Inter-Society Color Council *News*

Issue 470 Spring 2015

Board of Directors Corner

Hi, my name is Jack Ladson. I joined the ISCC in 1971. I served on the Board of Directors for 3 years before being elected in 1998 to the 6 year Presidential cycle. I served as Secretary from 2006 to 2009 and I functioned as the ISCC liaison to ASTM International for a second term on the ISCC BOD in 2015. It is a pleasure to return to the Board and once again become actively involved.

Prior to my career in color, I worked with NASA developing the guidance and navigational system for the APOLLO mission.

I am a principal in Color Science Consultancy, which was founded in 2002. I have the opportunity and privilege of teaching color and color science around the world. So far, I have taught in the US, Japan, Indonesia, Europe, Canada, Africa, and Thailand. My associates and I solve industrial, color problems for our clients. My wife thinks that my most exciting work is with make-up and hair color.

I write standards for ASTM and am chair of E12.02 on Spectrometry and Colorimetry and E12.06 on Display, Imaging and Imaging Colorimetry. I am a US expert on Digital Still Cameras (DCSs), and participate in writing standards for ISO. I am also an expert witness in the US Federal Court. My website is www.colorsciences.net.

Most recently, Michael Brill, Ellen Carter and I organized, along with Cameron Miller and Maria Nadal of NIST, the CIE, ISCC and ASTM Color Appearance Week at Gaithersburg in 2014. Today Michael Brill, Ellen Carter and I, together with Tom Chirayil of the SPE/CAD, are organizing the SPE/CAD-ISCC joint Color Conference in October 2015. This is the largest color conference organized in 2015 in the US. I hope that you will be in attendance. Please read the latest update on that event in this newsletter. I am a member and have served on the Board of Directors of the Society of Plastics Engineers (SPE) since 2007.

Danny Rich and I designed the award that Dr. Francoise Vienot will receive at the meeting Tuesday during the ISCC Business Awards Luncheon. It is a custom made Venetian bowl colored using alternating stripes of subtractive and additive primaries.

The ISCC is important to me because it connects me with all aspects of what's going on in the world of color – industrially, scientifically, in the world of art and education. I meet fascinating people who have expertise in aspects of color that I don't usually work in, and I enjoy learning from them. Practically, when I have a question that requires more expertise and knowledge, I have people I can call to obtain further insight.

I would like to remind everyone that the ISCC depends on volunteer members to contribute their

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Board of Directors Corner continued

technical and administrative expertise, and their creative ideas to bolster and grow your color organization, the ISCC. We need your help! Contact any member of the ISCC or me to learn how you can help and make a difference! There are plenty of opportunities to serve.

I am grateful to be a contributor to the ISCC Board of Directors and I look forward to the exciting future of the ISCC and all its activities. Don't forget to come to the SPE/CAD-ISCC Meeting in Indianapolis this fall.

Jack A .Ladson
Color Science Consultancy, ISCC BOD

SPE Color & Appearance Division

ISCC Interim Report on the SPE/CAD-ISCC Joint Color Meeting in October 2015

In the last issue of the ISCC News, we announced the joint meeting with the SPE/CAD (Society of Plastics Engineers Color Appearance Division) and the ISCC. We are jointly presenting a color conference at the SPE/CAD RETEC® at the Westin Indianapolis, October 4-6, 2015 in Indianapolis, IN.

We are pleased to announce that the following speakers are confirmed:

Keynote Speaker - Ron Beck, Americhem. *3D printing: The Disruptive Technology*. *3D printing is ranked sixth among the top 10 fastest growing industries in the United States with a growth rate of at least twenty percent per year.*

Breeze Briggs –BASF. *Heat Stability and Compatibility of Dyestuff with Engineering Plastics*

Steven Blazey – A. Schulman. *Manipulation of Polymer Refractive Index to Achieve Highly Chromatic Colors in ASA Polymers*

Michael Brill - Datacolor. *What is the shape of a color-tolerance surface?*

Paul Centore - Consultant**.** *Enforcing Constraints in the Kubelka-Munk Calculations*

Jiangning Che & Muditha Senanayake - California State Polytechnic University. *An Analysis of the Thermochromism Properties of Colored PVC Tiles for the Precise Color Measurement of Composite Materials*

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SPE/CAD-ISCC Joint Color Meeting continued

Keynote speaker – John Seymour "The Math guy". *Patenting a color. What can be patented? What keeps you from being able to get a patent granted? How inventive does an invention need to be? What is the most important part of a patent? When should you not patent a patentable idea? John Seymour will present a lively collection of stories from the patent archive to answer these questions and more.*

Denise Conner – DuPont Titanium. *Natural photo-initiators and oxidation reactions in natural materials*

Tad Finnegan - BASF. *The influence of ultraviolet absorbers on the color of plastics*

Nico Frankhuizen – TQC. *The apotheosis of quantitative Gloss measurement*

Romesh Kumar – Clariant. *Creating Appearance with Pigments and Polymers*

Jim Leland – Copia. TBD

ISCC Macbeth Award recipient - Francoise Vienot, Museum National d'History Naturelle. *Color vision fundamentals: A model for the future of colorimetry. In the future, specifying colour in the LMS space will offer novel opportunities to applications and to colour research. We will discuss applications that have already benefited from the cone fundamental framework and we will suggest further progress.*

