DALTONIANA

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The bulletin of the International Colour Vision Society

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Daltoniana on the web

Welcome to the 13th edition of the web based **Daltoniana**. This edition will be transmitted by email and mailed to members from locations in North America, Europe and Australasia.

Contents

Officers and Committee

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Message from the General Secretary

Approaching our biannual meeting in Seattle, we cannot escape considering the major changes in the world since we last assembled in Cambridge, changes that surely seem to have had an impact on the anticipated participation at this meeting. While the deadline is past for sending in an abstract, it is not too late to register and attend. Situated between the Cascades and the Olympics on Puget Sound and under the shadow of the majesty of Mount Ranier, Seattle is a visually stunning city, a must visit for those who have never been there and a welcome opportunity to return for those who already know it.

The scientific program looks exciting and we have been fortunate to have been offered publication of the proceedings in the journal *Visual Neuroscience*.

A few issues back, I voiced my sentiments concerning the tide that has swept significant numbers of vision researchers in the psychophysics and neuroscience communities to snub ARVO for the VSS meeting. It is unfortunate, however, that many seem to see ARVO/VSS as a choice rather than as an enlargement of opportunity for scientific interaction. Given limited time and resources, perhaps such a point of view is inevitable. ARVO, itself, is in no danger from the migration and continues to be the first place to hear about innovations and break-thoughs in vision research. As an example, witness the recent discoveries concerning spectral coding in the visual pathways mediating circadian rhythms, demonstrating, a few years ago, a special class of ganglion cell that responds directly to light stimulation or, this year, the discovery of what is possibly a new class of cone photoreceptor in the human eye, containing a novel photopigment functioning within the circadian system. In the context of these thoughts, I received a letter from Jay Neitz, attached below, that I feel summarizes a number of good arguments for continuing to support ARVO. As a core of color vision researchers continues to participate strongly in ARVO, perhaps we are not the ones to convince, in which case you might consider sharing these arguments with your colleagues.

Verriest Medal

The International Colour Vision Society is pleased to announce that the Verriest Medal will be awarded at the biennial meeting in Seattle USA to André Roth, Honorary Professor of Ophthalmology at the University of Geneva. This award is bestowed by the Society to honor long-term contributions to the field of color vision. André Roth created the Roth 28 Hue test for ophthalmological examination, and developed and standardized a sophisticated diagnostic set of tests based on color metrics for acquired color vision deficiencies. He developed an anomoloscope specially for the investigation of acquired and inherited color vision deficiencies in ophthalmology. As director of the Geneva University clinic, he has studied most eye diseases in which acquired color deficiencies play a significant role. Work for the IRGCVD and later ICVS was a significant part of his professional life. Together with Guy Verriest he belonged to the clinically oriented group, which recommended a separation of the IRGCVD from the AIC, to give ophthalmologists, physiologists and other clinicians a scientific home and a connection to color science. Soon after the death of Guy Verriest he took over the presidency of the Society from Wolfgang Jaeger and carefully led its further development, as clinical aspects become less prominent and genetic, molecular biological and other recent developments have come more to the forefront.
The selection committee members were: Ken Knoblauch, Barry Lee (Chair), Maureen Neitz, Joel Pokorny, Shoko Tanabe and Francois Viénot.

Reunite VSS with ARVO

Jay Neitz

I counted 123 VI abstracts total in the ARVO 2003 program compared to 875 abstracts in the VSS program (204 talks, 671 posters). Scientists interested in vision performance have voted their meeting preference, and obviously VSS has huge appeal. Thus, it is unclear what would be required to reincorporate VSS back into the ARVO meeting. Even though the "How" is a question, I believe there are compelling reasons "Why" VSS should be reunited with ARVO.

Why ARVO?

ARVO has a mission and a vision for the future that is important to all vision scientists. Its stated mission is to "serve as a global forum for dissemination and exchange of information about vision research, to meet the needs of vision scientists, and to be an advocate for vision science in order to facilitate the advancement of vision research."

Its vision for the future is to be recognized as the primary advocate for vision science worldwide. The organization seeks to promote innovative techniques for publication and dissemination of research findings and interactive communication with and among its members. It seeks to promote a diverse leadership and membership that is recognized for its collegiality, responsiveness and community spirit. This mission and these goals are worthwhile for all vision scientists. ARVO is much more than a meeting. Supporting it has advantages for all of us.

