degrees)	0, 20, …, 340	20°	D50	Relative
	Lightness	10,20,…,90	10		
ISORCG	Hue angle (degrees)	0, 10, …, 350	10°	D50	Relative
	Lightness	5,10,…,95	5		

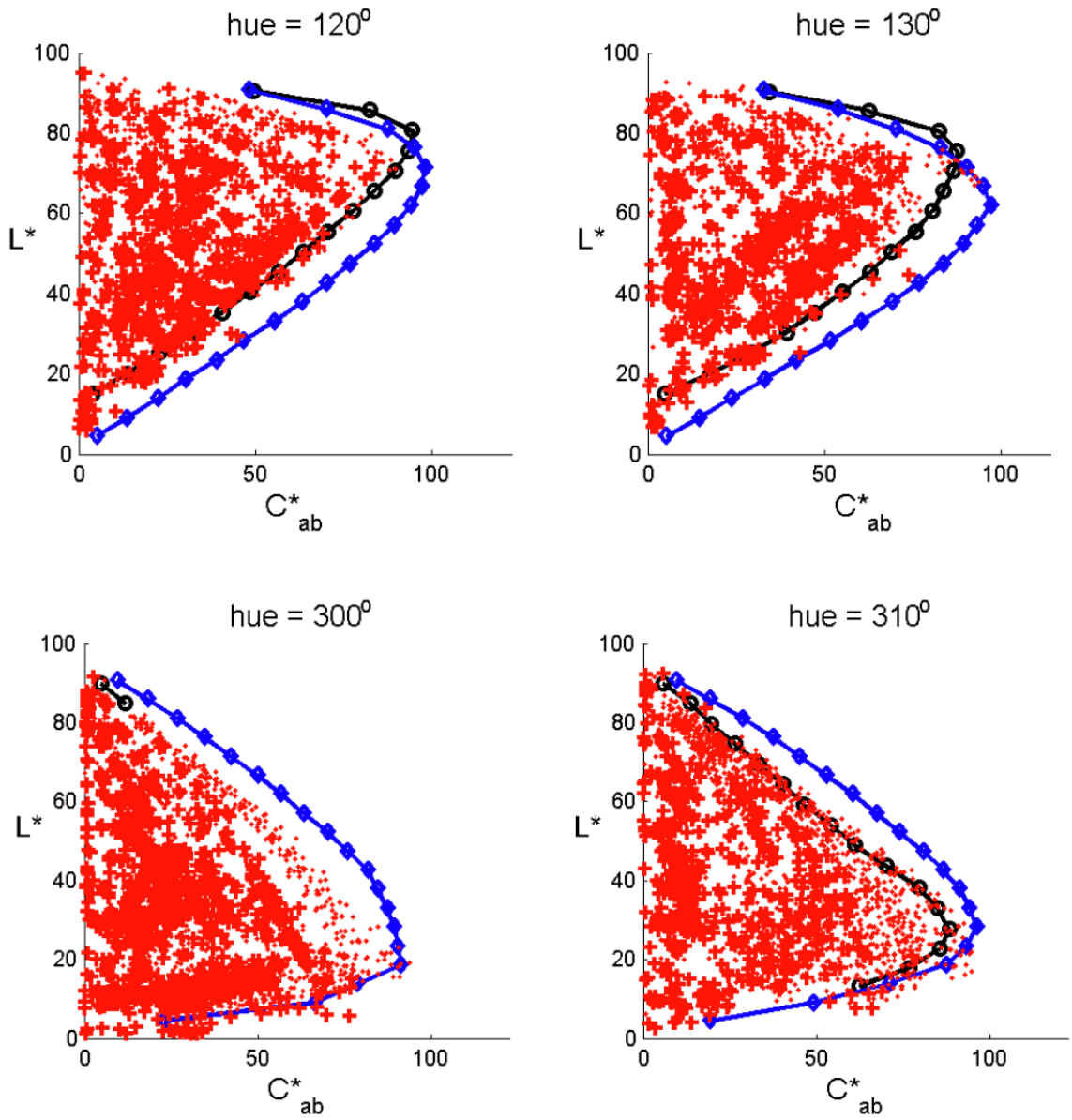
TC1-73
Real Color Gamut

Secondly, some available gamuts were surveyed;



Thirdly, gamuts were compared with real data.





Thus, neither the Pointer gamut nor the ISORCG gives a good fit to the real data.

1. The Pointer gamut is smaller than the new data in most regions of colour space;
2. the Pointer gamut is smaller than the ISORCG for hue planes between 0° and 40°, and between 180° and 350°;
3. in each of the hue planes from 50° to 80° and from 100° to 150° there is one part where the Pointer gamut is larger than the ISORCG, which is unexpected;
4. the ISORCG is larger than the real data in certain parts and is smaller than the real data for certain hue planes.

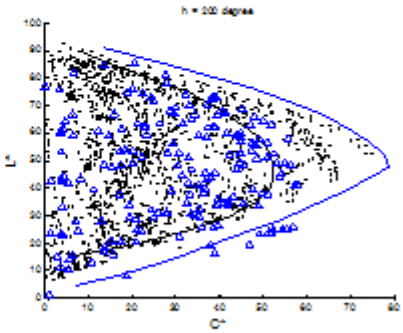
There is a need for a gamut defined in terms of reflectance in order to be able to make calculations under any illuminant.

TC1-73
Real Color Gamut

Recently, a study [2] was made based on the accumulated reflectance data.

Firstly, data reliability was investigated.

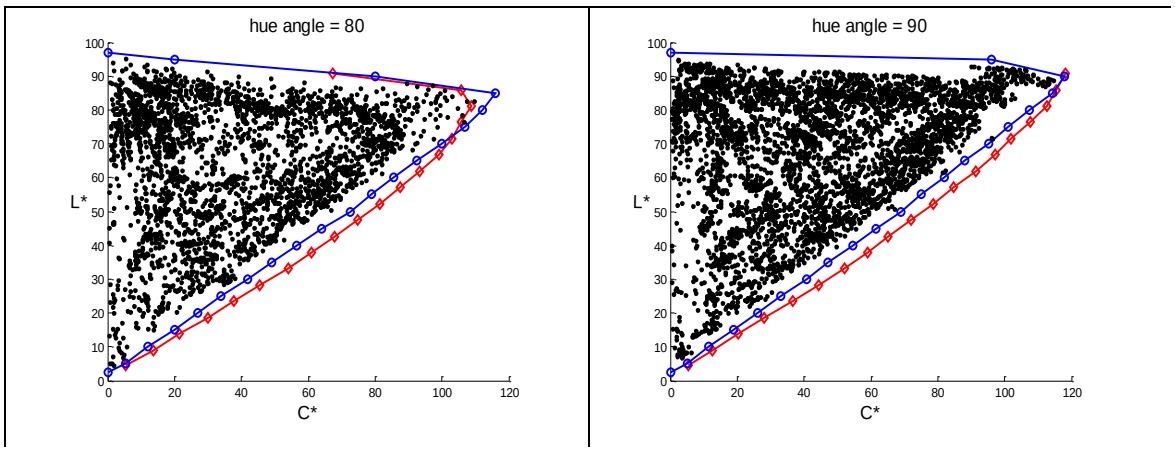
Data in the boundary comes from only one group was considered as questionable such as shown in triangles in the diagram on the right. (right or wrong?)



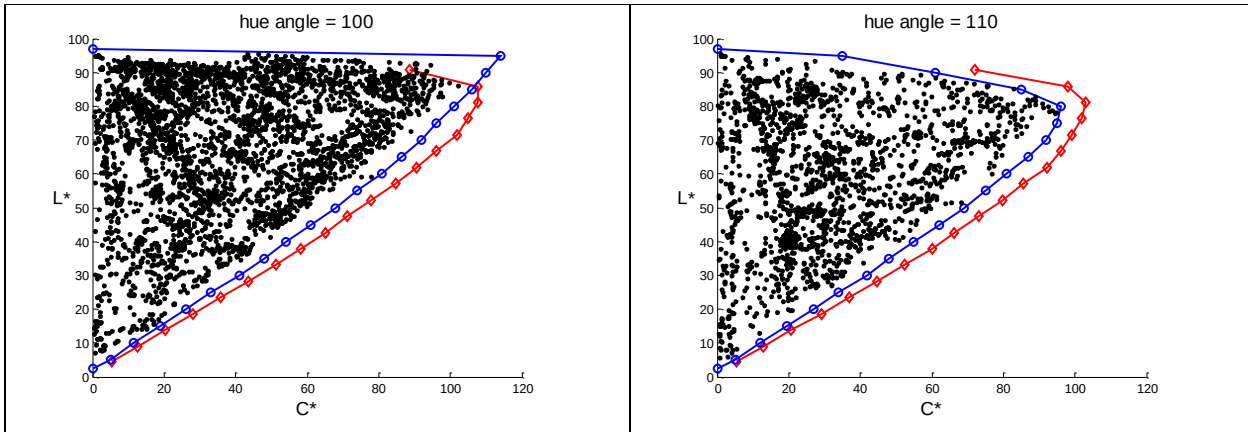
[2] Changjun Li, M Ronnier Luo, M R Pointer, Phil Green , Spectral Based Gamut for Object Colours, submitted to Color Research and Application

Basic Procedures

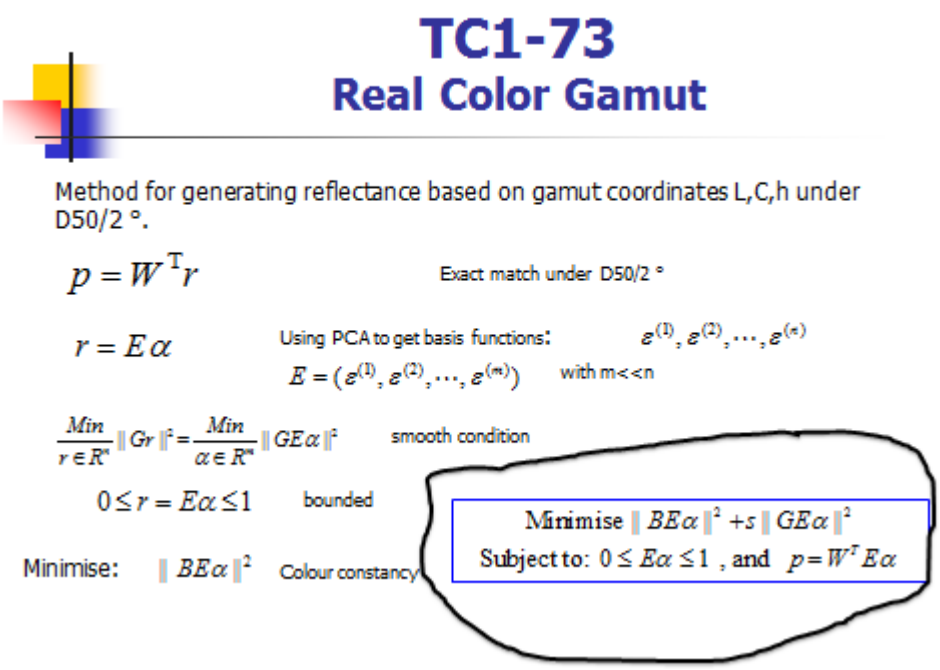
1. to compute tristimulus values XYZs under D50/2° and then transform them to $L^*C^*_{ab}h_{ab}$s;
2. to sort the computed coordinates according to CIELAB hue angle into 36 subgroups, i.e., from 0° to 350° at 10° intervals with a range of ±5°;
3. to display the coordinates in each subgroup in $L^*C^*_{ab}$ plane and find the convex boundary curve in terms of L^* and C^*_{ab};
4. to sample the L^* axis into 19 levels from L^*=5 to L^*=95, at 5 L^* unit interval, and find the corresponding C^*_{ab} values from each of the boundary curves obtained from step 3;



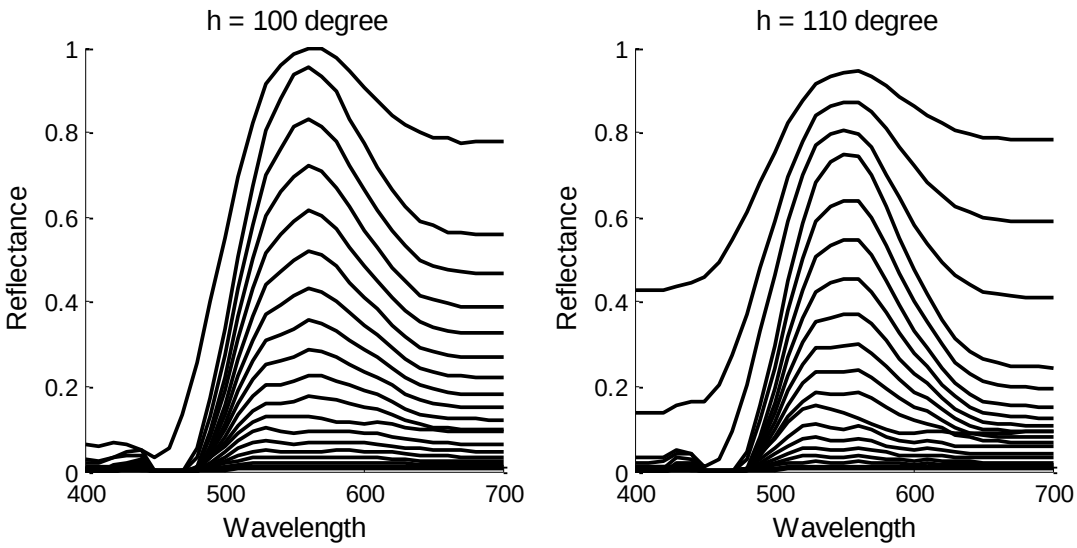
New gamut (named as CG): curve with open circle marks; ISORCG: curve with diamond marks .



Next, how to define a reflectance for each gamut points since there are no real reflectances for most of the gamut points?



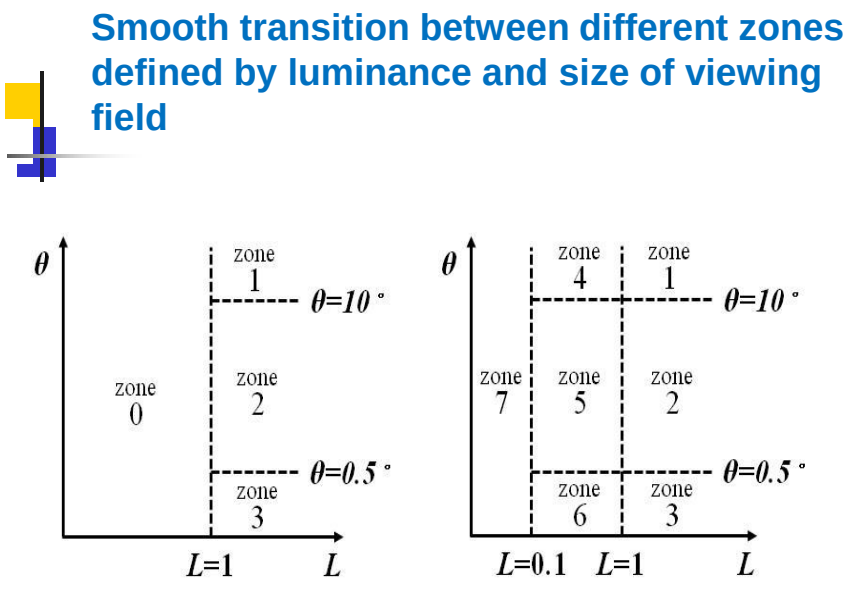
It was found for certain points, reflectances cannot be generated. In order to generate reflectances, those points should be moved inward, resulting in the spectral based gamut (named as SG). The problem changing from CG to SG is that some real points are outside of the boundary! Finally based on the SG, reflectances were generated. Thus, the SG gamut is defined in terms of both colorimetric coordinates (L*,C* h under D50/2) and reflectance functions.