Danny Rich - Sun Chemical. *Will color engineering ever be a reality?*

Renzo Shamey - NC State. *Supra threshold - small color differences*

Dymtro Tymonshenko – Sabic. *Pigment Black 7 in Polymer Melts: Chemical and Physical Interactions*

Mark Vincent - Dominion Colour Corporation. *New Pigment Developments for Plastics Industry*

Zhiling Xu and Michael H. Brill – Datacolor. *Second-order-diffraction correction in spectrophotometry*

Meeting Highlights

Sunday Night will be a welcoming reception for the SPE/CAD & ISCC. The SPE/CAD's ***Color Eye Blind Band*** will be playing. Their genre is blues-classic-southern rock founded in 1998. Regular musicians are; **Austin Reid**, DuPont Titanium Technologies; **Bruce Mulholland**, Ticona and **Brian West**, Techmer PM. Got talent? Contact us to interview for a guest appearance.

Monday activities include welcoming comments and introductions from the SPE/CAD by Scott Heitzmann, Sun Chemical; and Ellen Carter, Consultant, on behalf of the ISCC and for CR&A.

Our first Keynote speaker is **Ron Beck** of Americhem speaking on 3D printing. After lunch, **Doreen Becker**, A. Schulman CCNE, will conduct an exciting, lively discussion panel on *Color Trends for 2016 and beyond.*

Tuesday begins with a keynote delivered by **John Seymour**, "The Math Guy". *Patenting a color.*

The ISCC Business Meeting and Awards Luncheon is next where all registered participants are invited to hear Dr. **Francoise Vienot**, Museum National d'History Naturelle, *Color vision fundamentals: A model for the future of colorimetry*.

Tuesday evening the ISCC will hold their monthly Board of Directors' meeting, where all are welcomed and encouraged to attend. Location to be announced.

The SPE/CAD quarterly Board of Directors' Meeting occurs on Wednesday morning, where all are welcomed and encouraged to attend. Location to be announced.

Registration will be available in mid-May 2015. That information will be available at http://www.specad.org/and http://www.iscc.org.

Help Wanted

This is a great way to help your society and to meet with other members. These jobs do not require much time per month, and many are perfect for new members who want to "get their feet wet".

- Linked-In Group Activist
  - Post news and comments to our online group
- Audio/Video Assistance
  - Help with the audio and video at Council meetings, including online broadcasts
- Historian Committee
  - Help with categorizing and scanning documents, and sharing them with the world
- Art and Design exploration committee
  - We are considering formulation of a special committee to explore how the Council can better support the Art and Design community

For more information, contact the ISCC office at (866) 876-4816 or by email at isccoffice@iscc.org.

Metameric Blacks: A Color Curious Column

Ever wonder ... "Why does the moon look large on the horizon, but this doesn't show up in photographs?"

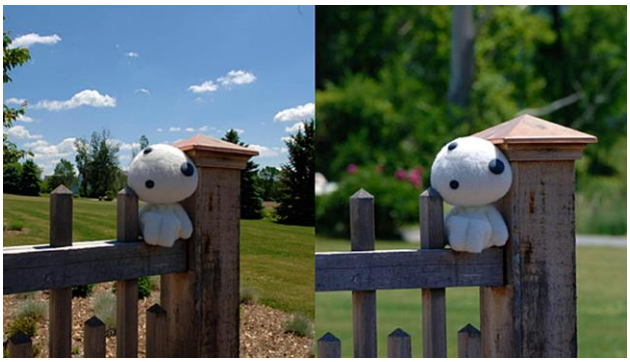
The answer to this question is still debated by scientists. It is known as the *Moon Illusion*. The moon is always almost exactly the same size when visible in the sky. The angle subtended by the moon is about 0.5 degree. (Coincidentally, the angle of the sun is also almost exactly 0.5 degree at the Earth's surface. That's why both lunar and solar eclipses can happen the way they do!). When the moon is on the horizon, it is 0.5-degree wide and when it is straight up overhead, it is 0.5-deg. wide. A camera simply records that physical geometry of the moon and the pictures make the moon look the same size (which it is) regardless of whether it is on the horizon or overhead.

Since there is no problem with the photographs, then the "error" must be in our perception of the moon. The moon looks larger on the horizon to us even though it really isn't and that is precisely the definition of the Moon Illusion. My favorite theory has to do with perceived distance and another visual phenomenon called size constancy. Size constancy refers to the perception that the sizes of objects appear the same whether they are nearby or far away. For example, if you are right next to me, you will see me as about 6-feet tall. If you see me from 100-yards away across a football field, I will still appear about 6-feet tall even though I would only take up a very small portion of what you can see. In other words, even though the image of me on your retina decreases in size when I am farther away, your perceptual system takes into account your perception of how far away I am and I appear to remain the same size (size constancy).

This could create the Moon Illusion because people seem to perceive the "distance to the imaginary surface of the sky" where the moon is to be much larger at the horizon than overhead. Thus if the moon is always the same size on our retinas (it is), then our perception of the moon will be that it is larger at the horizon because we mistakenly perceive it to be farther away (it isn't).