ARVO has strength in numbers and also in its diversity. To split from ARVO means separating from ARVO's powerful advantages. Some of these are:

1. ARVO is able to serve the vision community by publishing two journals, IOVS and JOV. JOV is a tremendous boon to the vision researchers with interests in visual performance and it is poised to be a major journal for those people. It has recently become indexed in PubMed and provides an unrivaled forum for rapid communication that is highly visible and widely accessible. To support ARVO is to support this incredibly valuable resource for disseminating our research and take part in shaping its future.
2. ARVO has been extremely successful in partnering with the National Eye Institute (NEI). This partnership has promoted appreciation and support for federal funding of eye research. Because of ARVO's numerical strength and diversity it has become important voice in NIH priority setting and the NEI vision research plan. ARVO has been very successful in promoting basic science both to the public and to the federal government. To separate from ARVO is to loose an opportunity to contribute to this voice and to be represented by it.
3. This is the most exciting time for vision research ever! The new technology that is being brought to bear on questions about the function of the visual system is simply amazing. Advances from functional imaging, adaptive optics, biomedical engineering, molecular genetics, biochemistry, cell biology, proteomics, and electrophysiology are revolutionizing our understanding of the healthy visual system and vision disorders. Ultimately, visual performance cannot be understood except in the context of its basic biological underpinnings that are being uncovered at an increasingly rapid rate. Conversely, complete understanding of the basic biology, physiology or genetics of the visual system can only be understood in terms of how they contribute to visual performance. To achieve the ultimate goal of understanding the visual system, communication between disciplines will be the key. The ARVO members in the BI, VN, RE, PH, RC sections need access to people who study visual performance. Splitting from the ARVO meeting is a missed opportunity to reach this audience. Conversely, researcher who do not go to ARVO miss out on opportunities to learn abut the exciting advances that are being made in other areas that will have a huge impact on understanding visual performance. Finally, in the area of interaction and cross fertilization, recently there has been a movement toward "translational research" in the scientific community. The time has come in which real opportunities exist to transition from basic science discovery to patient treatment. A unified ARVO meeting where clinicians and basic researchers in visual performance can interact has huge potential for bringing about new approaches to diagnose and treat vision disorders.

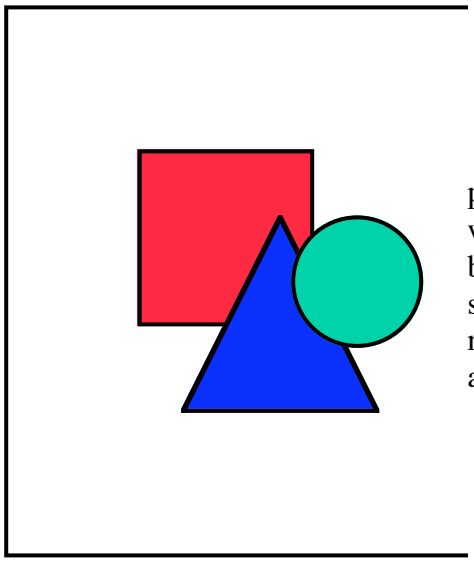
The stated goal of VSS is one that we can all resonate to, "Our primary goal is to host a yearly meeting where both new and established investigators can present and discuss their work in a relaxed informal setting." My thought is that it is possible to accomplish this goal within the framework of the annual ARVO meeting.

I am coming up on my twentieth ARVO meeting and I understand the appeal and the nostalgia of Sarasota. However, I have been able to find the really important things at ARVO in Ft. Lauderdale. My best memories are of meeting old friends and making new ones, of learning something completely unexpected and being able share a new discovery. From this perspective some of my best memories are from ARVO at Ft. Lauderdale.

It is not Sarasota but, now that I am use to that, I don't find Ft. Lauderdale to be a bad place to make a

memory.

From Beautiful Beaches to Sizzling Entertainment ... Fort Lauderdale -- A Truly Great Location!



With 23 miles of golden beaches Ft. Lauderdale is the perfect warm-weather destination. Take in popular watersports or simply bask in the sun along your favorite beach. In Ft. Lauderdale you'll find some of the freshest seafood around. Enjoy dinner at one of the many waterfront restaurants or head into town for culinary delights from around the globe.

17th Biennial Symposium of the International Color Vision Society

July 11 - 15, 2003

Kane Hall, University of Washington, Seattle, Washington

All scientific sessions in Kane Hall: oral presentations in room 210 (2nd floor), poster presentations in Walker-Ames Room (across hall from 210).

Friday, July 11

8:30-1:00 Directors' Committee Meeting and Lunch [Faculty Club]

12:00-1:30 Registration [Kane Hall, 2nd floor, hallway outside room 210]

1:30- 3:10		**Opening Session; Central Processing I [Kane Hall, room 210]**
	1:30	Opening remarks
	1:45	Discussant remarks
	1:50T 1	Nagy, A. L.; Neriani, K.; Young, T., *Color Mechanisms Involved in Selecting Stimuli for Attention and in Making Discriminations*
	2:10T 2	Shapiro, A.G.; D'Antona, A. D., *Perceived Contrast Asynchrony*
	2:30T 3	McKeefry, D. J.; McGraw, P. V.; Vakrou, C.; Whitaker, D., *Chromatic Adaptation, Perceived Location and Colour Tuning Properties*
	2:50T 4	Delahunt, P.; Webster, M.; Ma, L.; Werner, J., *Color appearance changes after cataract surgery reveal a long-term chromatic adaptation mechanism*
3:10- 3:30		**Coffee [hallway outside room 210]**
3:30- 4:45		**Session 2; Central Processing II**
	3:40	Discussant remarks
	3:45T 5	Lee, B. B.; Sun, H., *The chromatic input to cells of the magnocellular pathway: mean chromaticity and the relative phase of modulated lights*

