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DALTONIANA

- number 91 - February, 1999

The bulletin of the International Colour Vision Society

Edited by Stephen Dain

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Daltoniana on the web

Welcome to the third edition of the web based **Daltoniana**. This edition will be downloaded from the website and mailed to members from locations in North America, Europe and Australasia.

Contents

Officers and Committee

President	André Roth
General Secretary	Ken Knoblauch

Treasurer	Ted Sharpe
Membership Secretary	Anne Kurtenbach
Daltoniana Editor	Stephen Dain
Proceedings Editors	Dick Cavonius , John Mollon and Eberhart Zrenner
Committee	Jenny Birch , Dick Cavonius ,Stephen Dain , Kenji Kitahara , Barry Lee , Jean Leid , John Mollon , Jack Moreland , Joel Pokorny , Eberhart Zrenner

General Secretary's report

The publication of our proceedings in Vision Research is a grand success and I reiterate that the editors, C. R. Cavonius, J. Mollon and E. Zrenner, deserve all the credit and thanks for a job well done. Not only were the proceedings published a year in advance of our typical proceedings, but the society will surely benefit from the exposure in such a journal. It needs to be mentioned, however, that the bill for the overpage charges has been footed, for the moment, by us, the ICVS. We were able to reduce these charges somewhat by arguing that the altered format of Vision Research added some additional pages. But the charges that remain are substantial and we depend on you, the members, paying for your additional pages to keep us solvent.

Thank you, in advance.

Now, we can turn full attention to the next meeting being planned for this summer in Göttingen. We are investigating plans for how the proceedings for this meeting will be published.

We are interested in adding a FAQ (Frequently Asked Questions) about color deficiency to the web page. Your suggestions would be relevant and helpful.

Vale : Dorothea Jameson

Dorothea Jameson passed away unexpectedly on Easter Sunday, 12 April 1998 at the age of 77. She will be remembered for her work with her long time collaborator and husband Leo M. Hurvich which put the opponent-colors theory on a solid experimental and theoretical foundation. The work extended the theory to cover a large diversity of color phenomena including color appearance, adaptation, color deficiency, contrast, constancy, spatial and temporal mechanisms and the list can go on... She was also greatly interested in and published several articles on color phenomena in art. She was working on a book on this subject at the time of her death.

She studied at Wellesley College in Massachusetts and worked successively at Kodak, New York University and the University of Pennsylvania. In 1975, she was promoted at this latter institution to the post of Professor, and shortly thereafter elected to the National Academy of Sciences. The names of all the organizations and committees in which she participated are too numerous to cite here.

Several contributions from her can be found in our proceedings when we were still the IRGCVD, importantly on the limits of single-variable theories to account for anomalous trichromacy.

To those who had the privilege to work with her, her joy for science and understanding was clear. In the laboratory, she once remarked to me that for her new results were exciting not just for the answers that they provided to experimental questions that had been asked but perhaps even more so for the new questions that the results permitted us to pose.

Ken Knoblauch

The Verriest Medalist

The Verriest Medal is bestowed by the International Colour Vision Society* (ICVS) to honour long-term contributions to the knowledge of colour vision. The Medal was established in 1991 in memory of Dr. Guy Verriest, and is presented at the ICVS biannual Symposia. Previous recipients have been Harry Sperling (1991), Marrion Marré (1993), Vivianne Smith and Joel Pokorny (1995) and Jack Moreland (1997).

The 1999 Verriest medallist is Dr. John Krauskopf and he will present the Verriest Lecture in Göttingen.

Next Symposium

The XVth Symposium of the Society will be held in Göttingen in 1999 at the Max Planck Institute for Biophysical Chemistry, which is set in an attractive rural setting a little way (ca. 4 km) outside the city.

Göttingen is a small University town, which originally grew up as a trading center on one of the river valleys which pass through central Germany. Many half-timbered houses from that time have been preserved. After the 100 years war, it lost its commercial importance but was reawakened by the establishment of the University in 1735 by King George of Hannover and England. The Georg-Augusta University quickly became one of the major European centers for physics. For the Society, the most interesting period was the second half of the 18th century, when Tobias Mayer, Johannes Erxleben, Georg Christof Lichtenberg and others made significant contributions to Colour Science; it was while Lichtenberg was Professor of Physics that Thomas Young wrote his doctoral thesis in Göttingen.

Göttingen is readily accessible by car, train or plane (through Frankfurt or Hannover). The registration fee covers the scientific program, lunches, refreshments and the social program. The meeting begins at 2 p.m. on Friday July 23rd and finishes at 12 noon on Tuesday the 27th. The social program currently includes a welcome buffet and reception on Friday evening, a reception and concert in the University Aula on Saturday evening, a half-day excursion to the 'Wasserspiele' at Wilhelmshöhe Castle in Kassel followed by dinner in the country on Sunday, and the banquet on Monday evening. The program for accompanying persons also includes a tour of the city on Saturday and an optional excursion on Monday.

As well as invited oral presentations, volunteer contributions may be scheduled as oral presentations or posters. Abstracts for presentations, registration and hotel reservations should all be sent to the meeting secretariat at the Max Planck Institute. The official language of the meeting will be English.