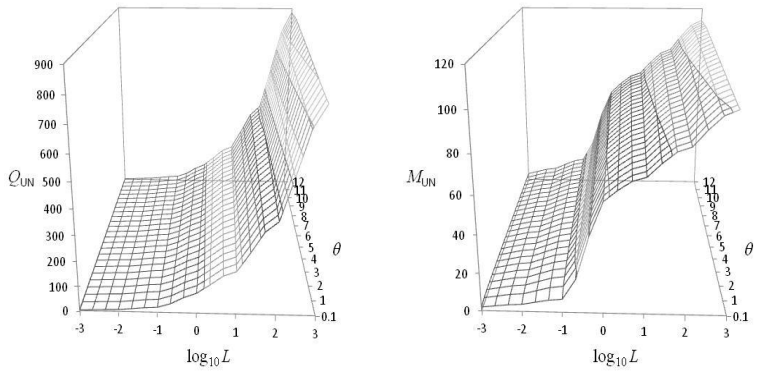
It is hoped that the studies of Li, Luo, Pointer and Green can provide a starting point and we can investigate what techniques can be used and what techniques must be improved in order to define a real object gamut in terms of reflectance functions. Thus it can be used under any viewing conditions. A meeting of this TC was held yesterday discussing the results described above.

TC1-75 A Comprehensive Model of Colour Appearance: M. Ronnier Luo GB

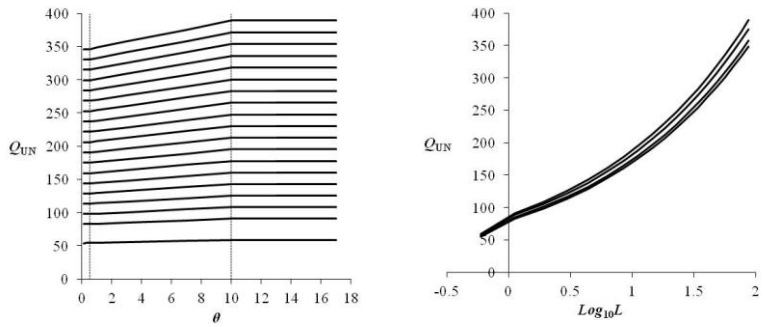
The work plan in June 2010 was to complete data collection. C. Fu's PhD data (Unrelated colours under photopic and mesopic regions) and K. Xiao's PhD data (Same colours under 6 different sizes) have been collected. In April 2014 the forward model was derived. A manuscript entitled 'Extension of CIECAM02 for varying-sized objects and unrelated colours', was submitted to Color Res and Appl., May 2014. On 15 May 2014 the paper and an Excel version of the software were circulated to TC members for feedback by 15 June. On 16th June the TC held a meeting at NIST to discuss that feedback.



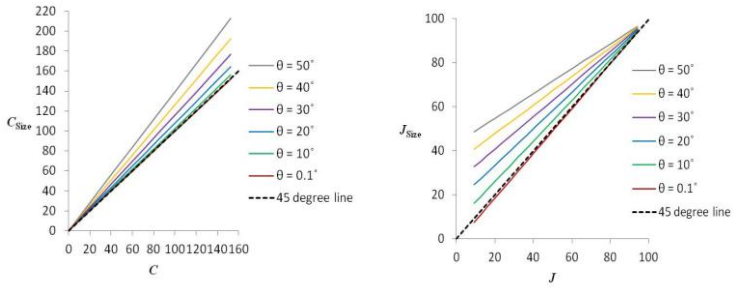
Smooth transition between different zones of luminance for calculating colourfulness and brightness



Smooth transition of brightness at different size of viewing field and luminance levels



The change of colourfulness and lightness between the 2° and different size of viewing field



The unresolved problems lie in the reverse model. For the inverse model, QUN, MUN and HUN attributes are insufficient. The Y tristimulus value of the sample, L, also needs to be known.

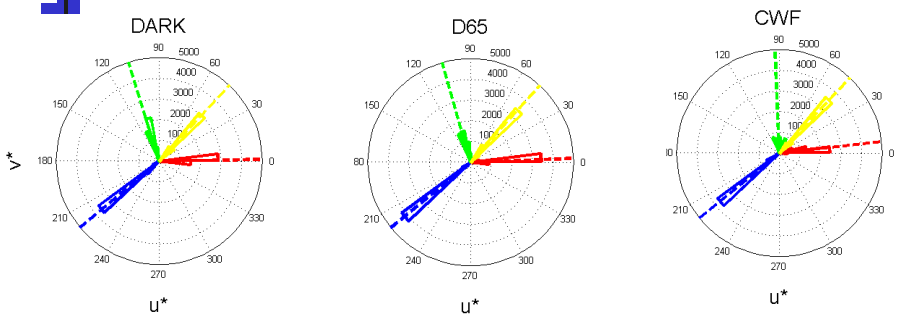
The current approach is an extension of the CIECAM02 but new proposals are welcome. The plan for the future at this point is:

1. July 2014:To receive comments from TCMs
2. July 2015:To derive the inverse model
3. July 2015:To receive the testing results from
   3.1 Dr. Y. S. Park: Ulsan National Institute of Science and Technology, Korea
   3.2 Dr. T. X. Lee: National Taiwan University of Science and Technology, R.O.C.
   3.3 Dr. P. Bodrogi: University of Darmstadt, Germany
4. July 2016: To write the technical report.

TC1-76 Unique Hue Data: Sophie Wuerger GB

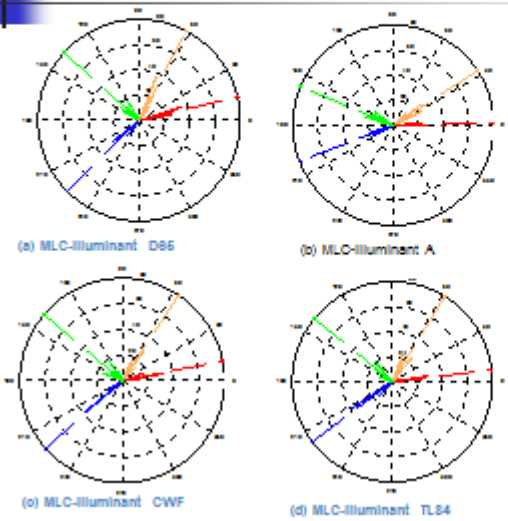
While Sophie Wuerger was unable to attend the division meeting, she provided data for self-luminous stimuli.

TC1.76
Unique Hue Data



Self-luminous colours: The unique hue settings for all 185 observers and the three illumination conditions are depicted. Median hue angles for different ambient viewing conditions are very similar and are within 5% of the grand mean.

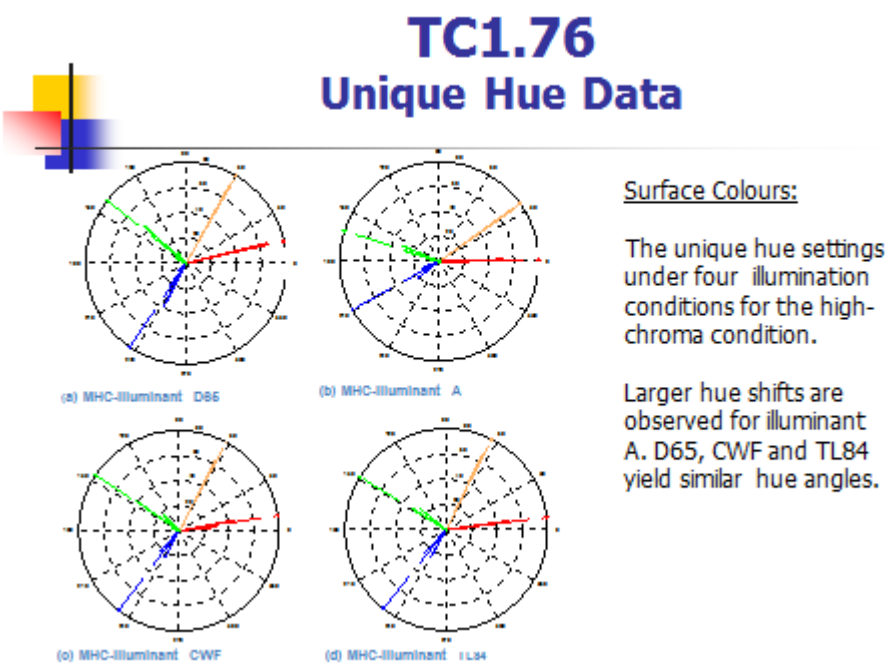
TC1.76
Unique Hue Data



Surface Colours:

The unique hue settings under four illumination conditions for the low-chroma condition.

Larger hue shifts are observed for illuminant A. D65, CWF and TL84 yield similar hue angles.



Unique hue settings of self-luminous colours are not affected by changes in illumination; larger hue shifts are observed for surface colours (Munsell chips).

For the Munsell chips, settings for D65, CWF and TL84 illuminants are commensurate, but large shifts occur when illumination A is used. The most significant changes in hue angles as a function of ambient illumination occur for unique green.

The ratio between inter- and intra-observer variability is about 1.86 for self-luminous colours and 2.3 for surface colours, demonstrating a relatively higher consistency across observers for self-luminous unique hues settings.

TC1-77 Improvement of the CIE Whiteness and Tint Equations: Robert Hirschler HU

Publications:

1. Hirschler, Oliveira and Azevedo presented a paper at the 23rd IFATCC congress (Budapest, 8 - 10 May 2013) on Whiteness determination of optically brightened textiles.
2. David Chen's PhD thesis was submitted to and successfully defended at the University of Leeds (supervisor M. Ronnier Luo) on Colour Measurement of Sample Containing Fluorescent Whitening Agent. Publication is expected in 2014.
3. Hirschler, Oliveira and Azevedo presented a paper at the AIC 2013 Congress (8-12 July 2013, Newcastle) on research on The effect of calibration on the inter-instrument agreement in whiteness measurements: CIE or Ganz-Griesser?
4. Melgosa, Katayama et al. presented a paper at the AIC 2013 Congress (8-12 July 2013, Newcastle) on Testing the performance of whiteness formulas using the PF/3 and STRESS indices.
5. Juan Lin's PhD thesis was submitted to the North Carolina State University (supervisor Renzo Shamey) on Factors Affecting the Perception and Measurement of Optically Brightened White Textiles. Two publications are expected in 2014; one aims to incorporate a texture factor into the CIE WI model, the other deals with assessment of whites for surface as opposed to self-luminous whites.
6. Coppel, Andersson, Norberg and Lindberg presented a poster at the Colour and Visual Computing

Symposium (CVCS 2013, Gjøvik, Norway, 5-6 September 2013) on the Impact of illumination spectral power distribution on radiance factor of fluorescing materials. A full paper is to be published in 2014.

Other activities:

1. Danny Rich (SunChemical) has started research on the performance of whiteness formulae under D50 illumination.
2. The TC had a meeting in Leeds (5th July 2013), where David Chen, Robert Hirschler and Danny Rich reported on on-going and planned research activities; Miyoshi Ayama reported on whiteness-related research in her laboratory as well as previous research by Uchida and by Katayama.

TC1-81 Validity of Formulae for Predicting Small Colour Differences: Klaus Richter DE

The second draft WD02 of a CIE Technical Report was discussed at a TC1-81 meeting, 16 June, in Washington.

The TC decided to discontinue the investigation on the Avramopoulos data and will start to write the TC report to be completed by the end of this year. Three topics should be covered:

1. To focus on the study of new data collected by this TC in addition to the four subsets of BFD, Witt, Leeds and RIT-Dupont. The new datasets are ZJU-perceptibility, ZJU-acceptability, Wang et al, BIGC-SCD, BIGC-TCD, Kittelmann, Richter and AUDI2000.
2. To test the available colour difference equations and uniform colour spaces and to report the test performance.
3. To plan a new TC or Reportership to study threshold data ($\Delta E^*_{ab} < 0.3$).

TC1-85 Update CIE Publication 15:2004 Colorimetry: Janos Schanda HU

This TC met yesterday at NIST. Draft 4 of the TR had been circulated on 2014.03.29. At the meeting discussion concentrated on the following sections that are either not yet complete or need input on some aspect of the section:

1. Standard observers
2. New section on cone fundamental based colorimetry(JH Wold)
3. Discussion how deeply the MacLoad-Boynton chromaticity diagram should be discussed in the Colorimetry document
4. Illuminants and sources
5. New sub-sections on smoothed illuminants and Illuminant E
6. Standards of reflectance and geometric conditions
7. New parts by D. Rich
8. Calculations & colour spaces
9. More details on CIEDE2000 (M. Melgosa)

The work that remains to be done includes: 1) an important section (still missing) on CIECAM02; 2) Much work to be done on Tables, and 3) finalization of draft before 2015 Session.

TC1-86 Models of Colour Emotion and Harmony: Li-Chen Ou TW

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

TC1.86
Models of color emotion and harmony

Data collected:

Contributor	Colour emotion	Colour harmony
Li-Chen Ou (TW)	Argentina, Chinese, France, Germany, Iran, Spain, Sweden, Taiwan and the UK	Argentina, Chinese, Iran, Spain, Taiwan and the UK
Wen-Yuan Lee (TW)	Taiwan and the UK	Taiwan
Suchitra Sueeprasan (TH)		Thailand
Tetsuya Sato (JP)	Japan	
Ferenc Szabó (HU)		Hungary

New color models:

Warm/cool:

$$\mathrm{WC} = -0.89 + 0.052\, C^*_{ab}[\cos(h_{ab} - 50°) + 0.16\cos(2h_{ab} - 350°)]$$

Heavy/light:

$$\mathrm{HL} = 3.8 - 0.07L^*$$

Active/passive:

$$\mathrm{AP} = -3.4 + 0.067\{(L^* - 50)^2 + 1.93(a^* + 1)^2 + 1.05(b^* - 9)^2\}^{\frac{1}{2}}$$

TC1.86
Models of color emotion and harmony

Predictive performance – additivity of colour emotion:

Predictive performance of each model using the additivity theory in terms of correlation coefficients (colour pairs)

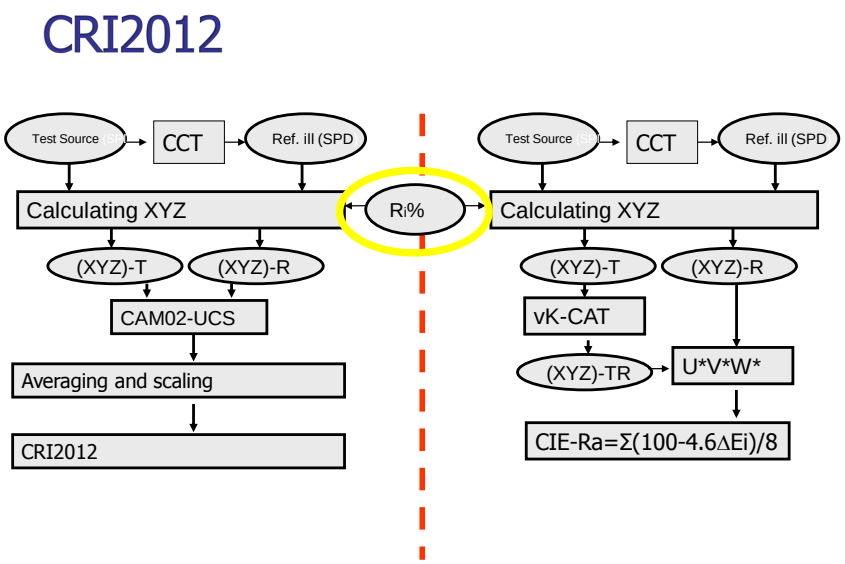
	WC	HL	AP
Argentina	0.85	0.76	0.87
British-1	0.65	0.67	0.72
British-2	0.77	0.78	0.80
Chiinese	0.76	0.79	0.74
French	0.81	0.77	0.81
German	0.82	0.87	0.79
Iranian	0.73	0.83	0.85
Spanish	0.84	0.77	0.85
Sweden	0.81	0.90	0.86
Taiwanese	0.83	0.82	0.77
mean	0.78	0.80	0.81

The plan from here forward is to model colour harmony and test the additivity of colour harmony. Then to write the first draft of the Technical Report.