4:05T 6	Sun, H.; Lee, B. B., *A single mechanism for both luminance and chromatic grating vernier tasks; evidence from temporal summation*
4:25T 7	Chase, C. H.; Dougherty, R. F.; Ray, N.; Fowler, S.; Stein, J., *Dyslexic Magnocellular Cone-signal Strength*
4:00- 6:00	**Exhibits set up [Walker-Ames Room]**
5:00- 6:15	**Invited Allen Edwards Lecture** Brian Wandell, *Computational Neuroimaging: Color* [Kane 210]
6:15- 8:00	**Reception [Walker-Ames Room]**

Saturday, July 12

8:30- 9:00	**Mount posters [Walker-Ames Room]**
9:00-10:30	**Session 3 - Genetics**
9:00	Opening remarks
9:05	Discussant remarks; Samir Deeb
9:10T 8	Deeb, S., *Genetics of color vision deficiencies*
9:30T 9	Neitz, M.; Carroll, J.; Renner, A.; Knau, H.; Werner, J.S.; Neitz, J., *The genetic causes of red-green dichromacy*
9:50T10	Crognale, M A.; Fry, M.; Highsmith, J.; Haegerstrom-Portnoy, G.; Neitz, M.; Neitz, J.; Webster, M. A., *Characterization of a Novel form of Incomplete Blue-Cone Monochromacy*
10:10T11	Rowe, M. P.; Jacobs, G. H., *Cone Pigment Polymorphism in New World Monkeys: Are All Pigments Created Equal?*
10:30-11:00	**Coffee, Posters, and Exhibits [Walker-Ames Room]**
11:00-12:35	**Session 4 - Genetics and Evolution**
11:00	Discussant remarks; Gerald Jacobs
11:05	Invited talk: Susan Brockerhoff, *Achromatopsia and red-blindness in zebrafish*
11:50	Invited talk: Shozo Yokoyama, *Evolution of Color Vision*
12:35- 2:00	**Lunch, Posters, Exhibits**
2:00- 3:30	**Session 5; Cone Mosaics**
2:00	Discussant remarks; Jay Neitz
2:05	Invited talk: Anita Hendrickson, *Expression Sequences for Primate Opsins During Retinal Development: How Do These Compare with Other Developmental Sequences?*
2:50T12	Neitz, J.; McMahon, C.; Hendrickson, A.; Neitz, M., *Development of the L/M Cone Mosaic and Its Variations Explained by Competition Between Factors that Promote Gene Silencing and Ones that Activate Gene Expression*
3:10T13	Carroll, J.; Hofer, H.; Neitz, J.; Neitz, M.; Williams, D. R., *Variation in the cone mosaics of dichromats revealed with adaptive optics*
3:30- 4:00	**Coffee, Posters, and Exhibits [Walker-Ames Room]**
4:00- 5:25	**Session 6; Cone Mosaics and Cone Mechanisms**
4:00	Discussant remarks; Maureen Neitz
4:05T14	Kurtenbach, A.; Heine, J.; Jaegle, H., *The multifocal ERG in normal and dichromat observers under cone isolating conditions*

	4:25T15	Murray, I. J.; Kremers, J.; Parry, N. R. A.; Stepien, M.; And Schild, A., *L- and M- cone distributions and flicker ERGs*
	4:45T16	Jameson, K. A.; Bimler, D., *Color Perception and Opsin Genes*
	5:05T17	pending
5:25- 6:30		**Presentation of Verriest Medal to André Roth**
		Verriest Lecture by André Roth [Kane 210]
6:45		**Group Photograph [Drumheller Fountain]**
7:00-11:00		**Dinner and tour of exhibits [Burke Museum of Natural History]**