Please note the assorted deadlines:

Abstract submission	April 9th 1999
Notification of Abstract Acceptance	May 21th 1999
Reduced rate Registration	May 31st 1999
Hotel Reservation	May 31st 1999

Looking forward to seeing you in Göttingen,

Yours sincerely,

Barry B. Lee

On behalf of the Organizing Committee:

Walter Paulus	Joel Pokorny	Lukas Rüttiger	Vivianne Smith

Secretariat:
ICVS 99, Barry Lee, Max Planck Institute for Biophysical Chemistry, 37077 Göttingen, Germany.

Phone +49-551-2011643; FAX +49-551-2011039.

Web Site: http://www.mpibpc.gwdg.de/abteilungen/141/ICVS99

E-mail blee@gwdg.de

Abstract submission form
Accommodation information and booking form
ICVS 1999 registration form
General Information and Preliminary Programme

TREASURER'S REPORT

The treasurer and membership secretary would like to thank those members who have paid their subscription for 1998 and would like to remind those (75%) members who have not yet paid. The membership list below documents the present status of members (paid or unpaid for 1998). Only those members who are fully paid up for 1998 and 1999 will be entitled to the 1999 (Goettingen) Symposium

Proceedings.

Because the Societyís finances are in a precarious position, we urge those members who have been billed for excess page charges for the 1997 (Ghent) Symposium Proceedings to honour their committments promptly.

Anne Kurtenbach (Membership Secretary)

Lindsay T. Sharpe (Treasurer)

ICVS WEBNEWS

The web site address is now http://orlab.optom.unsw.edu.au/ICVS/ . The old address now contains only a pointer to the new address
The useful links page. We are still waiting for submissions, if you have or know of useful colour and colour vision links to personal sites, organisational sites please let Stephen Dain know. The page has been started but is still in need of additions and embellishment

A frequently asked questions page. Again, we are still waiting for submissions, if you have a favourite question you keep being asked and/or an answer of which you are particularly proud please send them (preferably both) to Stephen Dain. We need the questions, the answers are helpful too.

Next issue - order your colour books through the web site and earn $$$s for the Society.

COLOUR NEWS

There has been a good deal of media coverage of the Chromagen lens from the UK and the Color-Max lenses from the US. They purport to be "New". They appear to be recycled versions of the X-Chrom lens of Zeltzer in the early 1970s. I take great delight in pointing out that the idea stems from Seebeck in 1817 !! After coverage on Australian national television we were receiving about 6 enquiries per day.

For the full hype on Chromagen see http://www.ultralase.co.uk/welcome.htm (have your $US220 per lens ready) and on Color-Max see http://www.color-vision.com/.

I have an information sheet (http://orlab.optom.unsw.edu.au/ICVS/Colouredlenses) which we give to prospective patients . Comments and suggestions appreciated. We also carried out a study in 1998 which showed that it assisted passing the Ishihara test, did not assist passing the Farnsworth Lantern Test and some people throught it improved their perception dramatically.

For an inexpensive and useful aid to teaching colour see http://www.colourcube.com/

Stephen Dain

MEMBERSHIP

A message from the Treasurer and Membership Secretary

Dear Member,

We are now requesting membership dues for 1999.

The conditions of payment are listed below. Please fill out the accompanying form, noting the appropriate method of payment, and return it to Lindsay T. Sharpe. Subscriptions are payable in German Deutschmark (DM) only. The basic fee for 1999 has been raised to 120 DM **plus service charges** (where applicable). This is roughly equivalent to AU$90, FRF405, GBP40, JPY7740 and US$67.

Please note that in order to receive the 1999 Proceedings volume from Göttingen, you must have paid membership fees for both 1998 and 1999 (DM 120 a year) **or** you must have paid the membership fee for 1999 (DM 120) **plus** the volume supplement (DM 75).

Payment may be made by any of the following methods:

i) Bank transfer or international cheque (drawn on a German bank)

membership renewals	120 DM
new members	120 DM
student/retired	30 DM
Proceedings volume supplement	75 DM

ii) Eurocheque

membership renewals	120 DM
new members	120 DM
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Proceedings volume supplement	75 DM

iii) Credit card (American Express or Mastercard/Eurocard or Visa)

membership renewals	128 DM*
new members	128 DM*
student/retired	33 DM*
Proceedings volume supplement	80 DM*

* (includes card service fee)

We would appreciate an early response.

Thank you.

Anne Kurtenbach	LindsayT. Sharpe

(Membership Secretary)	(Treasurer)

Memberships and Membership Renewals 1999

The full subscription is DM 120 for new members and renewing members or DM 30 for students and retired members (excluding credit card charges). Full members who are paid up for 1998 and 1999 are entitled automatically to the 1999 (Gttingen) Proceedings. A supplementary fee of DM 75 ensures this entitlement for new members joining in 1999. All members receive the ICVS newsletter *Daltoniana*.

Subscriptions, payable in **Deutschmarks (DM) only**, may be made by the following methods.