TC1-90 Colour Fidelity Index: Hirohisa Yaguchi JP

This TC had 2 meetings this year. The first in Kuala Lumpur had 13 people attending in person and 9 via WebEx. Presentations included a summary of correlation between Ra and CIR2012 by H. Yaguchi, and Modifications of CRI2012 by L. Whitehead. Then the Guidelines for visual experiments were discussed by H. Yaguchi, R. Luo, and E de Beer. The who, where, and when of the visual experiment of assessing color fidelity were discussed with a follow-up planned second meeting at NIST, Gaithersburg.

The 2nd TC meeting was held 15:30pm-17:00pm 16 June, 2014 at NIST. The meeting covered Analysis of CRI2012 by Y Ohno, the design of the new test color samples for CRI2012 by L Whitehead, reports of the visual experiments so far including those by R. Luo, Y Mizokami, S Jost, and O da Pos. L Whitehead responded to frequently asked questions about CRI, and then a guest, Prof. Michael Shur from Rensselaer Polytechnic Institute, gave a short presentation on Statistical Color Rendering Evaluation including Color Fidelity, Color Dulling, Color Saturation, and Hue Distortion.



The experimental sites include: 1) Zhejiang University (Luo, Liu), 2) NTUST (Luo, Chen); 3) Chiba University (Yaguchi, Mizokami); 4) Phillips Research (E. de Beer); 5) Granada University (Padro, Melgosa); 6) University of Pannonia (J. Schanda); 7) LGCB/ENTPE (S. Jost); 9) University of Padua (O. da Pos); 10) JCRI (Kobayashi, Komatsubara); 11) Panasonic (A. Tsukitani); and 12) Joshibi University of Art and Design (T. Fuchida).

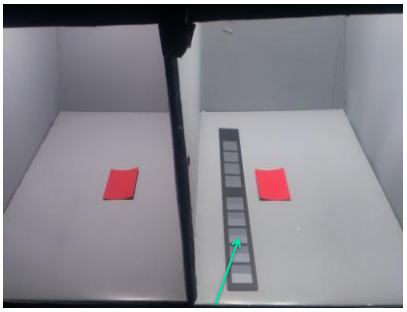
The future plans involve carrying out the visual experiments; making minute investigations of CFIs, analysing the visual experimental data and writing the TR.

A WebEx meeting is planned near the end of 2014, and then the TC will meet in conjunction with AIC2015 in Tokyo Japan 20-24 May, 2015, then again at the 28th Session of the CIE 28 June 28 – 4 July 2015 in Manchester, United Kingdom.

Below are pictures of the experimental booth for the experiments.

Experimental Booth
(Grayscale method Exp.)

Simultaneous comparison method



Gray scale

TC1-91 New Methods for Evaluating the Colour Quality of White-Light Sources: Yandan Lin CN

The 3rd meeting of TC1-91 was held in Kuala Lumpur, Malaysia (28 April, 2014) with 21 participants present and 6 participants via WebEx. The 4th meeting was held yesterday at NIST with K. Smets acting as location chair, and Y Lin participating by teleconference. The second round of data collection is completed. Available indices include: FCI, CQS, MCRI, & PS. Colour Harmony rendering index is proposed to be included (and Ferenc Szabó just submitted HRI data). Other contributions include: 1) Minchen Wei has summarized 22 measures based on 401 SPDs and proposed a 2-dimension system, 2) Yandan Lin has conducted a pilot study to explore the effect of application on the metric and 3) and 4) Contributions from Sophie Jost and Peter Bodrogi, respectfully.
The future activities are 1) to continue work on the draft technical report, 2) a parallel experiment to verify the existing indices with the same experimental settings 3) future meetings in Sept 2014 via CIE WebEx, and 2015 in Manchester, United Kingdom.

TC1-92 Skin Colour Database: Kaida Xiao CN

This TC met yesterday at NIST. The discussions included the uncertainty tests conducted at the Universities of Liverpool, Leeds, and Hangzhou. They are: 1) Uncertainty of skin measurement by a spectroradiometer; 2) Uncertainty of skin measurement by a spectrophotometer; 3) Uncertainty of skin measurement by a digital camera; 4) Agreement of skin measurement between instruments; and 5) Uncertainty of visual assessment of skin colours. A protocol for colour measurement will be developed based on those tests. Data were already collected using a spectrophotometer at Manchester Metropolitan University, UK, and Chulalongkorn University, TH. Data collection is in preparation at the University of Liverpool; Zhejing University, CN; and the University of Alicante, ES using spectrophotometers, spectroradiometers, and digital cameras. New research partners are very welcome.

The work plan is
1. To investigate uncertainty of skin colour measurements (1-12 months)
2. To recommend the protocol for skin colour measurements (13-18 months)
3. Combining the existing skin colour database (19-36 months)
4. Conduct skin colour measurement (19-36 months)
5. Development of skin colour database (37-42 months)

6. Write the TC report (42-48 months)

R1-42 Extensions of CIECAM02: Changjun Li CN

With the terms of reference of evaluating potential additions to CIECAM02 in liaison with D8, C Li reports that the yellow-blue and purple problems [Li CJ, Ji CJ, Luo MR, Melgosa M, Brill MH. CAT02 and HPE Triangles. Color Res Appl, Article first published online: 3 DEC 2013 | DOI: 10.1002/col.21859 and Li CJ, Luo MR and Wang ZF, Different Matrices for CIECAM02, Color Res Appl 2014;39: 143–153; and Jun Jiang, Changjie Ji, M. Ronnier Luo, Manuel Melgosa, Michael H. Brill and Changjun Li, An Optimum Solution to the CIECAM02 Yellow-Blue and Purple Problems, submitted to Color Research and Applications] for the CIECAM02 are solved. Further results may be available at the TC meeting in November 2014.

R1-51 Spectral Data Interpolation: Hugh Fairman US

Reporter Fairman reported at the meeting that he has not made progress on this reportership and suggested looking for a new reporter to take up the work. D Rich volunteered and was selected by a unanimous ballot at the meeting.

R1-53 Gloss Perception and Measurement: Frédéric Leloup BE

Leloup, FB, Obein, G, Pointer, MR and Hanselaer, P (2013), Toward the soft metrology of surface gloss: A review is available in Color Research and Application Early View as Color Res. Appl. doi: 10.1002/col.21846 and will be published in Issue #6, 2014.
Since then new experiments are planned that relate to gloss perception and measurements within a 3-year European project that started in early 2014. Gaël Obein is presenting a report entitled "xDReflect, a European Joint Research Project devoted to the metrology of the appearance of surfaces" at tomorrow's symposium [the abstract and slides of the report are available in the 2014 meeting section of the ISCC website]. An annual update will be provided that includes other work related to the field, for example performed by vision scientists.

R1-58 Liaison with ISO TC130 Graphic Technology: Phil Green GB

P Green reported on the progress to date:
1. Issues raised in TC130 liaison reports were investigated and a workshop held in Leeds in 2013
2. Greater understanding of TC 130 needs in D1
3. Substantial progress on application of CIEDE2000
4. Some other issues resolved or superseded

Further issues awaiting action by CIE include:\
1. L* > 100 - This is limited to highly-fluorescent materials; L*=100 is typically only exceeded by a small amount; although there is no psychophysical data, it may be reasonable to apply the cube-root function to Y/Yn in such values, rather than assume a discontinuity
2. Metrics for quality of LED light – Requires more research, which is concerns TC1-70, TC1-90, and TC 1-91, as well as the closed TCs 1-69 and 1-78.

R1-60 Future Colour Difference Evaluation: G Cui CN

Library	Papers or book chapters
Wiley Online Library	29
OSA OpticsInfoBase	65
Imaging.org Digital Library	8
AIC2013 Conference	12
IEEE Xplore Digital Library	45

In examining these publications, he found that most of the above publications relate to applications of color difference or colour spaces. However, there are 29 publications that relate to colour -difference evaluation or uniform colour spaces.

Concerning uniform color space – ULAB - Kim published a new uniform colour space – ULAB [Dong-Ho Kim, The ULAB colour space. Color Res Appl - Article first published online : 16 DEC 2013, DOI: 10.1002/col.21854.] ULAB is derived from the CIELAB colour space and can be converted to and from CIELAB. Kim reported that for the small colour differences, ULAB performed as well as CIEDE2000.

Concerning colour-difference sets – there were 3 new datasets published:
1. Black Data: Shamey et al.
2. Fogra Roses Data: Kraushaar
3. Gholami data: Gholami et al.

10. LIAISON REPORTS

L1-01 AIC: Paula Alessi
A report is attached to these Minutes.

L1-02 CCPR (Consultative Committee for Photometry and Radiometry): Michael Stock
A report is attached to these Minutes.

L1-03 ISO/TC6/WG3: Paper, Board and Pulp – Optical Properties: Joanne Zwinkels
A report is attached to these Minutes.

L1-04 ISO/TC38/SC1: Textile: Colour Fastness & Measurement: M Ronnier Luo
Nothing to report.

L1-05 ISO/TC42: Photography: Jack Holm
No report. Klaus Richter has been appointed as this Liaison in place of Jack Holm.

L1-06 ISO/TC130: Graphic Technology: Danny Rich
A report is attached to these Minutes.

L1-07 ISO/IEC JTC1/SC28 Office Equipment: Klaus Richter
Klaus Richter informed the Division that he has resigned as this liaison as he is no longer active on the ISO TC. Hirohisa Yaguchi has been formally appointed as liaison by ISO.

L1-08 International Association of Lighthouse Authorities: Malcolm Nicholson
No report.

L1-09 ISO/TC159/WG2 Ergonomics: Ken Sagawa
No report.

ISO Steering Committee for Image Technology (SCIT)
Klaus Richter has indicated that he would like to act as a liaison from ISO SCIT to CIE D1: formal appointment is awaited.

ISO TC159/SC4/WG2 Visual Display Requirement
Klaus Richter has indicated that he would like to act as a liaison from ISO TC 159/SC4/WG2: formal appointment is awaited.

11. CHANGES TO CURRENT WORK PROGRAMME

11.1 Changes to Technical Committees

TC1-94 It was agreed to change the TC Chairman from Janos Schanda (HU) to Ferenc Szabó (HU).

11.2 Changes to Reporters

R1-52 It was agreed to change the Reporter R1-52 from Hugh Fairman (US) to Danny Rich (US).

12. NEW WORK ITEMS IN WORK PROGRAMME

12.1 New Technical Committees

Two new Technical Committees were discussed and it was agreed that a final ballot would be made by email once the necessary forms had been completed.

Proposal by Ken Sagawa JP: Principle and Use of Equivalent Luminance

Terms of Reference:
To develop a report describing the concept, definition, and background of equivalent luminance and providing guidelines for its use in the photometric field.

Work Program:
To revise the report prepared by CIE TC1-46 with some more necessary discussions and to publish the report.

Time schedule:
The report to be completed by the next CIE Session in 2015.

Discussion:
While it was agreed that this was a useful proposal, it was agreed that a more appropriate way forward might be to produce a Reporters' Report in the form of a Technical Note. This was especially pertinent because most of the work would be done by one person, i.e. Ken Sagawa. This outcome would be conveyed to Ken as he was not present at the meeting.

Proposal by Yasuki Yamauchi JP: Metric for Consistent Colour Appearance

Terms of Reference:

To recommend guidelines and a quantitative assessment method for consistent colour appearance with different colour gamuts.

Background and Aim:

Recently, the gamuts of displays have been expanding, and several gamut sizes for printers depending on their usage have been proposed in ANSI. If we would like to handle an identical color, the gamut of the device cannot be ignored. For example, because of the difference in gamut size, difference in saturation and brightness (under the identical hue) has been observed (Figure below).

Different colors - The larger the number, the larger the gamut.

In order to solve this problem, it is important to keep the colour appearance consistent regardless of its device and its gamut size. The consistency of the colour appearance, however, cannot be evaluated with conventional metrics, such the as CIE colour difference metric (Yamauchi et al., CIC2014, submitted). Therefore, it is important to pursue empirically consistent colour sets in a colour space, which enables to define a new metric to describe its consistency. Also, the guideline for conducting the experiments is required. The activity will be fundamental perception research based on a psychophysical approach, so we would like to propose a new TC in D1.

Chair: Craig Revie GB Secretary: Yasuki Yamauchi JP

Potential members: Under negotiation: Ronnier Luo GB, Phil Green GB, Li-Chen Ou TW, Jan-Henrik Wold NO, Ellen Carter US, Dragan Sekulovski NL.

The proposer and the proposed TC Chairmen were encouraged to complete the necessary forms to progress the establishment of this proposed Technical Committee.

12.2 New Reporters

R1-61 Source Whiteness Metric: Aurelien David US

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.

R1-62 Typical LED Spectra: Sophie Jost FR

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.

13. NEXT MEETING

The 2015 Meeting of the Division will be held in association with the 28th Session of CIE from Monday 29th June to Friday 3rd July 2015 at the University of Manchester, Manchester, UK.

14. ANY OTHER BUSINESS

None.

15. CLOSE OF MEETING

The Director thanked everyone for attending and declared the meeting closed.

Dr Michael R Pointer
Secretary – CIE Division 1
01 September 2014

CIE DIVISION 1
VISION AND COLOUR
Seventh Meeting of the Luo Term
17June 2014

AGENDA — Day 2: 17 June 2014

	Division Meeting - Opening Session
09:00 – 09:30	1. Opening and welcome by Director, Ronnier Luo 2. Apologies for absence 3. Membership 4. Attendance 5. Approval of agenda 6. Approval of minutes of Taipei meeting 7. Matters arising from those minutes 8. Report from the Director: Ronnier Luo 9. Report from the Editor: Phil Green 10. Report from the Secretary: Mike Pointer
	Business Session
09:30 – 10:30	Vision Section: Report – Miyoshi Ayama
10:30 – 11:00	Vision Section: New work items
11:00 – 12:00	Colour Section: Report – Ellen Carter
12:00 – 12:45	**Lunch**
12:45 – 14:00	Colour Section: Report – Ellen Carter – continued
14:00 – 14:30	Colour Section: New work items
14:30 – 15:30	Liaison reports
15:30 – 17:00	Any other business: Location of next meeting
17:00	Close of meeting

All times are flexible - there will be a break for coffee/tea during the sessions.