Sunday, July 13

8:30-10:30		**Session 7; Color Constancy**
	8:30	Opening remarks
	8:35	Discussant remarks
	8:40T18	Almeida, V. M. N.; Fiadeiro, P. T.; Nascimento, S. M. C., *Colour constancy by asymmetric colour matching with real objects in 3-D scenes*
	9:00T19	Baraas, R. C.; Foster, D. H.; Amano, K.; Nascimento, S. M. C., *Ability of red-green dichromats to discriminate spectral-reflectance and illuminant changes with natural and Munsell surfaces*
	9:20T20	Foster, D. H.; Nascimento, S. M. C.; And Amano, K., *Colour information available to the eye from natural scenes under different illuminants*
	9:40T21	Nascimento, S. M. C.; Almeida, V. M. N.; Fiadeiro, P. T.; Foster, D. H., *Minimum-variance cone-excitation ratios and the limits of relational colour constancy*
10:00-11:00		**Coffee, Exhibits [Walker-Ames Room]**
10:00-11:00		**Session 8 - Poster viewing and discussion [Walker-Ames Room]**
11:00-12:30		**Session 9; Cone Signals and Mechanisms**
	11:00	Discussant remarks
	11:05T22	Alleysson, D., *Spatial and chromatic information in cone signals*
	11:25T23	Parry, N. R. A.; Plainis, S.; Murray, I. J.; McKeefry, D. J., *Effect of foveal tritanopia on reaction times to chromatic stimuli*
	11:45T24	Kitahara, K.; Oyama, K.; Nishio, Y.; Kubo, A., *Another Stiles mechanism for the long wavelength sensitive cones*
	12:05T25	Logvinenko, A. D., *Cone fundamentals as derived from Stiles & Burch 10 deg individual colour matching functions*
12:30-11:00		**Half-day excursion (Packed lunch provided). Pike Place Market and Blake Island, with traditional salmon dinner and Puget Sound cruise**

Monday, July 14

8:30-10:30		**Session 10; Color Deficiencies**
	8:30	Opening remarks
	8:35	Discussant remarks
	8:40T26	Formankiewicz, M.; Mollon, J. D., *The psychometrics of lustre detection in relation to monocular filters used with colour vision deficiencies*
	9:00T27	Mollon, J. D.; Foo, R.; Regan, B. C.; Brown, M. J., *The effects of sildenafil citrate on color discrimination*

9:20T28	Ventura, D. F.; Berezovsky, A.; Salomão, S.R.; Costa M. T. V.; Simões, A. L.; Pereira, L. H. M. C.; Costa, M. F.; De Souza, J. M.; Lago, M.; Faria, M. A. M.; Silveira, L. C. L., *Multifocal electroretinograms (mfERGs) correlate with color vision losses in mercury contaminated workers*
9:40-10:30	**Invited talk - Dennis Dacey**
10:30-11:00	**Coffee, Posters, and Exhibits [Walker-Ames Room]**
11:00-12:30	**Session 11; Color Appearance I**
11:00	Discussant remarks
11:05T29	Bouet, R.; Knoblauch, K., *Perceptual classification of chromatic modulation*
11:25T30	Hong, S. W.; Shevell, S. K., *Perceptual integration of neural signals with different polarities*
11:45T31	Shevell, S. K.; Cao, D., *Chromatic Assimilation is Unaffected by the Perceived Depth Plane of Inducing Light*
12:05T32	Smith, V. C.; Pokorny, J., *Interactions of chromaticity and luminance in edge identification depend on chromaticity.*
12:30- 2:00	**Lunch/free time/Posters/Exhibits**
	(strike exhibits and posters Monday afternoon)
2:00- 3:30	**Session 12; Color Appearance II**
2:00	Discussant remarks
2:05T33	Xian, X.; Shevell, S. K., *Changes in Color Appearance Caused by Perceptual Grouping*
2:25T34	Rudd, M.; Zemach, I., *Edge Integration in Achromatic Color Induction: Support for a Neurocomputational Model*
2:45T35	Zemach, I.; Rudd, M., *Edge Integration in Achromatic Color Induction: Dependence on Contrast Polarity*
3:05T36	Larson, K., *Individual differences in preference for color sub-pixel text rendering*
3:30- 4:00	**Coffee [Walker-Ames Room]**
4:00- 4:45	**Session 13; Rod-Cone Interactions**
4:00	Discussant remarks; Steve Buck
4:05T37	Pokorny, J.; Smith, V. C.; Fukushima, M., *Dual Rod Pathways?*
4:25T38	Thomas, L. P.; Buck, S. L., *Generality of rod hue biases with smaller, brighter, and photopically constant stimuli.*
4:45- 5:30	**Business meeting [Kane 210]**
6:30-10:00	**Conference Dinner [Faculty Club]**

Tuesday, July 15

9:00-10:30	**Session 14 - Color Testing and Standards I**
9:00	Opening remarks
9:05	Discussant remarks
9:10T39	Bailey, J.; Neitz, M.; Neitz, J., *Evaluation of an updated HRR color vision test*
9:30T40	Birch, J., *Audit of Occupational Colour Vision Standards implemented with the Holmes-Wright Lantern (Type A) at High Brightness*
9:50T41	Miyahara, E.; Pokorny, J.; Smith, V. C.; Szewczyk, E.; Mccartin, J.; Caldwell,