PLEASE SELECT THE APPROPRIATE SECTION

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Forschungsstelle für Experimentelle Ophthalmologie
Röntgenweg 11
D-72076 Tübingen
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Fax: + 49 7071 295777

The International Colour Vision Society proceeding Volumes for 1991, 1993 & 1995

To stimulate sales of the Proceeding volumes, we are offering them to all ICVS members, including new, student and retired members, at a reduced price. The price per volume, including postage, is DM 100 by bank transfer or EUROcheque and DM 106 by credit card. Only limited numbers of the Sydney (1991) and Tübingen (1993) Proceedings are available.

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1997 GHENT PROCEEDINGS (SPECIAL VISION RESEARCH ISSUE)

The special price is **DM 75**. Payments in **Deutschmarks (DM) only**, may be made by the following methods.

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Röntgenweg 11
D-72076 Tübingen
Germany

Fax: + 49 7071 295777

Membership List and request for email addresses

The mailed version of this Daltoniana has a list of members attached. This was not been made accessible from the web to minimise the possibility of inappropriate use. It is available to committee members only as a password protected file.
Please send email addresses for inclusion in the Membership List to any of

General Secretary	Ken Knoblauch
Treasurer	Ted Sharpe
Membership Secretary	Anne Kurtenbach
Daltoniana Editor	Stephen Dain

You could also include a personal website, if you have one, and we could start a list of those.

Book review

NEW FROM ELSEVIER SCIENCE

**Color for Science, Art and Technology, edited by K. Nassau,
AZimuth Volume 1**

This book comprises 15 chapters . These are purported to "....supply what almost any reader might want to know about color..." but then concedes that "....there might be a problem how to limit the number of volumes". Even so, a page and a half in about 450 on "color deficiency" is a substantial limitation !

The book is in 15 chapters split between 3 sections . In section I chapter 1 covers The Science of Color with chapters on "Fundamentals of Color Science" by K. Nassau, "The Measurement of Color" by R.T. Marcus, "Color Vision" by J. Krauskopf and "The Fifteen Causes of Colour" by K. Nassau. The first two are fairly standard treatments of the subject material. Chapter 3 covers the material in 22 pages which does not provide the depth which would give any satisfaction or challenge to ICVS members. This is the chapter in which color deficiency is covered. Chapter 4 covers 43 pages dealing with the causes of color in a readable and interesting form with some splendid colour plates (albeit down the end of the book). It is difficult to reconcile the imbalance between chapters 3 and 4.

Section II deals with Color in Art, Culture and Life with chapters on "Color in Abstract Painting" (S.Wurmfeld), "Color in Anthropology and Folklore" (J.B.Hutchings), "The Philosophy of Color" (C.L.Hardin), "Color in Plants, Animals and Man" (J.B.Hutchings), and "The Biological and Therapeutic Effects of Light" (G.C.Brainard). These chapters are quite short, even down to eight pages on the philosophy (a philosophy with brevity is quite a find!). The chapter on color in plants, animals and man

appears to have been written without reference to that on the fifteen causes of colour which means there is some unnecessary duplication or even some lack of detail which could have been assisted by some appropriate referencing. The chapter on the therapeutic effects of light, which an addendum on double blind testing, is a little longer and makes interesting reading in a controversial area.

Section 3 covers "Colorants, the Preservation and the Reproduction of Colour". Chapters on pigments (P.A.Lewis) and dyes (J.R.Aspland) provide useful back ground reading on the materials used and the methods of applying them written by industry based authors.There is a very short chapter on "Color Preservation" (K. Nassau) which really deals with exactly the opposite, why colours deteriorate and says little on preservation. Finally three chapters deal with colour imaging in printing and photography (G.G.Field), Photo CDs (written by two Kodak employees, E.J. Giorgianni and T.E. Madden) and colour CRT displays (H. Lang). The latter two overlap markedly given that display technology is covered in the former as well as being the main topic of the latter. The more interesting issue which is more related to Photo CDs, that of compression and acceptable images, is covered very superficially.

In summary, I can't see much appeal to the members of the ICVS. With the exception of the information on the causes of colour and the therapeutic effects of light, the subject matter that I suspect interests them is well covered in books they already probably have on their bookshelves. It is difficult to judge the appeal of the book to the non-colour specialist and it may have a place as a general interest book. For ICVS members I believe that "Color Vision" edited by W.G.K.Backhaus, R Kliegl and J.S.Werner (also published in 1998), which covers much of the same material, will be a more satisfying read at a cheaper price (being paperback) and with many more colour illustrations located in context..

Bibliographic details: 1998 510 pages Hardbound Price: NLG 230.00 / US$ 132.00 ISBN 0-444-89846-8

For a detailed description and full contents, go to our website at: www.elsevier.nl

or send an e-mail to: nlinfo-f@elsevier.nl

Farnsworth Lantern Availability

Stereo Optical Co 3539 North Kenton Avenue, Chicago, IL 60641

phone +1 773 777 2869 fax +1 773 777 4985.

Thery manufacture the OPTEC 900 ColorVision Tester which is accepted by the US Navy as a replacement for the FaLant. $US 5625.