Mike Pointer
Division Secretary

Additional Attachments:

Division 1 Liaison Reports

L1-01 International Color Association (AIC)

L1-02 CCPR (Consultative Committee for Photometry and Radiometry) 2014

L1-03 ISO/TC6/WG3 Paper, Board and Pulp – Optical Properties 2014

L1-05 ISO/TC42 Photography 2014

L1-06 ISO/TC130 Graphic Technology 2014

L1-07 ISO/IEC/JTC1/SC28 Office Equipment 2014

ISO TAG 14 and ISO SCIT 2014

R1-49 Above-threshold Pulsed Lights: Malcolm Nicholson

Report by Dr Peter Rhodes – see above Minutes

L1-01 International Colour Association (AIC): 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 will be published in the AIC 2014 Annual Report that will be issued soon. The new membership dues of 200 Australian dollars will begin in 2014. The dues invoices are scheduled to be sent out soon by the AIC Treasurer, T. R. Lee.

A Call for Nominations for the 2015 AIC Deane B. Judd Award was issued by Vice President, Nick Harkness. If you have a candidate you would like to nominate, please email Nick (nick@nhpl.com.au) with the appropriate documentation, as found in the website, by August 19th.

The AIC celebrated a very successful International Colour Day on March 21, 2014. Many member countries created memorable colour activities on that day all around the world. Please find more details about what happened on International Colour Day at
http://en.wikipedia.org/wiki/International_Colour_Day.

The AIC 2014 Interim Meeting will be held in Oaxaca, Mexico from October 21-October 24 2014. It will be hosted by Asociación Mexicana de Investigadores del Color. The theme will be Colors, Culture, and Identity: Past, Present and Future. Conference topics are 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. A Call for Papers has already been sent out with submissions due by February 21, 2104. Please see www.aic2014.org or www.amexinc.org.mx for more details.

The AIC 2015 Midterm Meeting will be held in Tokyo, Japan from May 19-22 2015. 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 2016. 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.asociaciondelcolor.cl or www.aic2016.org for more details.

The AIC 2017 13th Congress will be held in Jeju, Korea from October 16-20 2017. 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

L1-02 CCPR (Consultative Committee for Photometry and Radiometry): 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 23-24 February 2012. The CCPR working groups met during the same week and again on 22 and 23 April 2013. The next meeting of the CCPR will take place on 17 and 18 September 2014, at the BIPM. On 1 January 2013, Dr. Takashi Usuda from the National Metrology Institute of Japan (NMIJ) became the new President of the CCPR, following Dr. Franz Hengstberger. 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 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. The first comparisons to be repeated are for spectral regular transmittance, for luminous intensity and luminous flux, and for spectral responsivity in the visible and infrared regions. The results of the completed key comparisons of the first round 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 expected that in the near future, possibly in 2018, 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. For these reasons, the Strategic Planning Working Group of the CCPR held in 2012 a workshop on the *mise en pratique* of the candela to which representatives of the CIE had been invited. The workshop had the objective to guide the direction and to coordinate possible joint work between the CIE and the CCPR to prepare a new *mise en pratique* for the candela. The final decision was that a concise *mise en pratique* would be written by experts from the CCPR and that an additional more extensive document *Principles Governing Photometry* shall be published by a joint CCPR-CIE task group, which is be chaired by Dr. Ohno (NIST).

Another workshop was organized on 22 April 2013, on *SI units for Photometry and Radiometry*, again with representation from the CIE. One of the topics was a discussion of the proposal to replace the candela as the photometric SI base unit by the lumen. The CIE Division 2 Director, Dr Peter Blattner presented the outcome of discussion within CIE which resulted in the recommendation that "in the absence of compelling reasons to change from the candela to the lumen as the base SI unit, it is highly recommended to maintain the status quo." The participants at the workshop agreed with this recommendation. Other topics were the status of the *mise en pratique* of the candela and of the *Principles Governing Photometry*. Work on both documents is well advanced and it is planned to have final versions for the CCPR meeting in September 2014.

M. Stock, BIPM
25 April 2014

L1-03 ISO/TC6/WG3 Paper, Board and Pulp – Optical Properties: Joanne Zwinkels

ISO/TC6 had their most recent Working Group meetings and Plenary meeting at NEN (Netherlands Standardization Institute) in Delft, Netherlands, April 7-11, 2014. This was preceded by a two-day meeting of the representatives of the optical properties authorized laboratories (so-called Opal Group). The following decisions were taken at this meeting which may be of interest to CIE D1:

Four resolutions were taken with regard to Recommendations from WG3. These were:

- To begin a revision to update Annex A of all three parts of ISO 5631: ISO 5631-1 *Paper and board – Determination of colour by diffuse reflectance method – Part 1: Indoor illumination conditions (C/2 degrees)*, ISO 5631-2 *Paper and board – Determination of colour by diffuse reflectance method – Part 2: Outdoor illumination conditions (D65/10 degrees)*, and ISO 5631-3 *Paper and board – Determination of colour by diffuse reflectance method – Part 3: Indoor illumination conditions (D50/2 degrees)* to allow for calculations using ASTM E 308 for instruments that have bandpass correction, and still maintain the non-bandpass correction procedure. The project leader will be Sylvie Moreau-Tabiche (France) with the development track of 24 months starting with a DIS ballot.
- To prepare a New Work Item to revise ISO 4094 *Paper, board and pulps – International calibration of testing apparatus – Nomination and appointment of standardizing and authorized laboratories* irrespective of the results of the recent systematic review that confirmed this standard to allow a revised text that: 1) follows conformity assessment guidelines given in ISO/IEC Directives, Part 2, Clause 6.7; and 2) changes the title and limits the scope to the requirements for laboratories authorized for optical property measurements only. The revision is to be handled by WG3.
- To make a minor revision of ISO 8254-2 *Paper and board – Measurement of specular gloss – Part 2: 75 degree gloss with a parallel beam, DIN method* to include the editorial changes recommended during the Systematic Review.
- To make a revision of ISO 8254-3 *Paper and board – Measurement of specular gloss – Part 3: 20 degree gloss with a converging beam, TAPPI method* to include the editorial changes and preparation of a Precision Statement that was recommended during the Systematic Review. The project leader will be Joanne Zwinkels (Canada) with the development track of 24 months starting with a DIS ballot.

Another significant resolution that was taken at the ISO/TC6 plenary, based on a recommendation from the Adhoc group on the *Measurement and Characterization of Nanocellulose* (AHG1), was to expand the scope of this ISO TC. In particular, it was resolved to expand the scope to include cellulosic nanomaterials. The proposed new wording for the TC6 Scope is:

Standardization in the field of paper, board, pulps and ***cellulosic nanomaterials (CNM)****, including terminology, sampling procedures, test methods, product and quality specifications, and the establishment and maintenance of appropriate calibration systems*

At the TC6 plenary, I also gave a CIE Liaison Report, as the official CIE Liaison to ISO TC6. Of particular interest to the delegates present were the activities within the following D1 TCs: TC 1-85 since CIE 15:2004 is one of the Normative References listed in the WG3 colour standards: 5631-1, 5631-2, and 5631-3; and TC 1-77 since the CIE Whiteness equation is the basis of the following WG3 whiteness standards: 11475 and 11476. I also informed the delegates present of the upcoming D1 meeting in conjunction with Colour, Light and Appearance week at NIST, Gaithersburg.

The next Working Group meetings and Plenary meeting of ISO TC6 are planned for 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

L1-05 ISO/TC42: Photography: Klaus Richter

The author visited the 2013 plenary of ISO TC42 *Photography* at the National Museum of Denmark in Copenhagen. The ISO members were informed about the archiving activities of the National Museum and the National Museum of Photography in visits and presentations. These two locations indicate that archiving of colour artefacts by photographic and scanning methods is one working area of TC42. From the 15 ISO-P-members, 9 members were present in Copenhagen. The Secretary of TC42 has produced about 300 numbered ISO documents for the TC42 committees since the meeting in Copenhagen (within one year).

There are 13 active subcommittees. About 6 subcommittees are connected to the areas of the CIE D1 and D8, for example:

ISO/TC 042/WG 18 *Electronic still picture imaging*
ISO/TC 042/JWG 20 *Joint ISO/TC 42-IEC WG; Digital still cameras*
ISO/TC 042/JWG 22 *Joint IEC/TC 100-ISO/TC 42-TC 130 WG; Colour management*
ISO/TC 042/WG 23 *Joint TC 42-TC 130-CIE WG; Extended colour encodings for digital image storage, manipulation and interchange*
ISO/TC 042/WG 24 *Joint TC 42-TC 130 WG; Revision of ISO 3664 (viewing conditions)*
ISO/TC 042/JWG 26 *Joint ISO/TC 42-TC 46/SC 11-TC 171 WG; Imaging system capability qualification for archival recording and approval*

CIE members may have most interest in the recent work of the following three groups: JWG26, JWG20, and JWG18:

Within JWG26 *Imaging system capability qualification for archival recording and approval* there is a progress report from CIE TC8-09 on Archival Colour Imaging, with the following abstract:

> "The current focus of the committee is a multi-institution study to assess and compare the performance points of the protocols and methods that participating cultural heritage institutions use to capture representative materials that are within scope for the committee. As part of the study the committee is assessing the color accuracy of different color capture and encoding approaches with the goal of establishing a knowledge base and set of techniques which an institution can reference to either select or confirm the approach to color capture that is most compatible with its goals and capabilities. This report focuses on the tone capture and error performance of the capture of a standard test targets and sample prints across multiple institutions."

Another project of this group is the WD TR ISO 19263 *Archiving Systems – Image Quality Analysis*.

Of greater interest for CIE members may be the work of the group ISO/TC 042/JWG 20 *Joint ISO/TC 42-IEC WG; Digital still cameras*.

The published standards ISO 17321-1 and -2:2012 *Graphic technology and photography -- Colour characterisation of digital still cameras (DSCs)* have the titles:

Part 1: Stimuli, metrology and test procedures.
Part 2: Considerations for determining scene analysis transforms.

Two other parts are under work:

Part 3: Considerations for scene referred imaging applications.
Part 4: LED (Light Emitting Diode) colour target.

One problem of the proposed Part 3 is the definition of a colour scene and the RGB encoding of the scene colours. For example, the draft Part 3 includes the following statements in the section *Background*:

> "Today's imaging environment may be divided into two categories or interests: Consumer and Professional solutions. The consumer solution benefits from output referred transforms. However, the opposite is true for professional solutions. They rely on objective scene referred imaging transforms. These professional users often wish to achieve the following results for the User Interface (UI):
>
> a) The ability to access scene referred encoding values in the imaging device UI.
> b) The ability to access the same encoding values in host processing software UI.
> c) A consistent UI and workflow for chart based field calibration under different illuminants.
> d) A common RGB encoding definition that can be utilized as an internal encoding space for DSCs, scanners and raw image processing applications.
> e) An RGB encoding definition for storing scene referred „Use Neutral“ renditions."

The rgb* encoding by the visual elementary coordinates based on the relative CIELAB coordinates may be a solution for some of the problems, compare the 2014 Liaison report of ISO/SCIT & TAG14 to CIE D1. Here an intended "objective scene referred imaging transform" is produced. However, the visual rgb* encoding differs from the encodings used up to now.

Part 4 produces the spectral power distribution of many taking illuminants by 16 LED lamps which illuminate a sphere. The instrument allows to simulate the spectral power distribution of the CIE illuminants D65, D50, E, A and others for taking an "Illuminant sample" by photography. The intended spectral power distributions are produced by computer driven changes of the LED output. I addition the spectral stimuli of for example the "colour samples" of the "Macbeth Color Checker Classic" are produced. The "colour samples" are taken by photography. The study and the improvement of the RGB encodings is within the scope of the Part 4.

CIE members may be interested in the work of ISO/TC 042/WG 18 *Electronic still picture imaging*. For example the two standards ISO 20462-1 and -2:2005 *Photography -- Psychophysical experimental methods for estimating image quality*

Part 1: Overview of psychophysical elements

Part 2: Triplet comparison method

are under review. The new improved versions may be published in 2014.

The next meeting of ISO TC42 is scheduled for June 1 to 5, 2015 in Tokyo/Japan.

Klaus Richter

L1-06 ISO/TC130: Graphic Technology: Danny Rich

ISO TC 130 held its spring meeting in conjunction with IPEX at the ExCel Center, London, United Kingdom 23 to 28 March 2014.

The spring meeting does not include a plenary session.

The following were topics of discussion carried over from the fall meetings that are still open.

1. Based on last summer's successful symposium between CIE Division 1, the ICC and ISO TC 130, A white paper was presented to TC 130 Working Group 3 that gives guidance on converting CIELAB tolerances into CIEDE2000 tolerances. Good progress is being made on updating current standards to switch their requirements from CIELAB to CIEDE200
2. This issue of luminescent white materials with L* greater than 100 was again discussed but there was no consensus as to the relevance of these value. ISO TC 130 is still in need of direction from CIE Division 1 as to the applicability to the power function of Y/Yn for Y values greater than Yn?
3. The use of LED sources that produce some form of "white" light is increasing. ISO TC 130 is still concerned that there is no agreed method on how to assess and rank the quality of LED lamp light, particularly as it impacts both publication and packaging printing. Since graphic reproduction relies on achieving a controlled level of metamerism, uncontrolled sources provide unnecessary business risks. Additionally, neutral or gray reproduction is critical to the appearance of a process printed image and the LED lamps impact the metamerism of 3-color overprinted neutrals in a very different manner than more traditional lamps and D50 simulators.
4. ISO 13655 *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images* is under revision. The primary goal was to revise the normative annex on the optical properties of the white backing material to be placed behind printed materials before making instrumental determinations the surface color. In the process, a couple of additional items have been proposed for revision. First, the allowance of broadband sampling at 20 nm intervals and 15 nm to 20 nm bandwidth is being deprecated, well mostly. It will still be allowed in the case of embedded instrumentation in digital printers and presses where the color of the materials have been characterized separately and are thus well known. The broadband readings being used primarily to reset the print transfer characteristics back to factory settings. The preferred ("should") requirement is now the CIE Publication 15 recommendation of 5 nm intervals with 5 nm bandpass and the reading must ("shall") be taken with no larger than a 10 nm sampling interval and 10 nm bandwidth. The document will also call out the geometric requirements of CIE Publication 15 for the bidirectional 45°a:0° geometry preferred in the graphic reproduction industry. This standard already specifies the use of an instrument source that conforms to the requirements of ISO 3664 for daylight simulation, pointing to the ISO version of CIE Publication 13 and CIE Publication 51 for validation of the fit of the instrument source to CIE illuminant D50.

Respectfully submitted,

Danny C. Rich

Dr. Danny C. Rich

L1-07 ISO/IEC/JTC1/SC28 Office Equipment: Hirohisa Yaguchi

1. ISO/IEC CD17823 *Colour terminology for office colour equipment*

Scope of this project is as follows,

This International Standard provides definitions for colour terms used with office equipment, in particular for use with colour scanning and printing devices that have digital imaging capabilities, including multi-function devices.