	K.; Klerer, A., *Computerized Color Vision Test Based Upon Postreceptoral Channel Sensitivities*
10:10T42	Moreland, J.D., *The Moreland Match Revisited*
10:30-11:00	**Coffee [outside Kane 210]**
11:00-12:30	**Session 15 - Color Testing and Standards II**
11:00	Discussant remarks
11:05T43	Ramaswamy, S.; Hovis, J., *Ability of D-15, Adams D-15, and HRR pseudoisochromatic plates to predict performance in identifying VDT colours*
11:25T44	Hovis, J.; Ramaswamy, S., *Repeatability of the D-15 Tests*
11:45-12:30	**Session 16; Development of human color vision**
11:45	Discussant remarks
11:50T45	Pereverzeva, M.; Teller, D. Y., *Infant looking preferences change with changes of surround chromaticity in a simultaneous color contrast paradigm*
12:10T46	Teller, D. Y.; Civan, A.; Bronson-Castain, K., *Are infants' spontaneous "hue" preferences determined by saturation differences?*
12:30	**Concluding Remarks**
12:45	**Close of Meeting**

Poster Presentations

AUTHORS	TITLE
ACZEL, K., MARKÓ, G.	**Families with colour vision deficiency**
AGUIAR, M.J.L; VENTURA, D.F; SILVA FILHO, M; SOUZA, J.M DE; MACIEL, R; LEE, B.B	**Heterochromatic modulation photometry in carp horizontal cells**
ASAKAWA, K; NAKADOMARI, S; KITAHARA, K; ICHIHARA, Y; KURIKI, I; MIYAUCHI, S	**Dorsal V4 activation associated with not object color but environmental color change**
BIMLER, D L; KIRKLAND, J	**Multidimensional scaling of D15 caps: color-vision defects among tobacco smokers?**
BROWN, A.M.; LINDSEY, D.T.	**Language and color: the worldwide prevalence of Daltonism and a distinct word for "blue"**
BUCK, S; THOMAS, L.,	**Prevalence of rod hue biases among observers**
DAIN, S.J.	**Colorimetric analysis of four HRR PIC tests**
DRUM, B	**FDA Regulation of Labeling and Promotional Claims in Marginally Effective Color Vision Devices**
GERARDIN, P; SUSSTRUNK, S; KNOBLAUCH, K	**What systematic chromatic changes are necessary to perceive color transparency?**
GUNTHER, K.L; NEITZ, M; NEITZ, J	**Screening for DNA polymorphisms that correlate to differences in L:M cone ratio**
HAYASHI, T; OMOTO, S; KITAHARA, K; NISHIO, Y; KUBO, A; NAKAMURA, Y; KOZAKI, K; WATANABE, A; TODA, K; UEOKA Y	**Clinical heterogeneity between two Japanese siblings with congenital achromatopsia**

HOOD, S. M; MOLLON, J. D.	**Chromatic Discrimination in Protan and Deutan Carriers of a Colour Deficiency**
KELLY, J. P.; WEISS, A.	**Cone-isolating VEPs and full-field ERGs in children with cone dystrophy and Stargardt's disease**
KNIGHT, R	**Do rods maximize the variance of chromaticity of natural surfaces during twilight?**
LINDSEY, D.T; BROWN, A.M	**Field sensitivity curves in the isoluminant plane of DKL color space**
LIU, JI; WANDELL, B. A	**Response to color flicker in human primary visual cortex measured using fMRI**
LONG, F; PURVES, D	**Natural scene statistics as the basis of color assimilation**
MIZOKAMI, Y; PARAS, C; WEBSTER, M	**Chromatic- and contrast-selectivity in color contrast adaptation**
MONACI, G; MENEGAZ, G; SUSSTRUNK, S; KNOBLAUCH, K	**Color Contrast Detection in Spatial Chromatic Noise**
MONNIER, P; SHEVELL, S.K	**Chromatic detection with a moving target**
NAKADOMARI, S; TAKAHASHI, Y; KITAHARA, K; KURIKI, I; MIYAUCHI, S; ICHIHARA, Y	**Is Red a Special Color for Brain?**
PARAMEI, G V; BIMLER, D L	**Luminance-Dependent Hue Shift in Protanopes**
SVEC, L.	**Vascular Status and Color Vision Function**
THOMAS, P. B. M; MOLLON, J. D.	**Modelling the Rayleigh match**
WERNER, J.S; PINNA, B; SPILLMANN, L	**Flashing Anomalous Color Contrast**

CONFERENCE ORGANIZERS:
Steve Buck and Samir Deeb
http://depts.washington.edu/icvs2003/ or contact Steve Buck, sbuck@u.washington.edu.