H-R-R Plate Availability

Richmond products have released the new H-R-R plates some time ago.

Richmond International, Inc, Ophthalmic Instruments Division, Boca Raton, FL, USA. fax +1 561 994 2235

If anyone is expecting to see a faithful reproduction of the much prized and valued H-R-R plates, they

should prepare for extreme disappointment. This is a laser printed version which differs in chromaticity and texture very markedly from the original. Don't get rid of your first or second editions. I suspect the new product is about as good as my Indian colur photocopy edition of the Ishihara test !

Abstracts of colour vision papers. Compiled by Joel Pokorny

MOLECULAR GENETICS

Arbour, N. C., J. Zlotogora, R. G. Knowlton, et al. (1997).
"Homozygosity mapping of achromatopsia to chromosome 2 using DNApooling." Hum Mol Genet 6(5): 689-94.Achromatopsia is an autosomal recessive disease of the retina,characterized clinically by an inability to distinguish colors,impaired visual acuity, nystagmus and photophobia. A genome-widesearch for linkage was performed using an inbred Jewish kindredfrom Iran. To facilitate the genome-wide search, we utilized aDNA pooling strategy which takes advantage of the likelihood thatthe disease in this inbred kindred is inherited by all affectedindividuals from a common founder. Equal molar amounts of DNAfrom all affected individuals were pooled and used as the PCRtemplate for short tandem repeat polymorphic markers (STRPs).Pooled DNA from unaffected members of the kindred was used asa control. A reduction in the number of alleles in the affectedversus control pool was observed at several loci. Upon genotypingof individual family members, significant linkage was establishedbetween the disease phenotype and markers localized on chromosome2. The highest LOD score observed was 5.4 (theta = 0). When fouradditional small unrelated families were genotyped, the combinedpeak LOD score was 8.2. Analysis of recombinant chromosomes revealedthat the disease gene lies within a 30 cM interval which spansthe centromere. Additional fine-mapping studies identified a regionof homozygosity in all affected individuals, narrowing the regionto 14 cM. A candidate gene for achromatopsia was excluded fromthis disease interval by radiation hybrid mapping. Linkage ofachromatopsia to chromosome 2 is an essential first step in theidentification of the disease-causing gene.

Macke, J. P. and J. Nathans (1997). "Individual variation in sizeof the human red and green visual pigment gene array." InvestOphthalmol Vis Sci 38(5): 1040-3.
PURPOSE: To determine the size variation of the X-chromosomalhuman red and green visual pigment gene array in the general populationusing pulsed field gel electrophoresis and Southern blotting.METHODS: Peripheral blood lymphocytes were prepared from 67 anonymousmales. The cells were embedded in agarose and the genomic DNAdigested with restriction enzyme Not I. The resulting DNA fragmentswere resolved on a contour-clamped homogeneous electric fieldgel, and the Not I fragment containing the red and green pigmentgenes was visualized by Southern blot hybridization with a humangreen pigment cDNA probe. RESULTS: In DNA from each male, a singlehybridizing fragment was observed in Not I-digested DNA. The lengthsof the fragments from different males were observed to vary insteps of approximately 39 kilobases (kb), consistent with earlierstudies showing a visual pigment gene repeat unit of 39 kb anda head-to-tail tandem arrangement of the red and green visualpigment genes. In the population studied, the number of repeatunits per X-chromosome had a mean of 2.9 and a standard deviationof 0.94. CONCLUSIONS: The sizes of visual pigment gene arraysobserved in this study resemble those determined in earlier studiesbased on ratios of restriction fragments resolved by conventionalgel electrophoresis and visualized by whole genome Southern blotting,but differ significantly from those determined using ratios offragments obtained by the polymerase chain reaction.

Hagstrom, S. A., J. Neitz and M. Neitz (1998). "Variations incone populations for red-green color vision examined by analysisof mRNA [In Process Citation]." Neuroreport 9(9): 1963-7.

In the central human retina, there are estimated to be nearlytwo L cone photoreceptors for each M cone. The extent to whichthis value varies across individuals is unclear and little isknown about how the M:L cone ratio might change with retinal location.To address these questions, the ratio of M:L cone pigment mRNAwas examined at different locations. For patches of central retina,the average M:L ratio was about 2:3 which decreased to about 1:3for patches 40 degrees eccentric. There were also large individualdifferences among the 23 eyes examined. The extremes differedin central M:L mRNA ratio by a factor of > 3. The measured differencesin mRNA ratio are proposed to reflect differences in photoreceptorratio. Such variations provide unique opportunities for understandinghow the neural circuitry for color vision is affected by changesin cone ratio.