You can always check for yourself. Next time you see the moon, hold your thumb out at arm's length and compare the size of the moon to your thumbnail. The moon will be about half as wide as your thumbnail (yes, it really will!). Now repeat this experiment when you see the moon at different heights in the sky with different apparent sizes and you will notice that it is always about half the width of your thumbnail.

How do photographers sometimes capture this illusion? By changing focal length. Here are two pictures of my stuffed Kodama (a Japanese tree spirit) sitting on a fence. In the picture on the right, my



Kodama is about the same size as the flower bush in the background. In the picture on the left, that flower bush is so small you almost cannot see it. However, the Kodama is about the same size in both pictures. How can this be? It turns out the relative sizes of objects in a scene depends on the lens used to capture the image. The image on the left was captured with a wide angle lens that tends to make things in the background look very far away. The image on the right was captured with a telephoto lens that tends to make far-away background objects look much closer and larger. It is all a matter of perspective and the field of view of the two lenses.

Content of this column is derived from *The Color Curiosity Shop*, an interactive website, also available as both English-language and Spanish-language books, allowing curious students from pre-school to grad-school to explore color and perhaps become interested in pursuing a science education along the way. Please send any comments or suggestions on either the column or the webpage to me at <*mark.fairchild@rit.edu*> or use the feedback form at <*whyiscolor.org*>. This specific topic can be found at <*http://whyiscolor.org/Questions/6-5.html*>.

Mark D. Fairchild
Rochester Institute of Technology

A Blast from the Past: ISCC Newsletter 50 Years Ago

Number 176 May – June 1965 on ISCC website

This is the Annual Meeting issue summarizing the 34th ISCC Annual Meeting held at the Statler Hilton in New York City on April 25-26, 1965. This newsletter is so long because "the extent of the U.S. endeavor in color is thoroughly reviewed both in the Problems Subcommittee Meetings and in the Annual Meeting Reports of the member-body delegates." The level of detail and color activity is truly invigorating. I would encourage you to read the issue at your leisure. As Mike Brill points out, "you may find the report by Leo Hurvich (pp.23-25) amusing. It is literally a blast from the past. Look out, Land, Rushton, and Wald: The 'opponent' in 'opponent color theory' is flexing his muscles."

As a change of pace, this column will highlight color trend quotations from the Industrial Designers Society of America Member Body Report with pictures and colors inserted where appropriate. "Black is a popular car color when the country's economy is in the red. Back in the 20's, the first color preference study for automobiles found that sales of black cars ran a poor fifth (to blue, maroon, gray and green) in the prosperous days before The Crash. Came Black Friday, 1929, and suddenly sales of black cars boomed. Black remained the preferred car color all through the Depression. (Psychologists opined that people just didn't want to be ostentatious when others were selling apples on street comers.) The affluence of today's society is mirrored in a recent survey which showed that black has dropped to seventh in popularity among all car colors. Fittingly, white, the direct opposite of black, is now number one on the car parade for every model of the Big Three auto manufacturers.

http://www.mychurchgrowth.com/blog/category/1929-pontiac/1929-vehicles/page/3/

http://car.mitula.us/offer-detalle/2440285501224219 81298876/1/1/chevrolet-impala-blue-1965/Hemmings?cc=1

"Women respond strongest to personal feelings -- they must feel in their hearts that a product is right for them before exchanging it for their money and their loyalty. Color strongly influences women's coffee buying preferences, according to Stokely-Van Camp's marketing expert, Henry R. Warren, Jr. The tests he reports indicate women believe coffee presented in a **brown colored container is 'too strong.'** To them, a **yellow package suggests a coffee that is 'too weak.'** **Red coffee containers imply a 'rich brew.'**

"Preferred colors for home interiors. As in automobiles, off-whites, and even dead white, are today's favorite interior paint colors, either as the basic room color or as important accents. **Yellow**, from **pale lemon** to **gold** is still holding its place, but has a tendency to merge or be combined with **orange.** And **orange** is itself on the upswing in everything from a clear sherbet hue to **burnt orange**, **rust** and **terra cotta**. All variations of **blue** are slowly but definitely increasing in demand, but turquoise shades are being used largely as accent color. The high fashion colors are **monochromatic reds,** with emphasis on **pale pinks** and **deep bluish reds**, and, most especially **greens**. These are largely of the **yellow-green** variety, but with some **brilliant emerald** also in evidence. After being in eclipse for some years, **green** is once more emerging as a favorite color and is especially popular as an accent in almost any combination.

"Color is busting out all over the television screen. It took six years (1956- l962) to sell one million color TV sets. Estimates are that in the next four years (1962-1966) the number will be quintupled to five million. Studies to date indicate that there is about 50% greater recall for commercials in color than for those in black and white. The American system of transmitting color through the airwaves is currently battling it out with the French system for the dominance of the European network of sets. But, technical details aside, what is really needed is a more penetrating study of color psychology in relation to color television. This should be conducted concurrently with technical improvements to achieve a more realistic and meaningful degree of color fidelity.

"Technology affects taste. Consumer preferences in carpet colors are heading toward brighter, lively hues. One reason: technical advances, such as man- made fibers, which receive dye with greater depth and clarity, make brighter colors practical. There is a. trend away from **white, gray** and **beige,** and toward **turquoise**, **purple** and **burnt orange**."