ISO/IEC 17823 is not intended to replace terms and definitions published in documents or user interfaces issued or created by manufacturers.

CD2 circulated in May 2014 and DIS ballot plan to start in July 2014.

2. Automatic identification of colour resources using cloud technology

The objective is to enable office users to obtain office equipment manufacturers intended colour reproduction any time anywhere. The owner of this subject has been changed from US to UK. A new idea has been proposed based on a global profile sharing platform and it will be discussed at the next SC 28 Plenary in June 2014.

3. German NB proposal based on DIN33872 series

SC 28 received German NB proposal based on DIN33872 series at the SC 28 Busan Plenary 2009 and resolved as follows.

SC28 Resolution Busan 17/2009 AWG/PWG5 Review of Germany Presentation (j28n1280)

Based on the recommendation of AWG/PWG5, AWG reports that AWG/PWG5 agreed with the goal of improving the capability of systems to enable users to see a color output according to the user wishes, for example corresponding colors on monitors and then in print. However, **the proposed method is not consistent with the color related technology of office equipment.** SC28 recommends not pursuing this particular method as the solution of the aforementioned color management problems. Based upon AWG/PWG5 consensus, SC28 hopes to work on new ideas to address the goal.

(**Approve**. USA, Korea, Japan, China; **Disapprove**. Germany; **Abstain**. Austria)

SC28 Resolution Busan 18/2009 SC28 Review of the AWG recommendation on j28n1280

The German proposal included the concept of a human visual RGB. SC28 recognizes the importance of correct understanding of the human visual system and the potential importance and application of this understanding to office equipment and office systems. **SC28 welcomes the German plan to continue development of the human visual RGB within CIE Div 1 and CIE Div 8**. In addition SC28 welcomes a new proposal from Germany in the future based on this CIE human visual RGB work, potentially in relation to AWG/PWG5 NWI-9.

Unanimous

- SC 28 received the same German NB proposal based on DIN33872 series again for the SC 28 Berlin Plenary 2014 (SC28 N1805). It was confirmed by SC 28 Liaison to CIE Division 1 and SC 28 Liaison to CIE Division 8 that the condition set by the SC28 Resolution Busan 18/2009 has not been accomplished. JP, US and UK NB submitted NB comments to propose the accomplishment of the SC28 Resolution Busan 18/2009 again to German NB.
- Human Visual RGB appeared in the German NB proposal has not been standardized by any international standards organizations, so it conflicts with existing CIE, ISO, IEC and national standards of several other countries. SC 28 recognized standardization of colour system is out of SC 28 area of work.

4. Other PWI candidates

Other PWI candidates are,

- Office viewing environments - user interface chromatic adaptation
    - The intention is to categorize office lighting for the use of designing office equipment evaluation test. It will be based on the outcome of CIE TC8-10 Office Lighting for Imaging.
- Office reference print gamut - RGB encoding
    - Adequate shape and size of gamut may help achieving good score in terms of less eyestrain characteristics for office use document
- Monitor and digital projector office colour test method
    - Test images to provide a mechanism to determine a suitable tone response for projection system
    - Test images to provide a mechanism to determine the white point of projection system base on memory colour

5. Next meeting

SC28/WG5 meeting planned in Berlin, Germany on 18-19 June, 2014
TBD in January, 2015
Matsue, Japan on 02-03 June, 2015

Prepared by Hirohisa Yaguchi, 2014-06-17

From ISO TAG 14 and ISO SCIT

Remark: The Division 1 meeting in Leeds decided that the author of this report gives a report of the activities of ISO SCIT (Steering Committee of Image Technology). The first meeting of ISO TAG14 (Task Advisory Group) was on May 1-2, 2014 in Washington.

ISO/CS and ISO TAG14 listed *K. Richter* to represent the CIE according to the attached list. The final decision of a CIE member and a CIE alternate member depends on a CIE decision. The next face to face meeting of ISO TAG14 is scheduled for March 2015 in Geneva/CH.

Since the 2013 CIE Division 1 meeting *K. Richter* visited an ISO SCIT meeting in London and the first ISO TAG14 meeting in Washington. More information is given at the URL http://www.iso.org/scit which redirects to TAG14. The new web site of TAG14 with the information of the former SCIT website is in preparation.

Scope of TAG 14 (to be decided by ISO/TMB):

- *To enable the sharing of information* among those ISO Technical Committees and related standards organizations involved in image technology*, by:
- *identifying new work* as early as possible and optimizing the use and sharing of resources for the development of standards in image technology;
- *facilitating communication* between technical committees and encouraging the coordination of joint development activities (but not to assign or manage specific imaging standards projects).

* *Image technology* is defined as any system or process that is used for the formation, acquisition, storage, retrieval, rendering (display, printing, etc.) and reproduction of any combination or sequence of pictorial, textual, or graphical material and associated metadata.

At the last two meetings there were reports from activities of

JTC1 *Image Technology*
SC24 *Computer graphics, and image processing data representation*
SC28 *Office Systems*
SC29 *Coding of audio, picture, multimedia and hypermedia information*
ISO/TC 130 *Graphic technology*
ISO/TC 171 *Document management applications*
CIE Division 1 and 8 *Vision and Colour* and *Image Technology*
DIN-SCIT *German mirror group of ISO/SCIT* (since 2002)

The former ISO/SCIT reports will be available at the ISO/TAG14 website. Problems arise for standards which are intended for applications in many standard committees. For two committees ISO may create a joint group. However, CIE Technical Reports and Standards on colour are used in many committees. Another example is DIN 33872-1 to -6, see http://www.ps.bam.de/33872E, which may become an International Standard (see N1805 in SC28). This series uses CIE colorimetry for display, offset and printer output, compare http://130.149.60.45/~farbmetrik/outlin/

At both meetings therefore the application of CIE colorimetry has been discussed in available documents. New CIE documents may be a basis to define a Device-independent visual RGB* colour space, for example:

CIE R1-47:2009 *Hue angles of elementary colours*
CIE R1-57:2013 *Border between blackish and luminous colours*
CIE R8-09:2013 *Output linearization for printers and displays.*

At present for the last document a short version (4 pages) is public on the CIE Division 8 web site together with a proposal of Mr. Nakaya from SC28 to produce a TR in CIE Division 1 on the topic *Device-independent visual RGB* colour space*. The long version of R8-09 (38 pages) is at present only available for Division 8 members and under processing. In my view the recent developments und discussions may create a lot more work for the CIE. A larger CIE cooperation with many ISO committees seems appropriate, for example ISO TC42 *Photography*, ISO TC159/SC4/WG4 *Visual Display Requirements*, ISO TC 130 *Graphic Technology*, ISO TC171 *Document Management*. The intention is to improve the application of CIE colorimetry in these areas. The above three CIE Reportership Reports do not contain CIE Technical Recommendations and therefore do not have the status of CIE Technical Reports.

Three application examples for the intended CIE visual *RGB** colour space are presented in the following. Example *rgb** coordinates and the CIELAB LCh* data are given in Fig. 1.

Visual *rgb values, CIELAB *LCh** values, and Red hue plane**

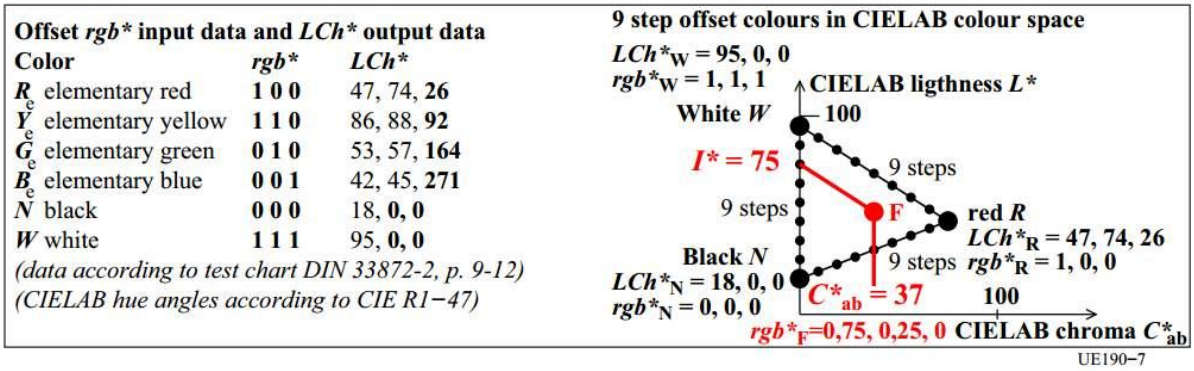


Fig. 1: Examples of *rgb and *LCh** data as table and in red hue plane**

Fig. 1 shows example *rgb** and CIELAB *LCh** data. There is a linear relation between *rgb** and CIELAB *LCh** data for any hue plane. For a colour F in Fig. 1 the *rgb** data are calculated from the *LCh** data (for the standard offset colour space according to ISO/IEC 15775).

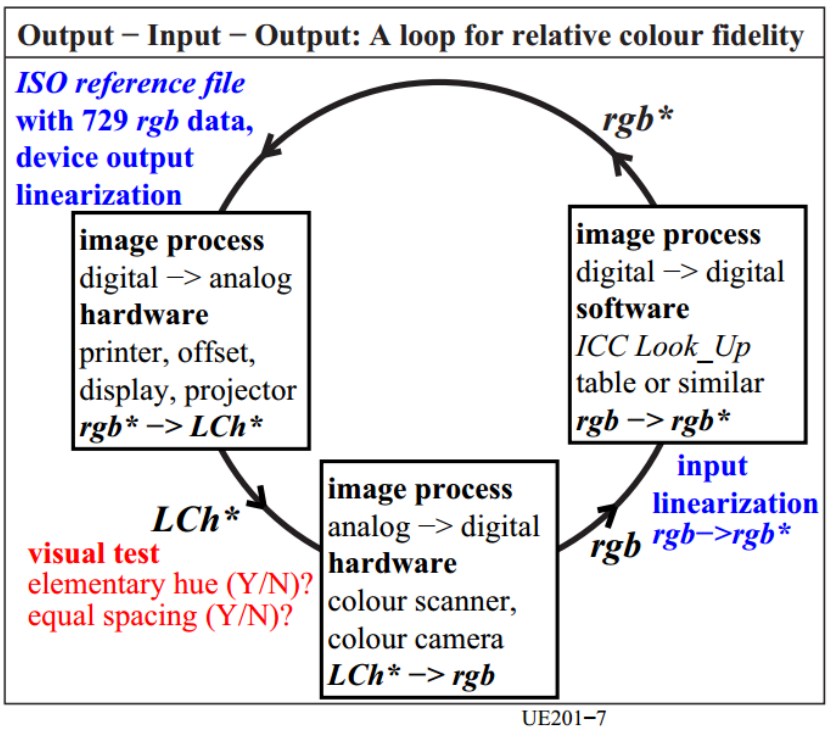


Fig. 2: Output - Input - Output: A loop for high colour fidelity

Fig. 2 shows the workflow of *rgb** and *LCh** data with visual output test. In Fig 2 (*left*) a reference file with 729 *rgb* data produces the intended *LCh** data by **output linearization**, for example by an *ICC* or the *R8-09* method. In Fig. 2 (*bottom*) a scanner or a camera produces from the output the *rgb* values which can be transferred to the intended *rgb** data, for example by an *ICC Look_up* table (Fig.2, *right*). If the linearized file (*rgb** values) is used again to produce an output on the printer, the result is approximately equal compared to the output of the reference file.

Application example: Multifunction colour device

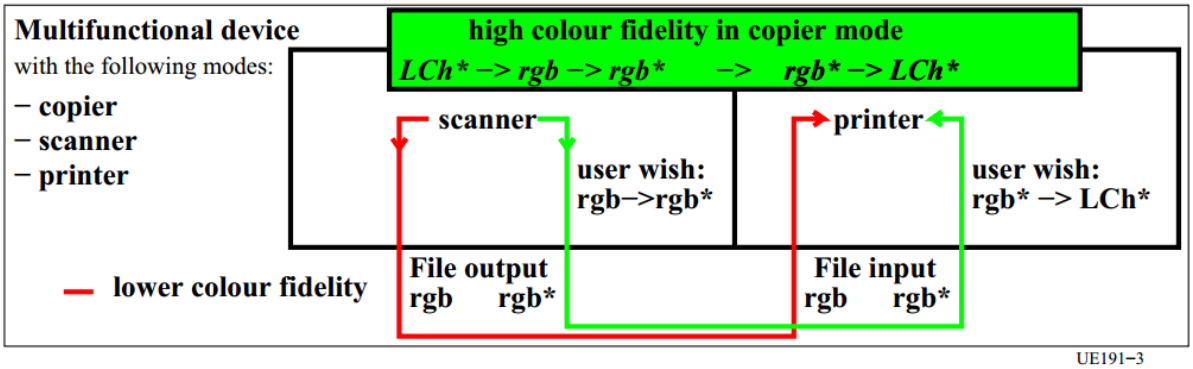


Fig. 3: Colour workflow similar to Fig. 2, user wish of colour fidelity

Usually the colour fidelity in the copier mode between the original and the copy is good *(green colour*). However, if the user takes the scan file and sends it later to the device to print the file, then the colour fidelity is often lower (*red colour*).

This device output property conflicts with user wishes in DIN 33872-X.

Application example: Output of 24 step hue circle

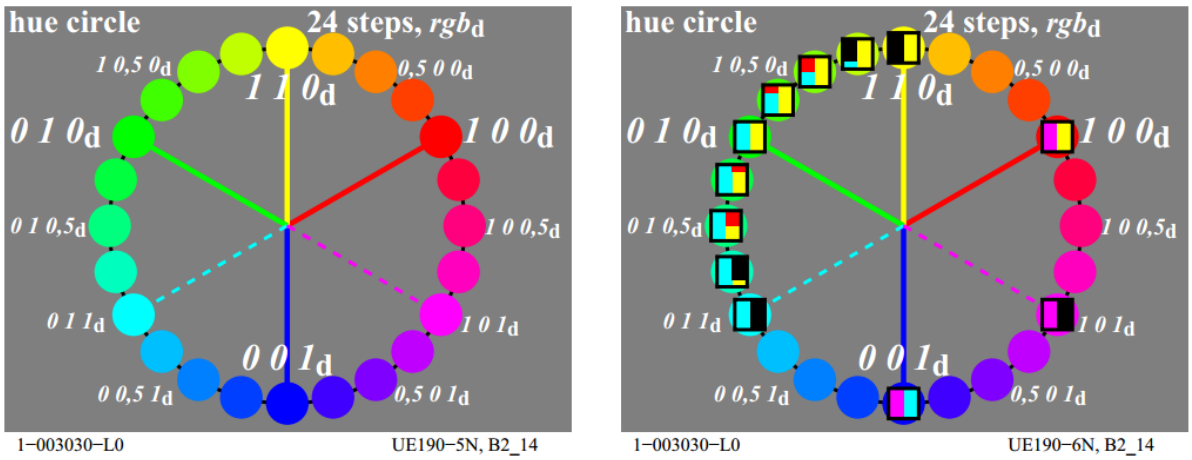


Fig 4: Change of *rgb* data and 24 step hue output of colours

Fig. 4 (*left*) shows the output of a 24 step hue circle. Many users evaluate that the example printer output of a leading printer company produces no hue difference between 5 green steps, 5 red steps, and 3 blue steps. In other words: only 14 of 24 hues steps are distinguishable. The example display and offset output produces 24 visible hue steps, see measurement for all devices: http://130.149.60.45/~farbmetrik/outlin/

Instead of a hue angle difference of 60 degrees between both ends of the 5 green steps, the CIE measurement shows a change of only 12 degrees. However, the four **elementary** hues *RYGB* are

approximately printed for *rgb* = (1 0 0), (1 1 0), (0 1 0), and (0 0 1). ***In summary***: The user wish "elementary hue output" is realized (no agreement with the sRGB colour space) and the user wish of DIN 33872-4 "hue discrimination" fails.