Kohl, S., T. Marx, I. Giddings, et al. (1998). "Total colourblindnessis caused by mutations in the gene encoding the alpha-subunitof the cone photoreceptor cGMP-gated cation channel." Nat Genet19(3): 257-9.
Total colourblindness (OMIM 216900), also referred to asrod monochromacy (RM) or complete achromatopsia, is a rare, autosomalrecessive inherited and congenital disorder characterized by photophobia,reduced visual acuity, nystagmus and the complete inability todiscriminate between colours. Electroretinographic recordingsshow that in RM, rod photoreceptor function is normal, whereascone photoreceptor responses are absent. The locus for RM hasbeen mapped to chromosome 2q11 (ref. 2), however the gene underlyingRM has not yet been identified. Recently, a suitable candidategene, CNGA3, encoding the alpha-subunit of the cone photoreceptorcGMP-gated cation channel, a key component of the phototransductionpathway, has been cloned and assigned to human chromosome 2q11(refs 3,4). We report the identification of missense mutationsin CNGA3 in five families with RM. Homozygous mutations are presentin two families, whereas the remaining families show compoundheterozygous mutations. In all cases, the segregation patternof the mutations is consistent with the autosomal recessive inheritanceof the disease and all mutations affect amino acids that are highlyconserved among cyclic nucleotide gated channels (CNG) in variousspecies. This is the first report of a colour vision disordercaused by defects other than mutations in the cone pigment genes,and implies at least in this instance a common genetic basis forphototransduction in the three different cone photoreceptors ofthe human retina.

Yokoyama, S. and F. B. Radlwimmer (1998). "The "five-sites" ruleand the evolution of red and green color vision in mammals." MolBiol Evol 15(5): 560-7.
Amino acid changes S180A (S-->A at site 180), H197Y, Y277F,T285A, and A308S are known to shift the maximum wavelength ofabsorption (lambda max) of red and green visual pigments towardblue, essentially in an additive fashion. To test the generalityof this "five-sites" rule, we have determined the partial aminoacid sequences of red and green pigments from five mammalian orders(Artiodactyla, Carnivora, Lagomorpha, Perissodactyla, and Rodentia).The result suggests that cat (Felis catus), dog (Canis familiaris),and goat (Capra hircus) pigments all with AHYTA at the five criticalsites have lambda max values of approximately 530 nm, whereasrat (Rattus norvegicus) pigment with AYYTS has a lambda max valueof approximately 510 nm, which is accurately predicted by thefive-sites rule. However, the observed lambda max values of theorthologous pigments of European rabbit (Oryctolagus cuniculus),white-tailed deer (Odocoileus virginianus), gray squirrel (Sciuruscarolinensis), and guinea pig (Cavia procellus) are consistentlymore than 10 nm higher than the predicted values, suggesting theexistence of additional molecular mechanisms for red and greencolor vision. The inferred amino acid sequences of ancestral organismssuggest that the extant mammalian red and green pigments appearto have evolved from a single ancestral green-red hybrid pigmentby directed amino acid substitutions.

ANATOMY AND PHYSIOLOGY

Benardete, E. A. and E. Kaplan (1997). "The receptive fieldof the primate P retinal ganglion cell, I: Linear

dynamics." VisNeurosci 14(1): 169-85
The ganglion cells of the primate retina include two majoranatomical and functional classes: P cells which project to thefour parvocellular layers of the lateral geniculate nucleus (LGN),and M cells which project to the two magnocellular layers. Thecharacteristics of the P- cell receptive field are central tounderstanding early form and color vision processing (Kaplan etal., 1990; Schiller & Logothetis, 1990). In this and in the followingpaper, P-cell dynamics are systematically analyzed in terms oflinear and nonlinear response properties. Stimuli that favor eitherthe center or the surround of the receptive field were producedon a CRT and modulated with a broadband signal composed of multiplem-sequences (Benardete et al., 1992b; Benardete & Victor, 1994).The first-order responses were calculated and analyzed in thispaper (part I). The findings are: (1) The first-order responsesof the center and surround depend linearly on contrast. (2) Thedynamics of the center and surround are well described by a bandpassfilter model. The most significant difference between center andsurround dynamics is a delay of approximately 8 ms in the surroundresponse. (3) In the LGN, these responses are attenuated and delayedby an additional 1-5 ms. (4) The spatial transfer function ofthe P cell in response to drifting sine gratings at three temporalfrequencies was measured. This independent method confirmed thedelay between the (first-order) responses of the center and surround.This delay accounts for the dependence of the spatial transferfunction on the frequency of stimulation.

Kiper, D. C., S. B. Fenstemaker and K. R. Gegenfurtner (1997)."Chromatic properties of neurons in macaque area V2." Vis Neurosci14(6): 1061-72We recorded from single cells in area V2 of cynomolgus monkeysusing standard acute recording techniques. After measuring eachcell's spatial and temporal properties, we performed several testsof its chromatic properties using sine-wave gratings modulatedaround a mean gray background. Most cells behaved like neuronsin area V1 and their responses were adequately described by amodel that assumes a linear combination of cone signals. Unlikein V1, we found a subpopulation of cells whose activity was increasedor inhibited by stimuli within a narrow range of color combinations.No particular color directions were preferentially represented.V2 cells showing color specificity, including cells showing narrowchromatic tuning, were present in any of the stripe compartments,as defined by cytochrome-oxidase (CO) staining. An addition ofchromatic contrast facilitated the responses of most neurons togratings with various luminance contrasts. Neurons in all threeCO compartments gave significant responses to isoluminant gratings.Receptive-field properties of cells were generally similar forluminance and chromatically defined stimuli. We found only a smallnumber of cells with a clearly identifiable double-opponent receptive-field organization.