Paula J. Alessi, *ISCC News Editor*

Rolf Kuehni Donates Letters to the ISCC Collection at the Hagley Museum and Library

Many thanks to our honorary member, Rolf Kuehni for donating correspondence to him from many national and international color science experts to the ISCC archival collection housed at the Hagley Museum and Library in Wilmington, Delaware. Rolf's collection features letters from David MacAdam, Dorothy Nickerson, Fred W. Billmeyer, Jr., Faber Birren, Gunther Wyszecki, David Wright, William Thornton, Keith McLaren, Leo Hurvich, Dorothea Jameson, Franc Grum, Robert Boynton, Jozef Cohen, Tarow Indow, Yoshinobu Nayatani, Robert W. G. Hunt, Henry Hemmendinger, Frans Gerritsen, Anders Hård, Deane B. Judd, Richard S. Hunter, Andreas Brockes, Ed Stearns, and L. F. C. Friele.

This letter collection truly is a treasure to the color science community. For example, there are 17 letters from David MacAdam to Rolf Kuehni spanning a time period from February 18, 1971 to December 5, 1988. These letters cover such interesting topics as color difference ellipse formulae MacAdam developed to fit some of Rolf's data, comments on FMC1 color difference formula, and comments on MacAdam's book, *Sources of Color Science*. The heart of these particular letters is found in those dating from December 18, 1974 to November 8, 1976. Here we see discussed the activities of Rolf Kuehni and David MacAdam in the CIE Committee on Colorimetry as it dealt with such hot topics as the development of the OSA Uniform Color Scales, and the CIE L*a*b* and L*u*v* color difference formulae. One also gets a feeling for where the United States National Committee of the CIE stood on these controversial issues. It was fascinating to read that after the 1976 CIE recommendations came out on the L*a*b* and L*u*v* color difference formulae, David MacAdam predicted that these "incorrigible CIE recommendations will not be replaced for decades". His prediction regarding replacement color difference formulae taking decades was actually quite accurate.

Another example is two letters to Rolf from Gunter Wyszecki. The first one dated August 13, 1973 refers to a debate about whether "the confusion in color discrimination is qualitative or quantitative". Wyszecki calls for more color-matching ellipsoid data to help settle the debate. Wyszecki also cautioned that the use of statistics to interpret visual data can sometimes be misleading. In a second letter dated April 9, 1974, Wyszecki weighs in on the usefulness of CIE L*a*b* and L*u*v* color spaces as being used to predict medium to large color differences. It is clear that he is getting ready to become a key player in the CIE's pursuit of the best color difference formula.

A final example is three letters from Faber Birren to Rolf. The first two letters refer to a paper that Birren plans to give at the 1985 ISCC Williamsburg Conference. The final title is "Color in Religious Mythology and Symbolism". His talk will discuss data he has collected on "symbolism, religion, healing, anthropology, and alchemy". He encloses a short abstract enumerating that he will discuss how color has played a symbolic role in religious mythology for such countries as Egypt, India, China, Greece, and Italy. With his last letter, he sends Rolf, as *Color Research and Application* editor, a new edition of Chevreuls' work that he edited. Birren is kindly asking Rolf to include a review of this work in an issue of the journal.

These letters were scanned before they were donated to the Hagley Museum and Library. Copies can be viewed on the ISCC website (http://iscc.org/resources/letters.php). Perhaps this donation will encourage others to add to this collection letters in their possession that will enhance the general knowledge about progress in the field of color.

Paula J. Alessi, *ISCC News Editor*

Want Ad

Richard and Marjorie Ingalls are looking for a new home for Fred W. Billmeyer's COMIC I, the first automated color matching system. This is a classic colorant mixture analog computer built by Davidson and Hemmendinger. For being more than 50 years old, it is in excellent condition. This device is about 7 ft. wide and 6 ft. tall. It desperately needs a new home to preserve it for historical and possibly educational reasons.

If you are interested in becoming the owner of this historical relic, please contact the Editor, Paula Alessi at geinhaus@frontiernet.net or 585-225-4614.

Tribute to a Great Man, Professor János Schanda

The vision, lighting and color science communities lost a truly great man. On March 8, 2015, Professor János Schanda passed away at the age of 82.

Dr. János Schanda was Professor Emeritus at the University of Pannonia, Hungary. He graduated in Physics at the Loránd Eötvös University in Budapest. His PhD thesis dealt with the "Spectroradiometric Investigation of Electro-luminescence".

The Hungarian Academy of Sciences granted him the degree of "Doctor of Technical Sciences" for his thesis work on colour rendering. He retired from the Research Institute for Technical Physics of the Hungarian Academy of Sciences as Head of the Department of Optics and Electronics and joined the University of Veszprém (now University of Pannonia) as professor of informatics. There he was head of the Department of Image Processing and Neurocomputing. Since his retirement he was Professor Emeritus and was running the "Virtual Environment and Imaging Technologies Laboratory".

For two decades, he was the face of the International Commission on Illumination (CIE). During the 1980's and 1990's, he served the CIE as its General Secretary and later Technical Manager. Also he served many functions in a number of honorary positions of the CIE. From July 2007 on, he was the Vice President Technical of the Commission, was Past Secretary, chaired several Technical Committees dealing among others with fundamentals of photometry, colorimetry and colour rendering. Even at the time of his death, he was working tirelessly as chair of Technical Committees within CIE Division 1.