The example printer uses two times 25% and two times 50% more toner as needed, marked by *red* colour in Fig. 4 (*right*). This property produces higher costs, and reduces in addition the visible hue steps from 24 to 14.

Summary: the increasing toner yield is a business model for the printer company and in addition a business model for toner saving companies on the market. The example printer output is **neither** in agreement with the *sRGB* standard **nor** with the user wishes of DIN 33872-4.

ISO/SCIT produces the Resolution 3-2013 "Colour Reproduction":
SCIT notes the presentation from Klaus Richter for his presentation on CIE developments in portrayal of colour on different devices and encourages SCIT members to take note of this work, given that with increasing storage of image data in the cloud, users need confidence that they get the same rendering of an image whatever the device they are using.

For the above areas CIE Division 1 and 8 may take own actions or wait for questions of ISO committees, for example in the areas:

- Definition of a device-independent visual RGB* colour space
- Accuracy of output linearization for printers, offset, display and projectors
- Use and accuracy of scanners and cameras for colour measurement.

In any case the nomination of a member and an alternate for ISO TAG14 (after resignation of J. Schanda three years ago) seems appropriate.

Klaus Richter

Apparent Intensity of Flashing Light

Peter A. Rhodes, University of Leeds

1. Introduction

Flashing lights are widely used at sea for navigation and to mark hazards. Due to the limited response of the human visual system, it has proven necessary to increase the brightness of flashing sources. A century of research has led to various attempts to model the effective luminous intensity of flashing light to provide a fixed-light equivalent, as summarised by Tutt (2010). Several problems remain, however, including the models being valid only at the achromatic threshold of vision. In addition, technology has rapidly advanced during the last century resulting in changes to the spectrum, flash profile and rival lighting.

The aims of this work are to repeat, verify and extend Toulmin-Smith and Green's [TSG] fundamental work on the relationship between the perceived intensities of steady and flashing light sources.

2. TSG Experiment

The original experiments conducted by Toulmin-Smith and Green (1931a and 1931b) consisted of two phases. The first of these attempted to establish whether there was any difference between observations made with one or two eyes (Figure 1). From the outset it should be noted that there is a degree of ambiguity in their descriptions and also a lack of detailed raw data reported in their results.

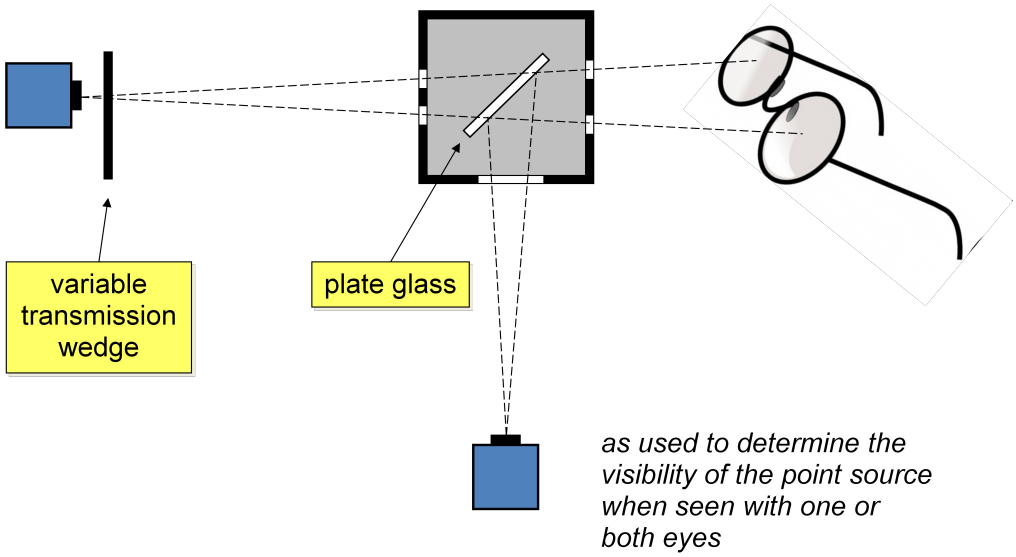


Figure 1: TSG experiment initial phase

The second phase used a clockwork-driven sector disc mechanism to generate a series of light pulses. The observer was able to alternate between flashing and steady light by pressing a key. The intensity of the flashing source was then manipulated by adjusting the position of a variable transmission wedge until a visual match was obtained. A block diagram (Figure 2) illustrates the main elements.

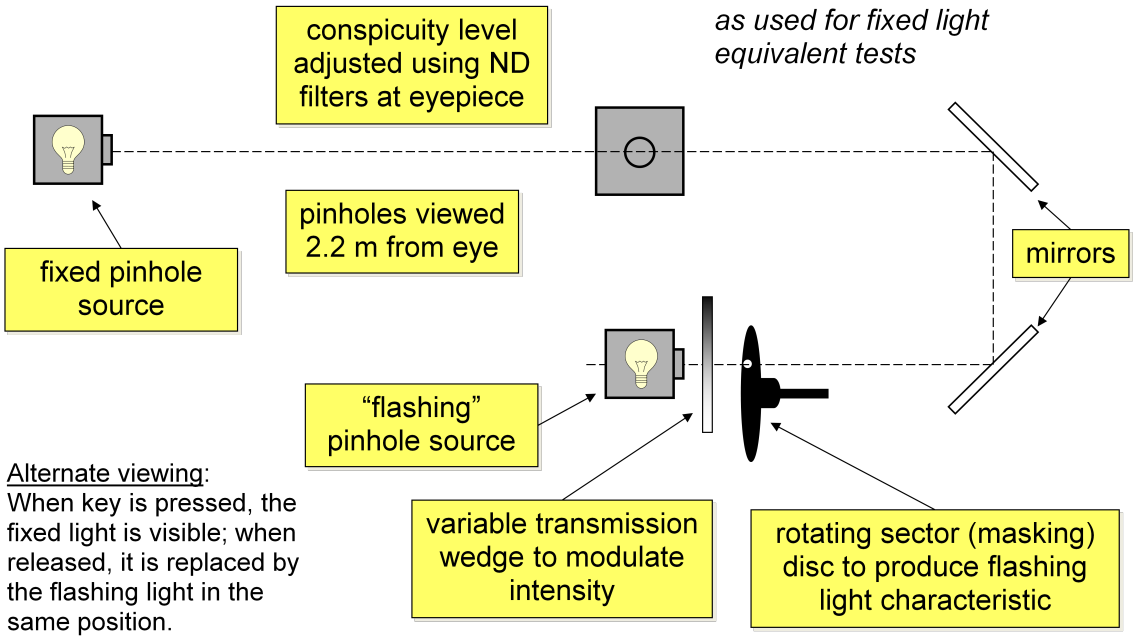


Figure 2: TSG second experimental phase

According to their results, TSG involved only a very limited number of observers (possibly as few as two or three) and many of their smooth curves which plot apparent intensity mask experimental noise. The mechanical set up as described would certainly lead to variations in timing and there was insufficient data to reach a conclusion over the typical variability of observers and the robustness of the conclusions.

3. Apparatus

3.1 Hardware

Due to the unique nature of this experiment, no off-the-shelf solution was available. With the assistance of Bentham Instruments, bespoke apparatus was designed to reproduce similar conditions to those used by TSG but using updated technology. A cross-sectional view of the resulting ILFD20QH unit is shown in Figure 3. Not shown here is the photopic matched photodiode at the surface of the integrating sphere which was used to measure light output.

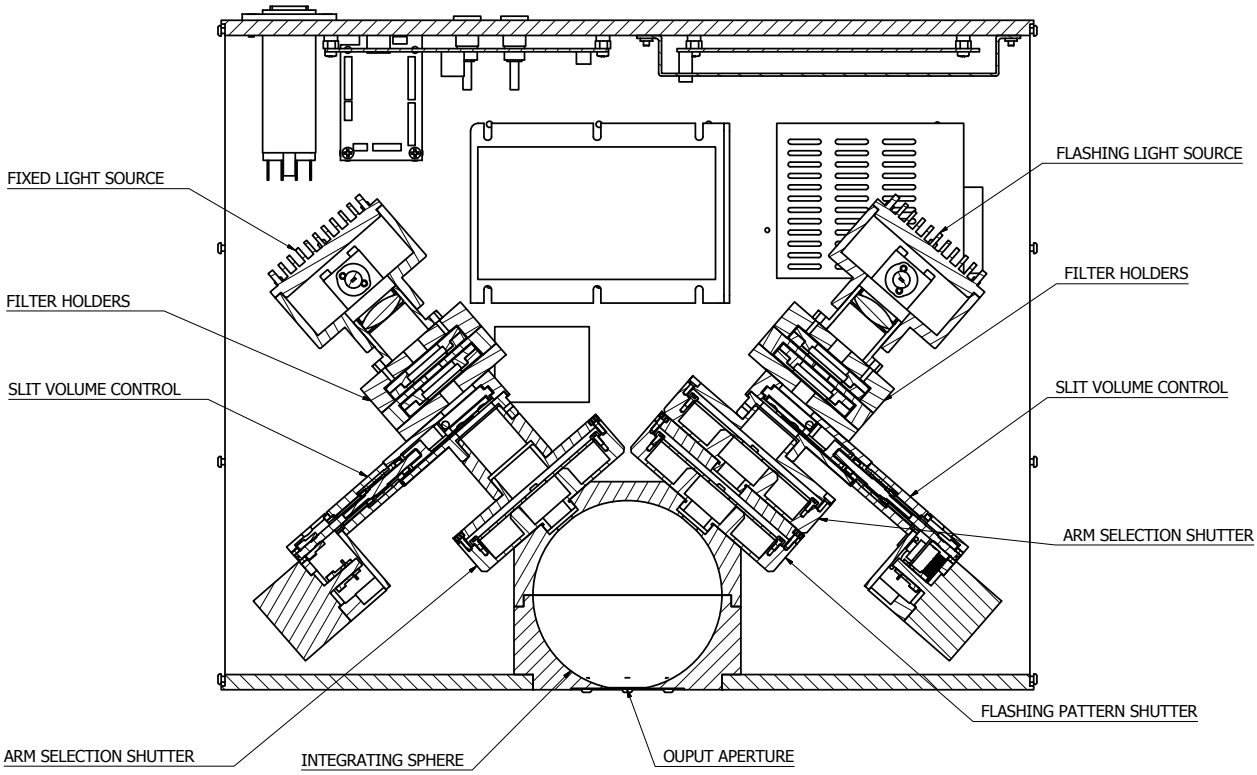


Figure 3: Bentham ILFD20QH

The switching characteristics of the electromechanical shutter used to module the flashing light were assessed by Bentham prior to supplying the finished apparatus. A typical 20 ms pulse is shown in Figure 4 which exhibits a rise/fall time of within 2 ms. The shutter itself is capable of operating over sustained frequencies ranging from 10 Hz to dc.

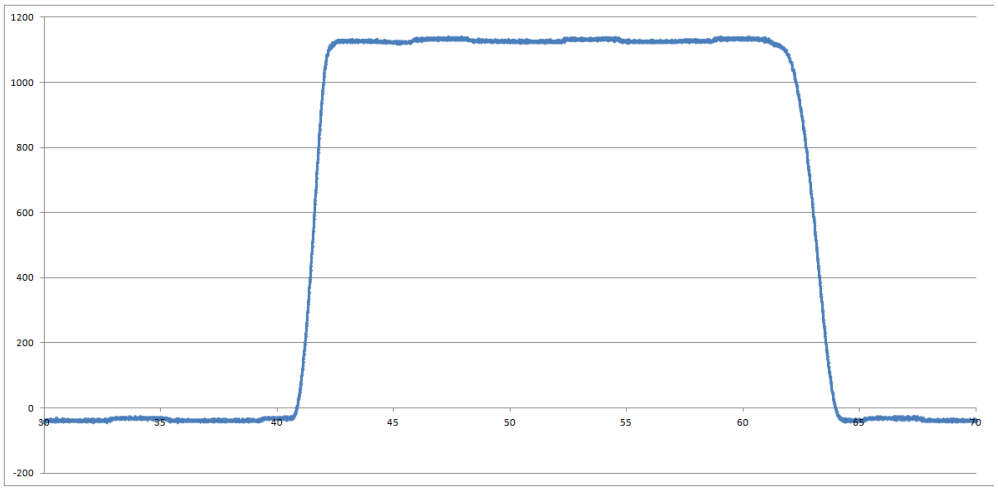


Figure 4: shutter output rise and fall times

Bentham also estimated the measurement uncertainty as being 2.5% on average during the unit's spectral calibration.

3.2 Software

A PC linked to the ILFD20QH source via USB ran software provided by Bentham (2013) having the following functionality:-

- *calibration* – to manually set the slit width or aperture, select or measure the light source (flashing or steady) and to re-calibrate the slit
- *flashing profiles* – graphically configure the duration in ms of the on and off times within a cycle for the flashing source
- *experiment profiles* – set the steady light intensity and assign multiple flash profiles which are to be used as stimuli in an experimental session
- *run experiment* – begin, pause or abort the execution of an experimental profile

Once an experiment had begun, each observer was then able to interact via a game controller (see Figure 6) which had buttons for toggling between the steady and flashing sources and also for changing the brightness of the flashing source. The brightness of the steady source was always that specified in the experiment profile. Each new stimulus began with a zero intensity flashing light. It was *not* possible for observers to adjust this to the same level each time simply by tapping the up button a certain number of times.

Figure 6: controller used by observers

Based on experience from the pilot study, the "next" button was disabled as it proved all too easy to press this by mistake with no easy way of recovering. Instead, the experimenter advanced stimuli via the PC user interface once the observer was satisfied with the match. After a session, the results were stored to a CSV file which included the date, observer name (if recorded), measured illuminances of the steady and flashing sources (in μlux) together with details of the flashing profiles used.

4. Experiment

Due to ambiguities in the description of the original TSG study, a small-scale pilot study was completed to validate the set up. Both experiments were conducted in complete black out conditions with observers seated 2.2 m away from a pinhole aperture, leading to a < 1′ arc visual angle. The pinhole was positioned at roughly the same height as observers' eyes. The ILFD20QH unit's two integrated 30W quartz halogen lamps required a ten-minute warm up before beginning and observers typically needed at least 15 minutes to acclimatise to the darkness – longer if coming from a bright environment. A further refinement was added to the software to add a switching delay, preventing instantaneous toggling between steady/flashing lights.