Kolb, H., P. Goede, S. Roberts, et al. (1997). "Uniqueness ofthe S-cone pedicle in the human retina and consequences for colorprocessing." J Comp Neurol 386(3): 443-60.
The purpose of this study was to investigate more fully theshape and content of ribbons and synapses to second-order neuronsin the short- wavelength cone (S-cone, blue cone) pedicle andto learn more concerning the uniqueness of the S-cone system inthe primate retina. A piece of well-fixed peripheral human retina(10 mm, 35 degrees nasal to the fovea) was serially thick sectionedin the tangential plane from the level of the outer segments tothe tops of the cone pedicles. Then serial electron microscope(EM) sections were collected through the whole depth of the pedicle-occupyingregion into the neuropil of the outer plexiform layer (OPL). Theresultant EM micrograph montages of a large field of cone pedicleswere perused, and S-cone pedicles were identified. Serial micrographsof a single S-cone pedicle, picked out of the montages, were digitizedand reconstructed by computer three- dimensional methods. TheS-cone pedicle arose from a slightly oblique axon and projected0.5-1 microm more vitread in the OPL than other cone pedicles.It was bilobed in shape, with synaptic invaginations and ribbonsin both lobes. No cone-contacting telodendria projected from theS-cone pedicle itself, but a small number of neighboring conessent telodendria to its surface to make small gap junctions. Neighboringrod spherules also made small gap junctions. Four robust

bipolarcell dendrites, most likely from S-cone-specific bipolar cells,made synapses at ribbons and basal (distal) junctions. A smallnumber of other bipolar cell dendrites made narrow-cleft basaljunction only. The majority of lateral elements were thought tobe from HII horizontal cells, and a minority from HI horizontalcells. We conclude that the S- cone pedicle has a unique morphologyand connectivity to second-order neurons that makes it quite differentfrom the other two longer wavelength cone systems, and we speculateon the consequences for color processing in the visual systemin general.

Martin, P. R., A. J. White, A. K. Goodchild, et al. (1997). "Evidencethat blue-on cells are part of the third geniculocortical pathwayin primates." Eur J Neurosci 9(7): 1536-41.
Colour vision in primates is mediated by cone opponent ganglioncells in the retina, whose axons project to the dorsal lateralgeniculate nucleus in the visual thalamus. It has long been assumedthat cone opponent ganglion cells project to the parvocellularlayers of the geniculate. Here, we examine the role of a thirdsubdivision of the geniculocortical pathway: the interlaminaror koniocellular geniculate relay cells. We made extracellularrecordings in the dorsal lateral geniculate nucleus of the commonmarmoset Callithrix jacchus, a New World monkey in which the interlaminarcells are well segregated from the parvocellular layers. We foundthat one group of colour opponent cells, the blue-on cells, waslargely segregated to the interlaminar zone. This segregationwas common to dichromatic ('red-green colour- blind') and trichromaticmarmosets. The result calls into question the traditional notionthat all colour information passes through the parvocellular divisionof the retino-geniculo-cortical pathway in primates.

Meissirel, C., K. C. Wikler, L. M. Chalupa, et al. (1997). "Earlydivergence of magnocellular and parvocellular functional subsystemsin the embryonic primate visual system." Proc Natl Acad Sci US A 94(11): 5900-5.
In both human and Old World primates visual information isconveyed by two parallel pathways: the magnocellular (M) and parvocellular(P) streams that project to separate layers of the lateral geniculatenucleus and are involved primarily in motion and color/form discrimination.The present study provides evidence that retinal ganglion cellsin the macaque monkey embryo diverge into M and P subtypes soonafter their last mitotic division and that optic axons projectdirectly and selectively to either the M or P moieties of thedeveloping lateral geniculate nucleus. Thus, initial M projectionsfrom the eyes overlap only in prospective layers 1 and 2, whereasinitial P projections overlap within prospective layers 3-6. Wesuggest that the divergence of the M and P pathways requires developmentalmechanisms different from those underlying competition-drivensegregation of initially intermixed eye-specific domains in theprimate visual system.

Takechi, H., H. Onoe, H. Shizuno, et al. (1997). "Mapping of corticalareas involved in color vision in non-human primates." NeurosciLett 230(1): 17-20.
Positron emission tomography (PET) was used to measure changesin the regional cerebral blood flow (rCBF) of rhesus monkeys performingvisual discrimination tasks. In comparison with both positionand brightness discrimination tasks, the color discriminationtask activated the posterior inferior temporal cortex and a ventromedialoccipital region, which is located along the anterior one-thirdof the calcarine sulcus. In contrast, the position task activatedthe middle temporal area and intraparietal cortex as comparedwith the color task. These results confirm the segregation ofvisual pathways and delineate the visual areas involved in colorvision. This approach might bridge the gap between invasive studiesin animals and functional imaging studies in humans.

Calkins, D. J., Y. Tsukamoto and P. Sterling (1998). "Microcircuitryand mosaic of a blue-yellow ganglion

cell in the primate retina."J Neurosci 18(9): 3373-85.