Dr. Schanda was a member of the Optical Society of America, The Society for Imaging Science and Technology and of several Hungarian Societies in the fields of light and lighting and optical measurements.

Professor Schanda was also very active in the International Colour Association (AIC). He served on the AIC Executive Committee from 1978-1981 as AIC Vice President. His active involvement in the Hungarian National Color Committee allowed him to co-chair the 7th AIC Congress, which was held in Budapest, Hungary. Not only did he arrange the technical program, but he was also our most gracious host.

He was on the editorial/international Advisory Board of Color Res. & Appl., USA, Lighting Research & Technology, UK, Light & Engineering, Russia and the Journal of Light & Visual Environment, Japan.

He received many awards and honors, including the 2010 Newton Medal from The Colour Group of Great Britain.

He was the author of over 600 technical papers and conference lectures. He is the father of CIE's publications on Colorimetry and all of its revisions. Here is a listing of some of his most memorable papers that he gave at AIC meetings from 1969 to 2013.

- 1969 AIC 1st Congress Stockholm

"Colour measurement of luminescent materials"

- 1977 AIC 3rd Congress Troy, NY

"Correlated colour temperature and the Delta Eab colour-difference formula"

- 1985 AIC 5th Congress Monte Carlo

"Variation of colour rendering index using different real samples"

- 1993 AIC 7th Congress Budapest

"Colour and the visual display unit"

- 1997 AIC 8th Congress Kyoto

"The new CIE rendering formula"

- 2001 AIC 9th Congress Rochester

"LED colorimetry"

- 2013 AIC 12th Congress Newcastle

"Colour preference – colour fidelity"

János, as most of his friends called him, was a remarkable man. He was a teacher dedicated to his students. He was a researcher who believed in doing current state-of-the-art work even if it meant crossing new frontiers to advance the science. His research went from color measurement to basic colorimetry, to color rendering to lighting to LEDs as the demand in our world grew for new technology. He believed in uniting the international color and vision world through his dedication to CIE and its relationship with other organizations like ISO.

He was a very gentle, professional and diplomatic man, always kind to all. It is hard to imagine attending a CIE Division 1 meeting without him being present.

János, you will truly be missed. There will always be a special place in our hearts for you! May you rest in peace!

HUE ANGLES

(Send contributions to mbrill@datacolor.com and see http://hueangles.blogspot.com))

All illuminants are equal-energy, but some are more equal than others

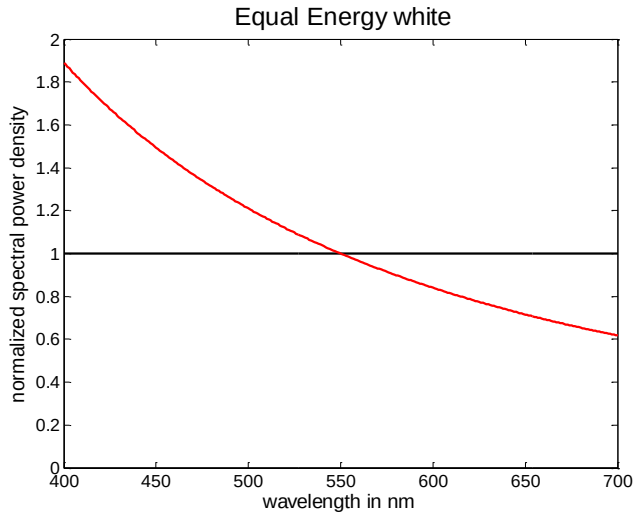
Equal-Energy White: Does it illuminate or obscure?

Once in a while I have to rant about a theoretical point that requires some mathematical discussion. I apologize in advance to those who expect a minimum of math in this column. But I believe some editorial space is warranted by something that consensus has given an undeserved special status.

We are often cautioned by the CIE not to confuse lights with illuminants: Lights are physically real but illuminants are just lists of numbers juxtaposed with wavelengths. The distinction can at times appear pedantic: Illuminants are derived from physical measurement, aren't they? Yes, but there is more to say. Some illuminants are more closely tied to physical reality than others. For example, D65 emerged from a principal-component analysis of measured spectra, but nobody has ever actually seen D65 because it is a statistical distillation---like the average family having a fractional number of children. Even farther from physical reality is the equal-energy white illuminant, which is not even a statistical distillation of any real measurements. Yet the CIE has dubbed it "Standard Illuminant E", it is sometimes called EE, and it has had an interesting history.

For many decades, the equal-energy white illuminant has been a bulwark of color science. Defined simply as a constant-in-wavelength spectral-power distribution, E was used in both the 1931 and 1964 CIE systems to area-normalize the color-matching functions (so E gives the "white" X = Y = Z by definition). It is the adaptation state that some believe we awaken in after a long sleep---and the adaptation state to which all colors are transformed in modern CIE color-appearance models.[1] Colorimetrists' affinity for a unit weighting function has also led to such functions being used to define colorimetric quantities that are not illuminant spectra. A unit weighting function such as heralds EE underlies all discussions of orthogonal color-matching functions from D. L. MacAdam to Matrix-R analysis, and is a hidden part of the structure of principal-component analysis of reflectances. (The principal-component eigenvectors are, after all, orthogonal with respect to the unit weighting function.) I will say no more about these non-illuminant choices here.