Book Review

ART AND COMPLEXITY

Edited by J. CASTI and A. KARLQVIST. Elsevier, Amsterdam, 2003. ISBN: 0-444-50944-5
This book includes the papers presented in May 1998 during the meeting held at the Scientific Center of Abisko, Sweden, nearly 100 miles north of the Arctic Circle.
The first step was to define the difficult notion of complexity from a scientific point of view. Complexity is what lies between order and chaos, at the interface between order and disorder (Crutchfield). The study of the way in which complexity arises from fundamental simplicity is a trans-disciplinary subject (Gell-Mann). Chaos theory taught us that even, if we know the laws of the nature, we still do not know what nature will look like (Norrestranders) and that the search for properties of

complex systems is intrinsically linked to the defining of complexity (Sommerer).
The application of these theoretical ideas to art was illustrated by papers on the geometric complexity of polygons and Chinese vases (Barrow), the American experimental music tradition (Perkis) and the study of the complexity of bird song (Sourthwick). For the visual physiologist, the most exciting paper will certainly be the careful analysis of the so called "fractal expressionism" in the paintings of Jackson Pollock (Taylor).
On the whole, some new ways of scientific exploration of the mechanisms of the arts are opened up in this book by the consideration of the concept of complexity.

Dr Philippe Lanthony

Membership 2002/3

To apply for membership for 2002/3, fill out the accompanying form, noting the appropriate method of payment, and return it to Anne Kurtenbach (e-mail**:** anne.kurtenbach@uni-tuebingen.de; Fax: + 49 7071 295038). Subscriptions are payable in EUROS only. Regular/new members are required to pay 120 EURO (students/retired 25 EURO). Please check that all bank charges are pre-paid and that the credit card supplement is added to your dues, to ensure that we receive the full amount.

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Thank you.

Anne Kurtenbach (Membership Secretary)

Lindsay T. Sharpe (Treasurer)

ICVS MEMBERSHIP 2002/2003

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Abstracts of color vision papers. Compiled by Joel Pokorny

Trichromacy

Arrese, C. A., N. S. Hart, N. Thomas, L.D. Beazley, J. Shand (2002). "Trichromacy in Australian marsupials." Current Biology **12**: 657-660.

Vertebrate color vision is best developed in fish, reptiles, and birds with four distinct cone receptor visual pigments. These pigments, providing sensitivity from ultraviolet to infrared light, are thought to have been present in ancestral vertebrates. When placental mammals adopted nocturnality, they lost two visual pigments, reducing them to dichromacy; primates subsequently reevolved trichromacy. Studies of mammalian color vision have largely overlooked marsupials despite the wide variety of species and ecological niches and, most importantly, their retention of reptilian retinal features such as oil droplets and double cones. Using microspectrophotometry (MSP), we have investigated the spectral sensitivity of the photoreceptors of two Australian marsupials, the crepuscular, nectivorous honey possum (Tarsipes rostratus) and the arhythmic, insectivorous fat-tailed dunnart (Sminthopsis crassicaudata); these species are representatives of the two major taxonomic divisions of marsupials, the diprotodonts and polyprotodonts, respectively. Here, we report the presence of three spectrally distinct cone photoreceptor types in both species. It is the first evidence for the basis of trichromatic color vision in mammals other than primates. We suggest that Australian marsupials have retained an ancestral visual pigment that has been lost from placental mammals.

Surridge, A. K. and N. I. Mundy (2002). "Trans-specific evolution of opsin alleles and the maintenance of trichromatic colour vision in Callitrichine primates." Molecular Ecology **11**: 2157-2169.

Many New World (NW) primates possess a remarkable polymorphism in an X-linked locus, which encodes for the visual pigments (opsins) used for colour vision. Females that are heterozygous for opsin alleles of different spectral sensitivity at this locus have trichromatic colour vision, whereas homozygous females and males are dichromatic, with poor colour discrimination in the red-green range. Here we describe an extensive survey of allelic variation in both exons and introns at this locus within and among species of the Callitrichines (marmosets and tamarins). All five genera of Callitrichines have the X-linked polymorphism, and only the three functional allelic classes described previously (with maximum wavelength sensitivities at about 543 nm, 556 nm and 563 nm) were found among the 16 species and 233 or more X-chromosomes sampled. In spite of the homogenizing effects of gene conversion, phylogenetic analyses provide direct evidence for trans-specific evolution of alleles over time periods of at least 5-6 million years, and up to 14 million years (estimated from independent phylogenies). These conclusions are supported by the distribution of insertions and deletions in introns. The maintenance of polymorphism over these time periods requires an adaptive explanation, which must involve a heterozygote advantage for trichromats. The lack of detection of alleles that are recombinant for spectral sensitivity suggests that such alleles are suboptimal. The two main hypotheses for the selective advantage of trichromacy in primates are frugivory for ripe fruits and folivory for young leaves. The latter can be discounted in Callitrichines, as they are not folivorous.

Color beyond peripheral receptive fields

MacLeod, D. I. A. (2003). "New dimensions in color perception." Trends in Cognitive Sciences **7**: 97-99.