4.1 Pilot Study

Achieving a completely black environment initially proved challenging, in part because the equipment emitted stray light from power indicators, etc. These were concealed, however it soon became apparent that total darkness created significant problems for observers. Without anything else to look at, the visual system rapidly "lost interest" in between flashes, and most people found it difficult to locate and re-focus the eyes during the brief instant that a flash was emitted. To remedy this, a very dim "reference" light was added so that they had something else to fixate on in between viewing the pinhole source. This reference light was constructed by shining a Kingbright L-7113SEC-E 5 mm orange LED light driven at 1.83 V into a 10 cm integrating sphere having a 2 cm aperture which was positioned at the same distance but above and to the right of the pinhole. The final set up is shown in Figure 5. Even with this light, the conditions were close to the limits of vision leading to the potential for considerable visual fatigue. To minimise this, each session was limited to around 45 minutes (excluding acclimatisation).

For this experiment, only one brightness level was used for the steady light: 0.2 μlux. Using a fixed off-time of 1000 ms, the following 19 different on-time flash profiles were used as stimuli (in ms units).

50	75	100	125	150	175	200	225	250	275
300	325	350	375	400	425	450	475	500	×

The results from this experiment were eventually combined with those of the main experiment, and so will be discussed in the next section. Some adjustments were subsequently made to the range of flash durations in light of the initial findings.

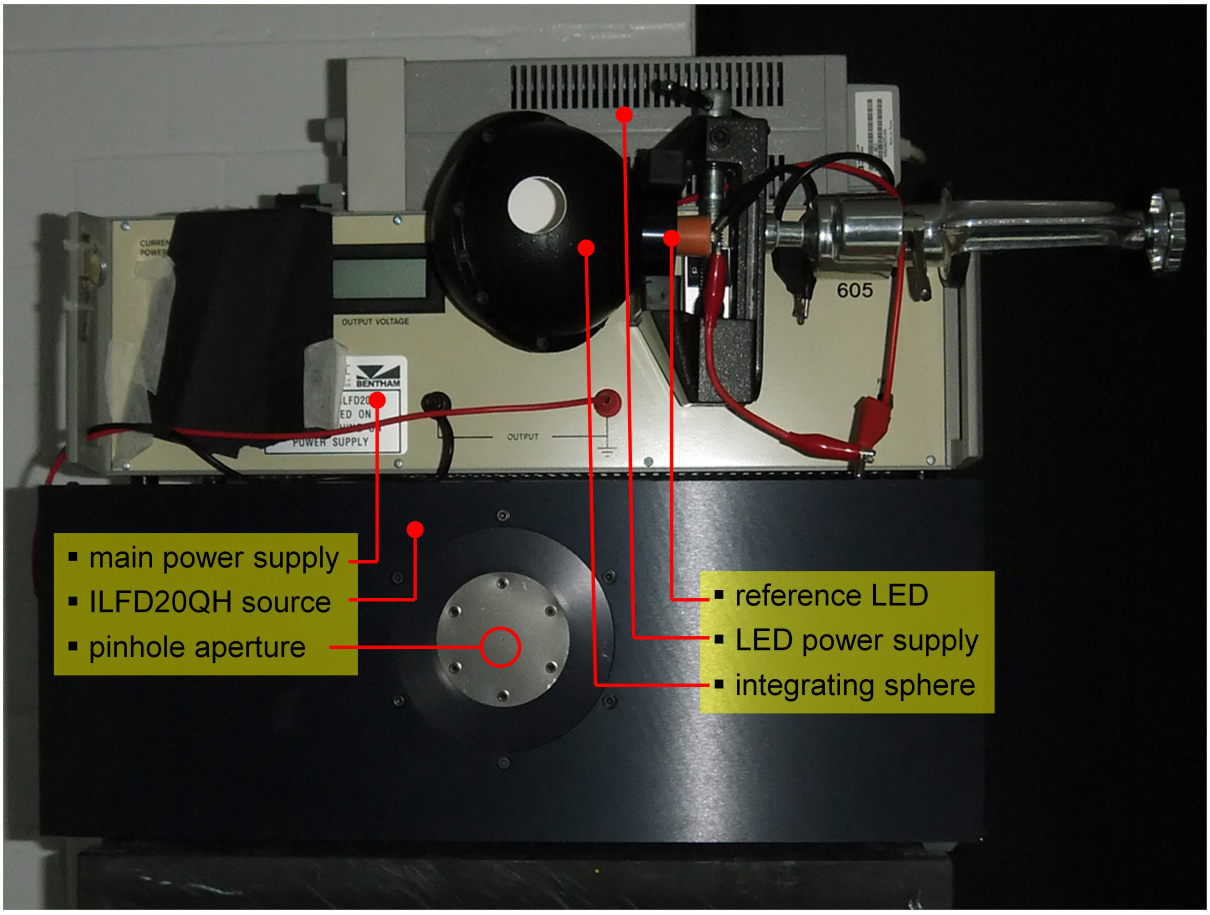


Figure 5: experimental stimulus generation

4.2 Main Experiment

Extending the groundwork laid in the previous section, a further four off-time flash durations were added covering intervals both longer and shorter than the pilot. Each of these four phases included the following sixteen flash durations (in ms) which were again compared with the same 0.2 μlux steady reference:-

25	50	75	100	125	150	175	200
225	250	275	300	350	400	450	500

A total of six observers took part in each phase, although not all observers took part in all phases. Each observer was required to make four observations of each set of stimuli, this being done on different occasions. A new visual acuity test was added based on a modified Snellen chart (1862) which was redesigned to be viewed at the same 2.2 m distance as the light sources. Observers attained scores equivalent to the range 20/16 to 20/25 with vision corrected where applicable.

A list of the participants and the phases they took part in is given below. They were a mixture of professional staff from Trinity House and the University of Leeds.

Observer	Flash Duration (ms)				
	250	500	1000	1500†	2000†
Chris			✓		
David	✓		✓		
Gavin		✓			
Link	✓	✓			
Malcolm	✓	✓	✓		
Neal	✓	✓	✓		
Peter	✓	✓	✓		
Sophie	✓		✓		
Travis		✓			

Before their first session, observers were allowed to practice with a few test stimuli to familiarise themselves with both the task and the controls. They were instructed to make the match in the central part of the vision. Although flashing lights are significantly more conspicuous in peripheral vision, early findings from the pilot study showed that this was not a reliable way of judging brightness. Observers were also encouraged to rest their eyes whenever vision became "fogged" with after images. The reference light proved to be very helpful in this regards.

5. Results and Discussion

After some practice, the majority of observers seemed to adopt the strategy of increasing the brightness of the flashing stimulus until it was just visible before comparing it with the steady light and then switching back to fine tune the match. Several cycles of toggling back and forth between steady and flashing stimuli were usually required; however it should be noted that if a match could not be obtained within a few minutes, the task became progressively harder due to visual fatigue.

Two other observers were excluded from the experiments because their results were found to be highly non-repeatable and "noisy". Performance did not appear to be related to age, experience or visual acuity; although further work would be needed to establish this conclusively. A key finding from this work is the typical variability of observers, which is important in establishing tolerances around the overall trends that were uncovered. The TSG experiments seemed to pay very little attention to this aspect.

† Experiments for the 1500 and 2000 ms phases are still ongoing.

Based on the matching data recorded by the experimental software, the ratios of steady to flashing intensity were calculated. These were plotted against flash duration for each of the phases. To better understand the robustness of the results, standard error bars were included. Since the occasional incorrect result was inevitable due to the highly challenging nature of the task, the median was used when averaging an observer's results as this statistic is not influenced by outliers.

5.1 Observer Reliability

A comparison was made between individual observer's results and the mean results from all observers. These are plotted in detail in Appendix A where the size of the error bars signifies the magnitude of individual variation (i.e. *precision*). For an observer to be *accurate*, their error bars should encompass the mean overall data (red bars) for a given stimulus.

From these graphs, the following points can be identified:-

- qualitatively, the spread of results seems greater than that found by TSG
- the typical standard error for observers was around 0.06 however certain individuals (i.e. Chris and Sophie) exhibit a very much greater variation
- some observers produce either higher matches (e.g. David) or lower matches (e.g. Peter) than average, whilst for others (e.g. Malcolm) this seems to vary according to the interval between flashes
- contrary to expectations, shorter flashes seem to be judged more consistently than brighter ones

To improve overall precision, either more observers would need to be used or alternatively the existing observers could complete more repeat judgements. It is also possible to selectively exclude some observers or specific observer data, however this would need to be justified on the basis of it being anomalous as opposed to representative of the typical human variation for this task.

5.2 Overall Results

Figure 6 summarises the overall results from each of the three phases that have been completed. It can be seen quite clearly that the flash duration time has the biggest impact on apparent intensity, with flashes lasting 250 ms or more being perceived in the same manner as steady sources. This does not seem to be affected significantly by the interval between flashes, although observers found longer off periods much harder to judge. Separate plots for each of the three phases are given in Appendix B in which the spread of individual observer median results can be seen.

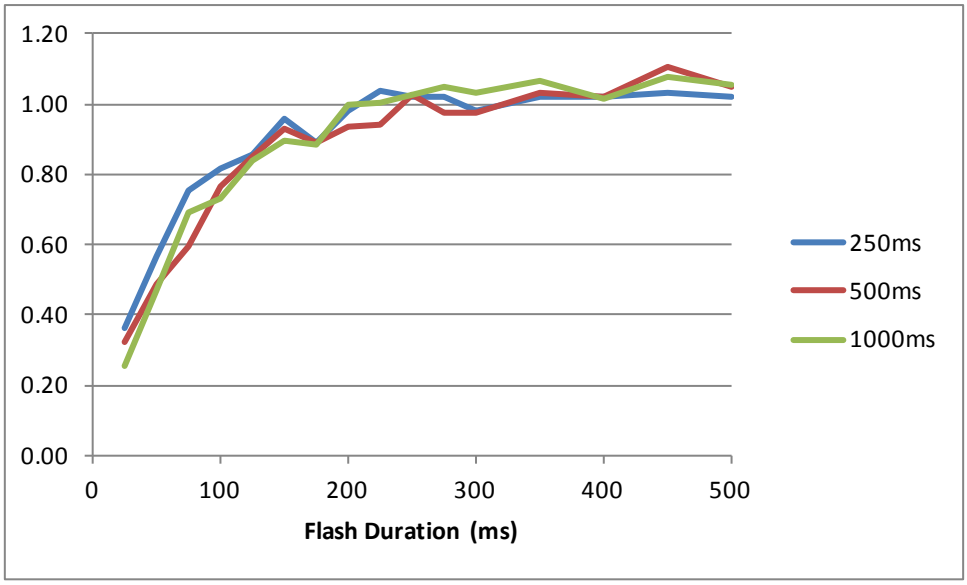


Figure 6: overall results for each dark-time series

6. Conclusions

The findings presented here reveal a definite trend from the observers: for durations of less than 250 ms, flashing stimuli are perceived to be dimmer than steady lights. This means that a flashing light needs to be made progressively more intense as it becomes shorter in duration in order for it to be judged as equivalent in brightness to a steady light. In addition, it has been possible to fully define the experimental procedure and investigate observer variation – both of which go beyond the results of Toulmin-Smith and Green.

Aside from the number of observers used, one possible limitation here is that stimuli were always presented in the same order (i.e. ascending flash length). While this could potentially lead to bias, the intention here was to help reduce the considerable visual fatigue by making the task seem progressively easier. Judging the brightness of such brief and dim sources is at the limits of human vision and not a task that most of us are used to doing. It would therefore be interesting to invite the participation of astronomers as their assessment of the magnitude of stars is probably the closest real-world task.

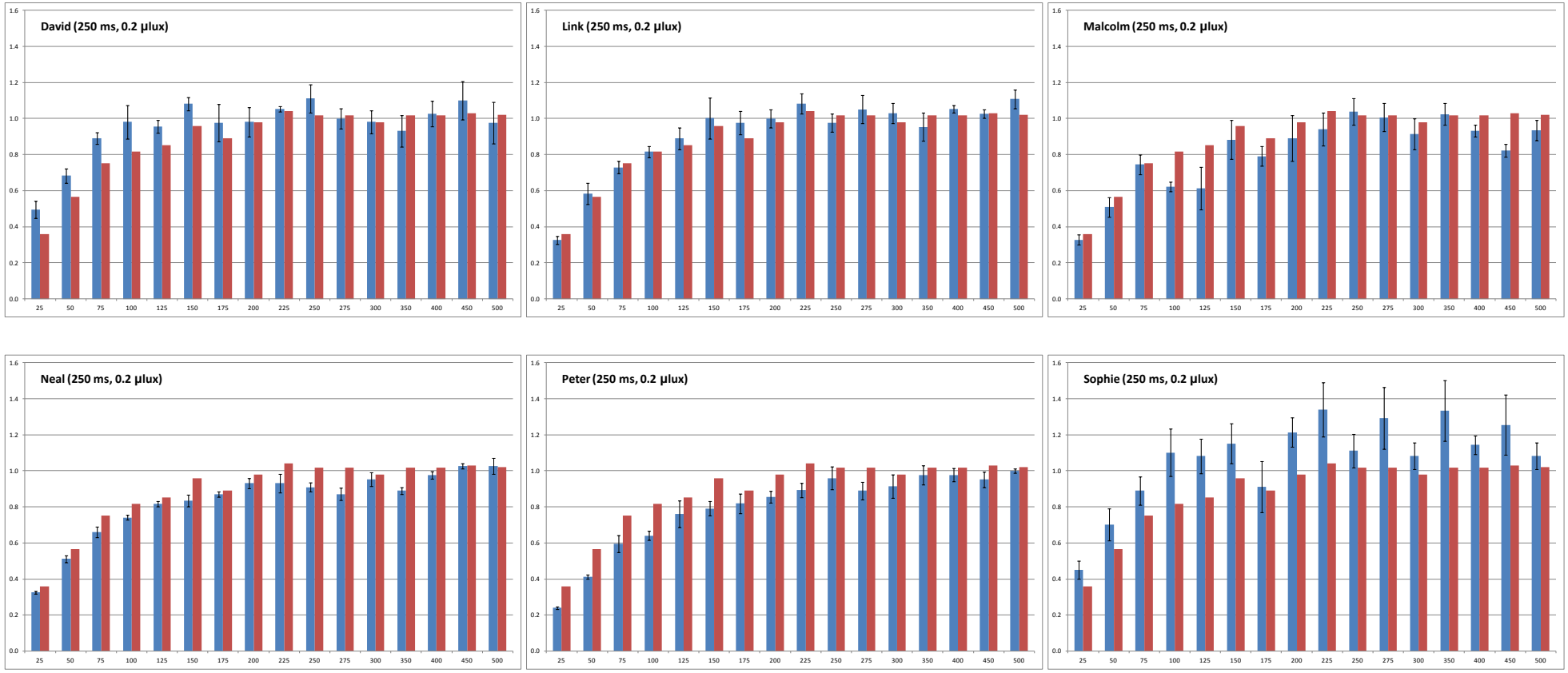
Within this study, data still needs to be collected for the 1500 and 2000 ms flash duration. Further work should then be considered to look at different intensities for the steady light before moving on to the impact of colour of light. In the longer term, the further complexity could be added by adding different coloured (or even moving) backgrounds together with rival lights. This would closely mimic the real world scene experienced by mariners close to land.