Perception of hue is opponent, involving the antagonisticcomparison of signals from different cone types. For blue versusyellow opponency, the antagonism is first evident at a ganglioncell with firing that increases to stimulation of short wavelength-sensitive(S) cones and decreases to stimulation of middle wavelength-sensitive(M) and long wavelength-sensitive (L) cones. This ganglion cell,termed blue-yellow (B-Y), has a distinctive morphology with dendritesin both ON and OFF strata of the inner plexiform layer (Daceyand Lee, 1994). Here we report the synaptic circuitry of the celland its spatial density. Reconstructing neurons in macaque foveafrom electron micrographs of serial sections, we identified sixganglion cells that branch in both strata and have similar circuitry.In the ON stratum each cell collects approximately 33 synapsesfrom bipolar cells traced back exclusively to invaginating contactsfrom S cones, and in the OFF stratum each cell collects approximately14 synapses from bipolar cells (types DB2 and DB3) traced to basalsynapses from approximately 20 M and L cones. This circuitry predictsthat spatially coincident blue-yellow opponency arises at thelevel of the cone output via expression of different glutamatereceptors. S cone stimuli suppress glutamate release onto metabotropicreceptors of the S cone bipolar cell dendrite, thereby openingcation channels, whereas M and L cone stimuli suppress glutamaterelease onto ionotropic glutamate receptors of DB2 and DB3 celldendrites, thereby closing cation channels. Although the B-Y cellis relatively rare (3% of foveal ganglion cells), its spatialdensity equals that of the S cone; thus it could support psychophysicaldiscrimination of a blue-yellow grating down to the spatial cutoffof the S cone mosaic.

Chan, T. L. and U. Grunert (1998). "Horizontal cell connectionswith short wavelength-sensitive cones in the retina: a comparisonbetween New World and Old World primates." J Comp Neurol 393(2):196-209.

Recent studies in the Old World macaque monkey have shownthat the two horizontal cell types H1 and H2 differ with respectto their connections to short wavelength-sensitive (SWS) cones.We wanted to establish whether this pattern of connectivity iscommon to all primates. The connections of horizontal cells withSWS cones were studied in the retinas of two species of New World(marmoset and tamarin) and two species of Old World (orangutanand chimpanzee) primates by using a double-labelling technique.Horizontal cells were labelled with DiI and then photoconverted;SWS cones were labelled immunocytochemically. The marmoset showsa sex-linked polymorphism of colour vision: All males are dichromats,whereas most females are trichromats. In contrast, Old World primatesare usually trichromats. Our results show that the horizontalcells of both New World and Old World primates have a comparablepattern of connectivity with SWS cones and thus indicate thatthe wiring of horizontal cells with SWS cones does not differbetween dichromats and trichromats and is common to all primates.The H1 cells make no or only sparse contact with SWS cones. Inmarmoset, H1 cells have on average 0.8% of their dendritic terminalsat SWS cones. The H2 cells contact all SWS cones in their dendriticfield. In marmoset, H2 cells have on average 11.8% of their dendriticterminals at SWS cones. The axon of H2 cells contacts SWS conesbut presumably also contacts other cones.

Lankheet, M. J., P. Lennie and J. Krauskopf (1998). "Distinctivecharacteristics of subclasses of red-green P-cells in LGN of macaque."Vis Neurosci 15(1): 37-46.

We characterized the chromatic and temporal properties ofa sample of 177 red-green parvocellular neurons in the LGN ofMacaca nemestrina, using large-field stimuli modulated along differentdirections through a

white point in color space. We examined differencesamong the properties of the four subclasses of red-green P-cells(on- and off- center, red and green center). The responses ofoff-center cells lag the stimulus more than do those of on-centercells. At low temporal frequencies, this causes the phase differencebetween responses of the two kinds of cells to be considerablyless than 180 deg. For isoluminant modulations the phases of on-and off-responses were more nearly 180 deg apart. A cell's temporalcharacteristics did not depend on the class of cone driving itscenter. Red center and green center cells have characteristicallydifferent chromatic properties, expressed either as preferredelevations in color space, or as weights with which cells combineinputs from L- and M-cones. Red center cells are relatively moreresponsive to achromatic modulation, and attach relatively moreweight to input from the cones driving the center. Off- centercells also attach relatively more weight than do on-center cellsto input from the class of cone driving the center.

Lankheet, M. J., P. Lennie and J. Krauskopf (1998). "Temporal-chromaticinteractions in LGN P-cells." Vis Neurosci 15(1): 47-54.