Colors are generally ordered in three dimensions, with hue and saturation as polar coordinates of a color circle, and brightness as the third dimension. Intuitively, lines of constant hue (but variable saturation) in such a color space should converge on an achromatic point devoid of hue. However, in new experiments by Ekroll et al. using colored patches in colored surrounds, constant hue lines converge not on 'gray' but on the surround color. This paradoxical observation suggests that the standard three-dimensional conception of perceived color is inadequate.

Cardinal, K. S. and D. C. Kiper (2003). "The detection of colored Glass patterns." Journal of Vision **3**: 199-208.
The detection of many chromatic stimuli is mediated by mechanisms that sum their inputs linearly. As a result, these mechanisms have a broad range of selectivity in color space, as do the majority of cells in the early stages of visual processing. In extrastriate cortex, there are cells with a narrow tuning in color space. The function of these cells is not fully understood: they could be involved in color categorization, or could mediate the detection of stimuli such as Glass patterns, whose properties make them undetectable by early stages of processing. We measured the tuning properties of the mechanisms responsible for the detection of colored Glass patterns and found that they have a broad tuning in color space. Our results suggest that Glass patterns are detected by a multitude of mechanisms that sum their inputs linearly.

Beaudot, W. H. and K. T. Mullen (2003). "How long range is contour integration in human color vision?" Visual Neuroscience **20**: 51-64.
We quantified and compared the effect of element spacing on contour integration between the achromatic (Ach), red-green (RG), and blue-yellow (BY) mechanisms. The task requires the linking of orientation across space to detect a contour in a stimulus composed of randomly oriented Gabor elements (1.5 cpd, sigma = 0.17 deg), measured using a temporal 2AFC method. A contour of ten elements was pasted into a 10 x 10 cells array, a ndbackground elements were randomly positioned within the available cells. The effect of element spacing was investigated by varying the mean interelement distance between two and six times the period of the Gabor elements (lambda = 0.66 deg) while the total number of elements was fixed. Contour detection was measured as a function of its curvature for jagged contours and for closed contours. At all curvatures, we found that performance for chromatic mechanisms declines more steeply with the increase in element separation than does performance for the achromatic mechanism. Averaged critical element separations were 4.6 +/- 0.7, 3.6 +/- 0.4, and 2.9 +/- 0.2 deg for Ach, BY, and RG mechanisms, respectively. These results suggest that contour integration by the chromatic mechanisms relies more on short-range interactions in comparison to the achromatic mechanism. In a further experiment, we looked at the combined effect of element size and element separation in contour integration for the Ach mechanism. We found that the critical separation decreases linearly with the spatial frequency, from about 5 deg at low spatial frequency (larger elements) to about 1 deg at high spatial frequency (smaller elements) suggesting a scale invariance in contour integration. In both experiments we also found no differences between closed and open jagged contours detection in terms of element separation. The neuroanatomical implications of these findings relatively to area V1 are discussed.

Clifford, C. W., B. Spehar, S. G., Solomon, P. R., Martin, Q. Zaidi (2003). "Interactions between color and luminance in the perception of orientation." Journal of Vision **3**: 106-115.
At the early stages of visual processing in humans and other primates, chromatic signals are carried to primary visual cortex (V1) via two chromatic channels and a third achromatic (luminance) channel. The sensitivities of the channels define the three cardinal axes of color space. A long-standing though controversial hypothesis is that the cortical pathways for color and form perception maintain this early segregation with the luminance channel dominating form perception and the chromatic channels driving color perception. Here we show that a simple interaction between orientation channels (the tilt illusion) is influenced by both chromatic and luminance mechanisms. We measured the effect of oriented surround gratings upon the perceived orientation of a test grating as a function of the axes of color space along which the gratings were modulated. We found that the effect of a surround stimulus on the perceived orientation of the test is largest when both are modulated along the same axis of color

space, regardless of whether that is a cardinal axis. These results show that color and orientation are intimately coupled in visual processing. Further, they suggest that the cardinal chromatic axes have no special status at the level(s) of visual cortex at which the tilt illusion is mediated.