All seems well in using the equal-energy white as a preferred spectrum, until one thinks: What if we had adopted the EE illuminant as equal-energy per terahertz of frequency ν instead of per nanometer of wavelength λ? The colorimetric world as we know it would be quite different numerically. For example, the figure below shows the current equal-energy white illuminant (the horizontal black line) and also the wavelength-density plot of the spectrum that is constant in frequency-density over the visible range (the red curve, normalized to 1 at 550 nm). Relative to the former, the latter emphasizes the short-wavelength end of the spectrum. [The red curve is $f(\lambda) = c/\lambda^2$, derived from $\nu = c/\lambda$ and the equal-energy-in-ν relation $f(\lambda)\,|d\lambda| = 1\,|d\nu|$.]



Of course, looking at wavelength- and frequency-based equal-energy spectra doesn't exhaust the possibilities. Any positive-definite spectrum g(λ) is a viable equal-energy white in a function of wavelength $w(\lambda) = \int_{400nm}^{\lambda} g(x)\,dx$. [This is implied by the equal-energy-in-w condition $g(\lambda)\,|d\lambda| = 1\,|dw|$.] But of all the possible white spectra, wavelength-based EE is the one considered special by color research. To paraphrase from George Orwell's *Animal Farm*: All illuminants are equal-energy, but some are more equal than others.

Would some benefit be conferred by re-selecting the domain in which E is equal-energy—perhaps an improved visual performance of principal-component approximations? Regardless of the

continued on the next page

Hue Angles continued

answer, it may be beneficial to re-frame colorimetry so as not to depend on the primacy of the wavelength domain over, say, frequency. Or perhaps it is enough to be careful that our scientific conclusions don't depend on E as a special illuminant.

What do ISCC readers think?

[1] Of course, a spectrum of light is not uniquely connected to an adaptation state, as any metamer of that spectrum would produce the same adaptation state.

Michael H. Brill
Datacolor

COLOR research and application

IN THIS ISSUE, Spring 2015

About eight percent of men (and ½% of women) in the general population have deficient color vision with the majority of those having some form of deuteranopia. Shigeharu Tamura, Yousuke Okamoto, Seiji Nakagawa, Takashi Sakmaoto and Yasushi Shigeri realized that the transition from current lighting to LEDs provides lighting designers and engineers an opportunity to optimize the light spectrum for special situations. They thought that with a specially selected spectrum people with deuteranopia would be able to discriminate the differences between certain colors better. In their article "Practical color barrier-free illumination for deuteranopia using LEDs" they report how, by careful selection of the combination of specific red, green and blue LEDs, they produce an illumination that allows both normal and deuteranopic observers to identify better the color numerals on the Ishihara color test and increase their ability to distinguish the hues of a color chip continuously in Farnsworth Panel D-15 test.

While we are on the topic of color vision tests, in our next article, "Test/retest and inter-test agreement of color aptitude measures", Andrew John Anderson and Alan Johnston examine both the reliability of and agreement between five color aptitude tests: the Farnsworth-Munsell 100 Hue Test, the HVC Color Vision Skills Test, the ISCC Color Aptitude Test, the Nagel Anomaloscope, and a custom designed two-color discrimination test. Since no test can agree more with another test than it agrees with itself, they demonstrate that a principal reason why the color aptitude tests show poor inter-test agreement is that they each have a high degree of test/retest variability.

Next we have an article on color management. When an image is moved from one device, say a camera, to another device such as a printer or display, the color in the image is adjusted so that it will appear as similar as possible to the original. Usually this is done by mapping to and from an intermediate color space by using a standard chart to develop the correction factors for the colors. If the lighting on the standard chart is not even across the chart, the correction factors will be need to be adjusted for the uneven lighting conditions. Graham David Finlayson, Maryam Mohammadzadeh Darrodi, and Michal Mackiewicz have developed a new, simpler method to make the adjustment. They call it "The alternating least squares technique for non-uniform intensity color correction." Their method removes the need for an additional image of the gray chart.

The Munsell color order system was created in 1095 by Albert H. Munsell, who was a practicing artist and teacher. By using a coordinate system of hue, value and chroma, any color could be described clearly avoiding the confusion arising from common color names. The system is still widely used today. However, now we have computers and other digital devices that use a three phosphor display to make colors. When one wants to display on a computer, a color that has be specified by its Munsell notation, the notation must be transformed to a digital system relating to the three phosphors of the computer, e.g., sRGB. To accomplish this Shih-Wen Hsiao and Cheng-Ju Tsai propose "A residual modified transformation formula from Munsell to sRGB color system."

A series of articles on "Unique hue data for colour appearance models" has been published in this journal in years: Part I: Loci of unique hues and hue uniformity was published in 2011; Part II: Chromatic adaptation transform in 2013 and now in 2015 we have "Part III: NCS unique hue data" in this issue. In this study Kaida Xiao, Michael Pointer, Guihua Cui, Tushar Chauhan, and Sophie Wuerger use NCS unique hue data to evaluate whether the NCS unique hue data are consistent with the default unique hue angles used in the CIECAM02 color appearance model. They found a clear discrepancy between the NCS and the default unique hue loci for unique yellow and unique blue of CIECAM02. They also wanted to investigate the agreement of the unique hues in CIECAM02 across different media. So they compared physical samples of NCS colors

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with unique hue data of CRT self-luminous stimuli, and found that two data sets agree reasonably well in CIECAM02.