References

- Tutt, I. A "Variable a" Approach to Apparent Intensity. *Research & Radionavigation* 2010; Report RR 102.
- Toulmin-Smith A.K., Green H.N. The Fixed Light Equivalent of Flashing Lights. *The Illuminating Engineer* 1933; 26: pp.304-306.
- Toulmin-Smith A.K., Green H.N. The Fixed Light Equivalent of Flashing Lights. *RAE Electrical and Ignition Department* 1933; Memo 94.
- Bentham Instruments Ltd. *IFLD20QH Software User Manual*, January 2012.
- Snellen H. *Probebuchstaben zur Bestimmung der Sehschärfe*, Utrecht 1862

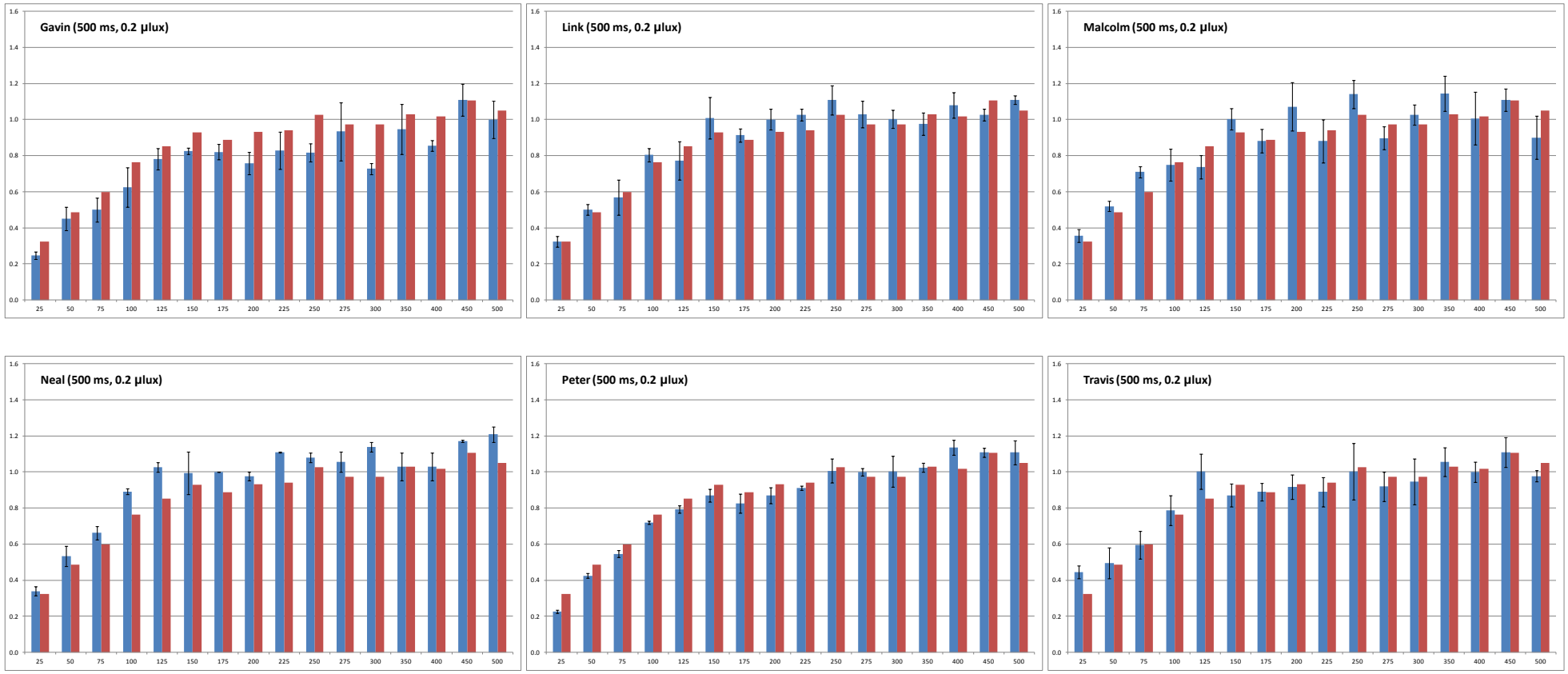
Appendices

A1. Observer Spread for the 250 ms Phase



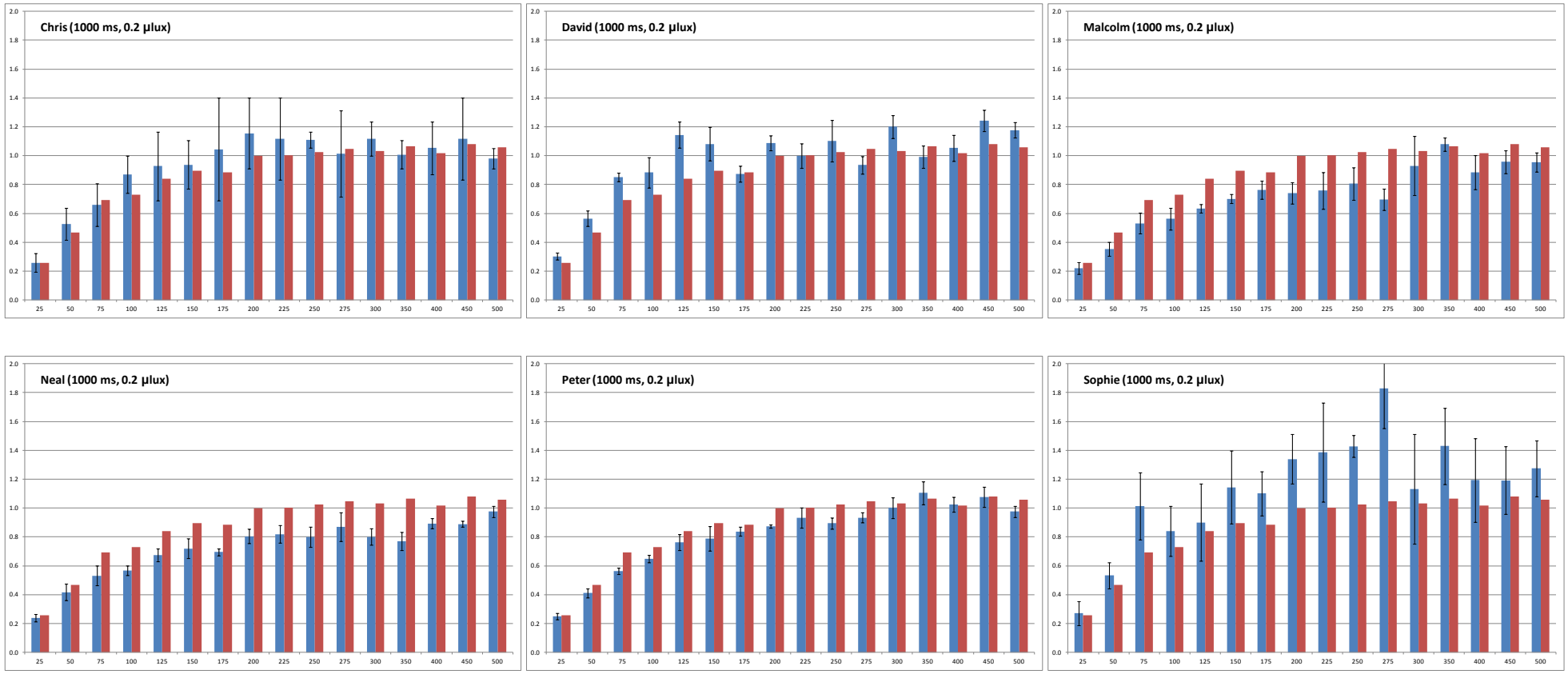
Red bars signify the average over all observers, blue bars represent the median observer result and errors bars show the spread.

A2. Observer Spread for the 500 ms Phase



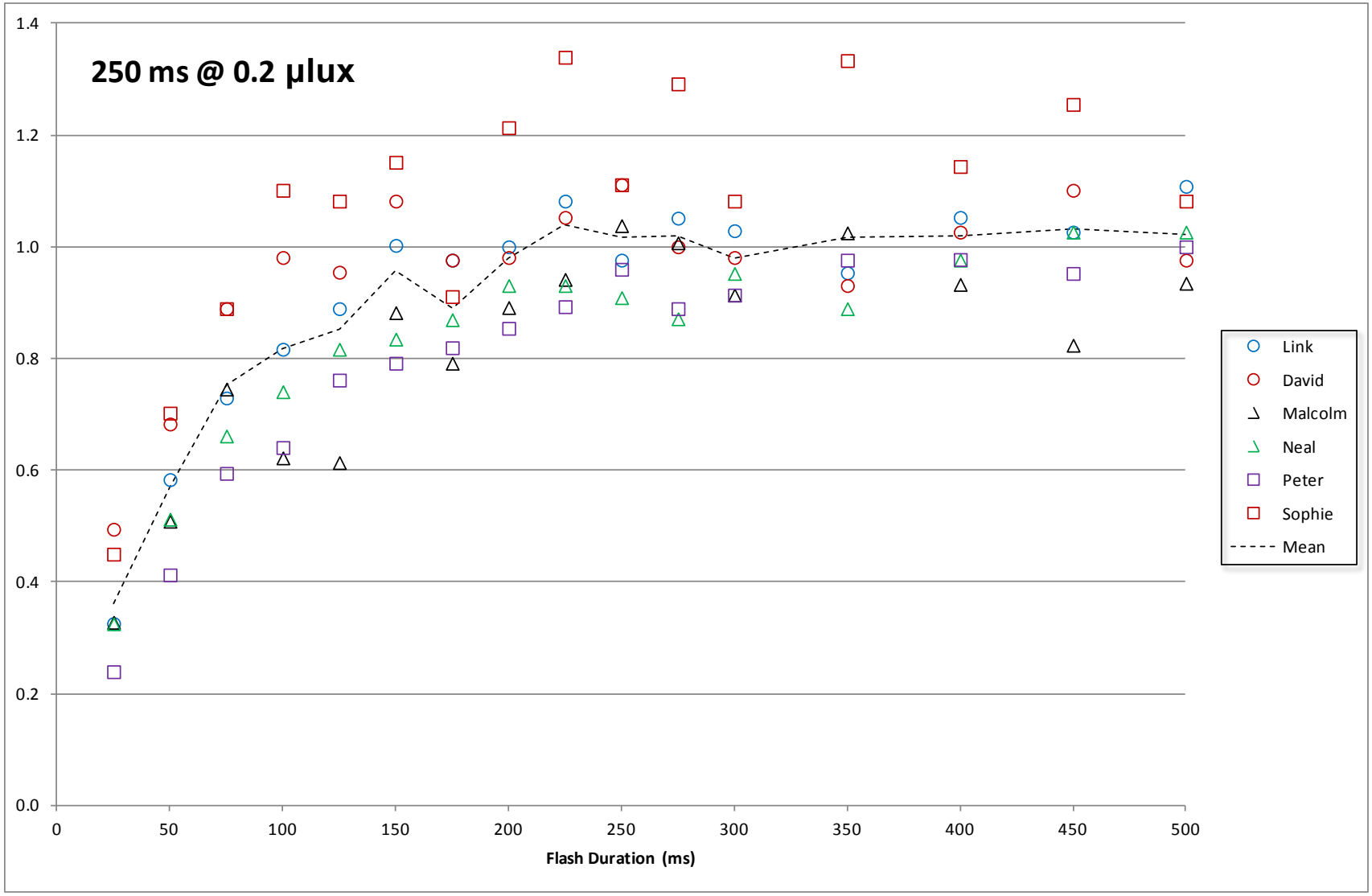
Red bars signify the average over all observers, blue bars represent the median observer result and errors bars show the spread.

A3. Observer Spread for the 1000 ms Phase

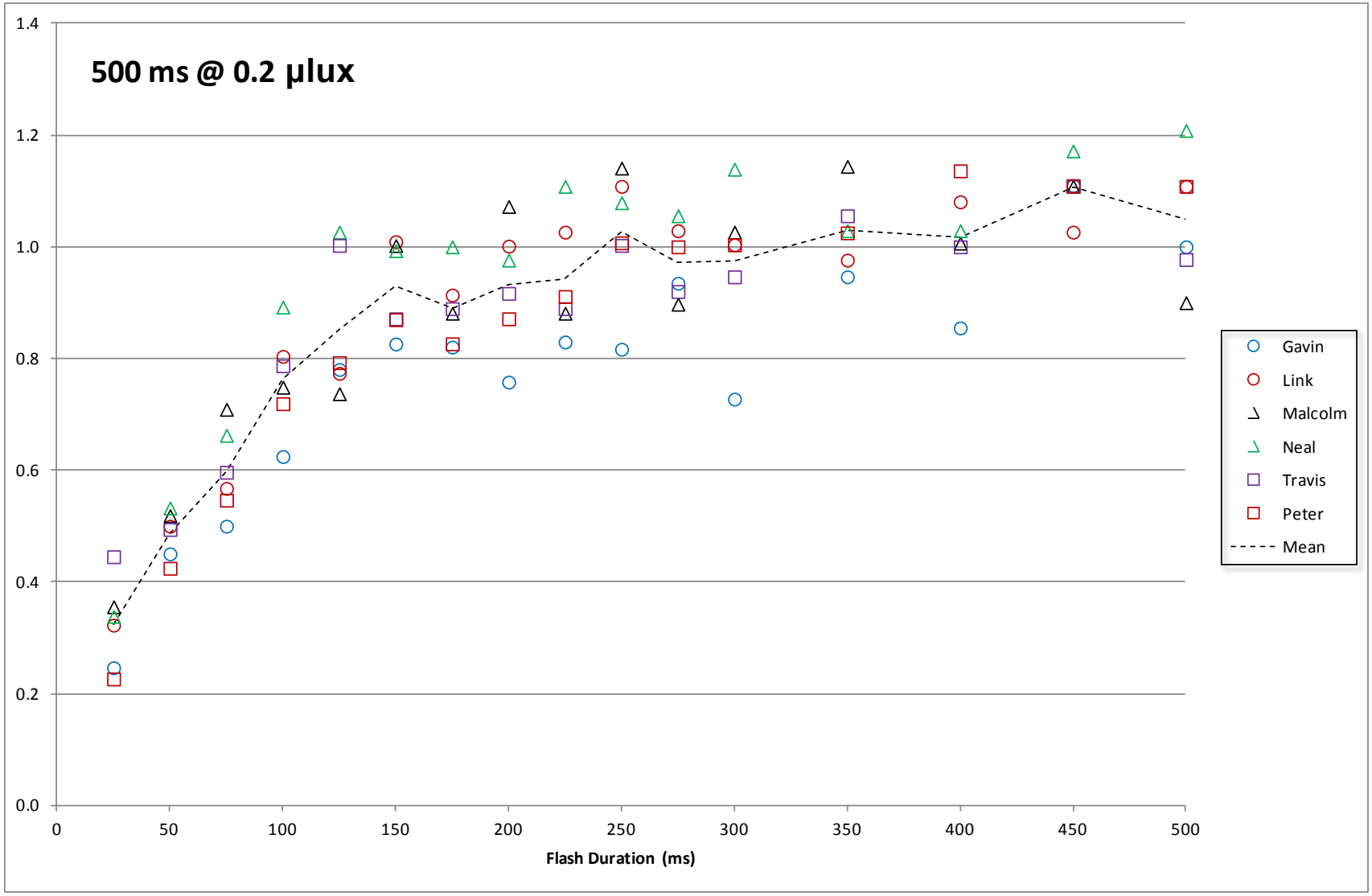


Red bars signify the average over all observers, blue bars represent the median observer result and errors bars show the spread.

B1. Overall Results for the 250 ms Phase



B2. Overall Results for the 500 ms Phase



B3. Overall Results for the 1000 ms Phase