Friedman, H. S., H. Zhou, R. von der Heydt (2003). "The coding of uniform colour figures in monkey visual cortex." Journal of Physiology **548**: 593-613.
Psychophysical studies indicate that perception of the colour and brightness of a surface depends on neural signals evoked by the borders of the surface rather than its interior. The visual cortex emphasizes contrast borders, but it is unclear whether colour surface signals also exist, whether colour border signals are orientation selective or mainly non-oriented, and whether cortical processing tends to separate colour and form information. To address these questions we examined the representation of uniform colour figures by recording single neuron activity from areas V1 and V2 in alert macaque monkeys during behaviourally induced fixation. Three aspects of coding were quantified: colour, orientation and edge selectivity. The occurrence of colour selectivity was not correlated with orientation or edge selectivity. The fraction of colour-selective cells was the same (64 % in layers 2 and 3 of V1, 45 % in V2) for oriented and non-oriented cells, and for edge-selective and surface-responsive cells. Oriented cells were often highly selective in colour space, and about 40 % of them were selective for edge polarity or border ownership. Thus, contrary to the idea of feature maps, colour, orientation and edge polarity are multiplexed in cortical signals. The results from V2 were similar to those from upper-layer V1, indicating that cortical processing does not strive to separate form and colour information. Oriented cells were five times more frequent than non-oriented cells. Thus, the vast majority of colour-coded cells are orientation tuned. Based on response profiles across a 4 deg square figure, and the relative frequency of oriented and non-oriented cells, we estimate that the cortical colour signal is 5-6 times stronger for the edges than for the surface of the figure. The frequency of oriented colour cells and their ability to code edge polarity indicate that these cells play a major role in the representation of surface colour.

Classic and new methods
Berendschot, T., P. J. DeLint, D. van Norren (2003). "Fundus reflectance - historical and present ideas." Progress in Retinal and Eye Research **22**: 171-200.
In 1851 Helmholtz introduced the ophthalmoscope. The instrument allowed the observation of light reflected at the fundus. The development of this device was one of the major advancements in ophthalmology. Yet ophthalmoscopy allows only qualitative observation of the eye. Since 1950 attempts were made to address the challenging, quantitative assessment of the amount of light reflected by the fundus. At first, only comparative measurements were possible, applied in the study of macular and visual pigments. With improvements in light detecting techniques, and with the advent of microprocessors, the measurement of spectral and spatial distribution of the reflectance became feasible. This led to the development of models that explained the observed wavelength dependence and the directional behavior of light reflected from the fovea. The models allowed a quantitative assessment of many parameters on absorption and reflection by structures in the human eye. This paper provides a review of both the experimental and theoretical progress, and summarizes the results of fundamental and clinical research using fundus reflectometry.

Dacey, D. M., B. B. Peterson, F.R. Robinson, P.D. Gamlin (2003). "Fireworks in the primate retina: In vitro photodynamics reveals diverse LGN-projecting ganglion cell types." Neuron **37**: 15-27.
Diverse cell types and parallel pathways are characteristic of the vertebrate nervous system, yet it remains a challenge to define the basic components of most neural structures. We describe a process

termed retrograde photodynamics that allowed us to rapidly make the link between morphology, physiology, and connectivity for ganglion cells in the macaque retina that project to the lateral geniculate nucleus (LGN). Rhodamine dextran injected into the LGN was transported retrogradely and sequestered within the cytoplasm of ganglion cell bodies. Exposure of the retina to light in vitro liberated the tracer and allowed it to diffuse throughout the dendrites, revealing the cell's complete morphology. Eight previously unknown LGN- projecting cell types were identified. Cells could also be targeted in vitro for intracellular recording and physiological analysis. The photodynamic process was also observed in pyramidal cells in a rat neocortical slice.

Clinical testing yardsticks

Kinnear, P. R. and A. Sahraie (2002). "New Farnsworth-Munsell 100 hue test norms of normal observers for each year of age 5-22 and for age decades 30-70." British Journal of Ophthalmology **86**: 1408-1411.

AIMS: To provide normative data for chromatic discrimination on the Farnsworth-Munsell 100 hue test particularly for observers under 23 years of age. METHODS: Normal observers were screened for congenital colour vision deficiencies using the Ishihara test leaving 382 observers. RESULTS: New total error score (TES) norms (means and 95th percentiles) are presented for each year of age from 5-22 and for 10 year age groups from the 30s to the 70s. These norms are presented as actual values (TES) and also as square root values (radical TES). Other data include partial error scores for red-green and blue-yellow axes discrimination. CONCLUSION: This study provides the most detailed set of normative data to date. The data are also in agreement with other reports of chromatic discrimination, showing that the performance in this task varies as a U-shape function with age, the best being achieved at 19 years of age.

Geller, A. M. (2001). "A table of color distance scores for quantitative scoring of the Lanthony Desaturate color vision test." Neurotoxicology and Teratology **23: 265-267.**

The Lanthony Desaturate Panel D-15 (D-15d) color vision test is used in neurotoxicological testing to assess acquired color vision deficits. The original test design included a qualitative scoring method. Quantitative scoring requires mapping the colored objects used in the test into a color space describing perceptual distances. A table of these distances has previously been published for the saturated version of this color vision test, but not the desaturate test. This communication includes a table of color distances for the calculation of Bowman's Total Color Distance Score (TCDS) for the D-15d. This table should be useful for non-computerized scoring under field test conditions or for devising one's own computerized scoring methods using the tabulated color distances for a look-up table. Data analysis programs using SAS or Matlab are available from the author.