In our next article, another group of authors also studied the unique hues of the Natural Color System (NCS). Remember, the International Lighting Vocabulary defines unique hue as a hue that cannot be further described by the use of hue names other than its own. The unique hues are red, yellow, green, and blue. The NCS also has intermediate hues placed halfway between the unique hues on the color circle. Renzo Shamey, Weethima Sawatwarakul, and Rolf G. Kuehni invited 24 participants to make a cognitive or mental comparison of a test hue to two reference hues and assess the possibility that the test hue could be generated from two reference component hues, in the mind, without any tools to physically perform a match or make adjustments to stimuli. The test hues were either unique hues or intermediate hues from the NSC system. They found responses for the two sets of panels were significantly different, giving credence to Hering's concept of unique hues that is the basis of the NCS. See their article "Cognitive comparison of unique and intermediate hues" for further details and results.

Most experiments in color naming use colored patches, but people commonly look at objects and confidently give the color of the object, even though the shape of the object causes the color to vary due to highlights, shadows, and dimensional effects. In "Color naming experiments using 2D and 3D rendered samples" Midori Tanaka, Takahiko Horiuchi, and Shoji Tominaga describe a study of 218 test colors comparing the color names observers gave to two-dimensional patches or three-dimensional objects colored with the same colors. They found a number of generalizable results, such as for chromatic colors, darker color terms are generally chosen for 3D samples in comparison to the corresponding 2D samples of the same color. They also found that changing the illumination position changed the color terms and the average brightness level of the sample. However, the samples with the same brightness level were ascribed different color terms depending on whether they were 2D or 3D.

Continuing with lighting issues, we have two articles. First, studies have shown that the correlated color temperature (CCT) of the illumination can affect visual performance of office tasks, but is a higher CCT always better? Rong-Hwa Huang, Leemen Lee, Yi-An Chiu, and Yi Sun investigated the "Effects of color temperature of LED desk lighting on work attention." They compared three LED desk lighting conditions 2700K, 4300K, and 6500K when testing business students with the Chu Attention Test, which measures focused and sustained attention. They found that there was a significant performance improvement under the LED light with the CCT of 4300K as compared to the LED of 6500K.

Spot lights are used in stores, public buildings, and increasingly in homes to highlight particular objects or spaces. Like other lights, they have been characterized by their CCT and color rendering index. However, satisfaction of spot lighting seems to be based on the visual perception of color uniformity of the field. In our next article, Anne Teupner, Krister Bergenek, Ralph Wirth, Pablo Benítez, and Juan Carlos Miñano describe the "Optimization of a merit function for the visual perception of color uniformity in spot lights." The merit function, a linear regression of four basic functions (color difference, shape, contrast, and symmetry) was developed by looking at the correlation between observer preferences and measureable factors of the uniformity of the illuminated field. The proposed merit function enables an objective analysis of measurements and optical simulations according to human preferences in a wide range of spatial color distributions.

Our last three articles in this issue are from the field of textile coloration. While textiles have traditionally been colored by dying either the threads or fabrics themselves, printing color onto the fabric has also gained acceptance. However, inkjet printing on textiles can be very different from printing on paper. Textiles can vary greatly in surface textures, and this affects the coverage and penetration of the inks. Kyung Hwa Hong, Jihyun Bae, and Traci Lamar report on The "Effect of texture on color variation in inkjet-printed woven textiles." In their study, they found that the interaction of color and texture is complex. Texture had sufficient impact on color variation to affect pass/fail evaluation in an industrial setting, even when many printing variables are held constant. They conclude that instrumental measurements of surface texture may be valuable in anticipating visual response to texture in a production setting where use of visual perception measures is impractical.

Next Dejun Zheng proposes "A novel method for fabric color transfer." It involves automatic selection of the colors from the natural images to develop a color design for fabric. An image of the color design makes it possible to obtain the membership function of the color deviations of the image.

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Then colors can be changed and transferred to a new image that preserves a similar texture appearance, but with significantly different color effects.

Color is one of the primary factors in determining whether a textile will be accepted or rejected by the buyer. With complex coloration on some textiles, instrumental determination of whether color variations will be acceptable or not can be involved and complex. Pengfei Li, Jing Wang, and Jun-feng Jing point out that an optimized back propagation neural network has a simple structure, shorter training time and better accuracy when coupled with the CIEDE2000 color difference formula. In their article, "Application of improved BP algorithm in chromatism detection of fabric", they describe an experiment that shows that color difference of fabrics can be detected with a high accuracy and efficiency when using this method.

We end this issue with a brief announcement about the CIE Standard General Sky Guide. Aimed at general users and designers, this report collects information for the application of the CIE Standard General Sky including an extensive list of references and recommendations for prediction methods, tools and computer programs.

Ellen Carter
Editor, Color Research and Application

Calendar

2015

May 7-8 **Workshop: Attention & Conscious Perception,** York University, Toronto jbeck@yorku.ca

May 10-15 **Fifteenth Annual Vision Sciences Society Meeting (ARVO),** TradeWinds Island Resort,. St. Pete Beach,FL, http://www.visionsciences.org/schedule.html

May 12-15 **CORM 2015 Annual Technical Teleconference,** NIST, Boulder, CO, http://www.cormusa

May 13-15 **Computational and Mathematical Models in Vision (MODVIS),** Tradewinds Resort, St. Pete Beach, FL, http://www.conf.purdue.edu/modvis/.

May 19-22 **AIC Midterm Meeting Color and Image,** Toyko, Japan, www.aic2015.org

May 19-22 **Archiving 2015,** The Getty Center, Los Angeles, CA, Info: archiving@imaging.org

June 8-12 **23rd Conference on Computer Graphics, Visualization and Computer Vision 2015, Primavera Congress Center, Pilsen, Czech Republic** (http://www.wscg.eu

June 23-26 **International Conference on Perceptual Organizaton,** Toronto, CA, http://cvr.yorku.ca/conference2015

Jun 24-25 **ASTM E12 Color and Appearance,** Harbor Beach Marriott, Ft. Lauderdale, FL

Jun 28-Jul 3 **28th Session of the CIE, 2015,** Manchester, UK, website coming soon

July 3-7 **International Colour Vision Society (ICVS 2015) Katahira campus, Tohoku University, Sendai, Japan** http://www.vision.riec.tohoku.ac.jp/ICVS2015/

July 25-31 **Gordon Research Conference on Eye Movements and associated 2015 Gordon Research Seminar on Eye Movements, Bentley University, Waltham MA** http://www.grc.org/chairs.aspx

Aug 23-27 **38th European Conference on Visual Perception (ECVP),** Liverpool, UK, http://www.ecvp.org/2015 or ecvp2015info@gmail.com

Aug 25-26 **Colour and Visual Computing Symposium 2015 (CVCS 2015) Gjøvik, Norway** http://www.colourlab.no/events/cvcs2015

Sep 2-4 **Computer Analysis of Images and Patterns (CAIP) 2015,** Mediterranean Conference Center, Valletta (Malta), http://caip.eu.org/caip2015/

Sep 9-11 **The Eye, The Brain, & The Auto International Conference,** Dearborn, MI, Info: Carolyn Barth, clbarth@dioeyes.org

Sep 13-14 **ACM Symposium on Applied Perception (ACM SAP), formerly APGV,** Tuebingen,. Germany, http://sap.acm.org/2015/

Oct 4-6 **SPE/CAD RETEC & ISCC, Show Your Colors,** Westin Hotel, Indianapolis, IN, Info: Betty Puckerin, betty.puckerin@ampacet.com

Oct 19-23 **Imaging Science and Technology (IS&T), Color and Imaging Conference CIC 23,** Darmstadt, Germany, http://www.imaging.org/ist/conferences/cic/

Oct 25-28 **32nd Biennial Western Coatings Symposium (WCS),** Paris Hotel,. Las Vegas, NV, http://www.westerncoatings.org

Dec 3-5 **First International Workshop on Computational Models of the Visual Cortex (CMVC)** New York City, http://bionetics.org/2015/show/home

ISCC Sustaining Members

Sustaining Members of the ISCC are organizations who support the mission and goals of the ISCC through financial or other support. With our Member Bodies, Sustaining Members also provide a critical connection to the color community. If you feel your company or organization should support the ISCC in this way, please contact the office for more information about member benefits.

Avian Technologies	www.aviantechnologies.com	603-526-2420
Datacolor	www.datacolor.com	609-895-7432
Hallmark	www.hallmark.com	816-274-5111
Hunter Associates Laboratory, Inc.	www.hunterlab.com	703-471-6870

We could still use your help!

ISCC has positions in the organization that need filling. We can help identify a place for you depending on your skills and desires. Contact Nomination Chair Scot Fernandez, scot.fernandez@hallmark.com

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ISCC Member Bodies

At its foundation, the ISCC is composed of many related societies. These societies, our Member Bodies, help the ISCC maintain a relationship with each organization's individual members. We frequently hold joint meetings to further the technical cross-pollination between the organizations.

If you belong to one of our member body organizations, we encourage you to work with ISCC and your society to further the connection. Contacting the ISCC President is a good place to start. If your organization is not on this list and you think it should be, the ISCC office can provide you with details about membership.

Or use our new online application: www.iscc.org/applicationForm.php

American Association of Textile Chemists and Colorists (AATCC)
American Society for Testing and Materials International (ASTM)
American Society for Photogrammetry & Remote Sensing (ASPRS)
The Color Association of the United States, Inc. (CAUS)
Color Marketing Group (CMG)
Color Pigments Manufacturing Association (CPMA)
Council on Optical Radiation Measurements (CORM)
Detroit Colour Council (DCC)
Gemological Institute of America (GIA)
Illumination Engineering Society of North America (IESNA)
International Color Consortium (ICC)
National Association of Printing Ink Manufacturers (NAPIM)
Optical Society of America (OSA)
The Society for Color and Appearance in Dentistry (SCAD)
Society for Information Display (SID)
Society for Imaging Science and Technology (IS&T)
Society of Plastics Engineers Color and Appearance Division (SPE/CAD)