We studied the interaction between the chromatic and temporalproperties of parvocellular (P) neurons in the lateral geniculatenucleus (LGN) of macaque monkeys. We measured the amplitudes andphases of responses to stimulation by spatially uniform fieldsmodulated sinusoidally about a white point in a three-dimensionalcolor space, at a range of temporal frequencies between 1 and25 Hz. Below about 4 Hz, temporal frequency had relatively littleeffect on chromatic tuning. At higher frequencies chromatic opponencywas weakened in almost all cells. The complex interactions betweentemporal and chromatic properties are represented by a linearfilter model that describes response amplitude and phase as afunction of temporal frequency and direction in color space alongwhich stimuli are modulated. The model stipulates the cone inputsto center and surround, their temporal properties, and the linearcombination of center and surround signals. It predicts the amplitudesand phases of responses of P-cells, and the change of chromaticproperties with temporal frequency. We used the model to investigatewhether or not the chromatic signature of the surround in a red-greencell could be estimated from the change in the cell's chromaticproperties with temporal frequency. Our findings could be equallywell described by mixed cone surrounds as by pure cone surrounds,and we conclude that, with regard to temporal properties, thereis no benefit to be gained by segregating cone classes in centerand surround.

Lee, B. B. and T. Yeh (1998). "Receptive fields of primate retinalganglion cells studied with a novel technique." Vis Neurosci 15(1):161-75.

We have reinvestigated receptive-field structure of ganglioncells of the macaque parafovea using counterphase modulation ofa bipartite field. Receptive fields were mapped with luminance,chromatic, and cone- isolating stimuli. Center sizes of middle(M) and long (L) wavelength cone opponent cells of the parvocellular(PC) pathway were consistent with previous estimates (Gaussianradii of 2-4 min of arc, corresponding to center diameters of6-12 min of arc). We calculate that a large factor of the enlargementrelative to cone radius could be blur due to the eye's naturaloptics. Maps were consistent with cone selectivity in surroundmechanisms, which had radii of 5-8 min of arc. For magnocellular(MC) cells, center size estimates were also consistent with gratingmeasurements from the literature (also Gaussian radii of 2-4 minof arc). The surround mechanism contributing the MC- cell frequency-doubledresponse to chromatic modulation appears to possess a subunitstructure, and we speculate it derives from nonlinear

summationof signals from M,L-cone opponent subunits, such as midget bipolarcells.

PSYCHOPHYSICS

Brainard, D. H., W. A. Brunt and J. M. Speigle (1997). "Colorconstancy in the nearly natural image. I. Asymmetric matches."J Opt Soc Am A 14(9): 2091-110.

Most empirical work on color constancy is based on simplelaboratory models of natural viewing conditions. These typicallyconsist of spots seen against uniform backgrounds or computersimulations of flat surfaces seen under spatially uniform illumination.We report measurements made under more natural viewing conditions.The experiments were conducted in a room where the illuminationwas under computer control. Observers used a projection colorimeterto set asymmetric color matches across a spatial illuminationgradient. Observers' matches can be described by either of twosimple models. One model posits gain control in one-specific pathways.This diagonal model may be linked to ideas about the action ofearly visual mechanisms. The other model posits that the observerestimates and corrects for changes in illumination but does soimperfectly. This equivalent illuminant model provides a linkbetween human performance and computational models of color constancy.

Brettel, H., F. Vienot and J. D. Mollon (1997). "Computerizedsimulation of color appearance for dichromats." J Opt Soc Am A14(10): 2647-55.

We propose an algorithm that transforms a digitized colorimage so as to simulate for normal observers the appearance ofthe image for people who have dichromatic forms of color blindness.The dichromat's color confusions are deduced from colorimetry,and the residual hues in the transformed image are derived fromthe reports of unilateral dichromats described in the literature.We represent color stimuli as vectors in a three-dimensional LMSspace, and the simulation algorithm is expressed in terms of transformationsof this space. The algorithm replaces each stimulus by its projectiononto a reduced stimulus surface. This surface is defined by aneutral axis and by the LMS locations of those monochromatic stimulithat are perceived as the same hue by normal trichromats and agiven type of dichromat. These monochromatic stimuli were a yellowof 575 nm and a blue of 475 nm for the protan and deutan simulations,and a red of 660 nm and a blue-green of 485 nm for the tritansimulation. The operation of the algorithm is demonstrated witha mosaic of square color patches. A protanope and a deuteranopeaccepted the match between the original and the appropriate image,confirming that the reduction is colorimetrically accurate. Althoughwe can never be certain of another's sensations, the simulationprovides a means of quantifying and illustrating the residualcolor information available to dichromats in any digitized image.

Brown, R. O. and D. I. MacLeod (1997). "Color appearance dependson the variance of surround colors." Curr Biol 7(11): 844-9.

BACKGROUND: The perceived color at each point in a visualscene depends on the relationship between light signals from thatpoint, and light signals from surrounding areas of the scene.In the well known phenomenon of simultaneous color contrast, changingthe overall brightness or hue of an object's surround

inducesa complementary shift in the perceived brightness or hue of theobject's color. Color contrast is thought to contribute to colorconstancy with changes in illumination. RESULTS: We report a newtype of simultaneous color contrast, in which changing only thevariance (i.e. contrasts and saturations), but not the mean, ofcolors in a test spot's surround induces a complementary shiftin the perceived contrast and saturation of the test spot's color.Objects appear much more vivid and richly colored against low-contrast,gray surrounds than against high- contrast, multicolored surrounds.CONCLUSIONS: Color appearance depends not just on the mean colorof the surround, but also on the distribution of surround colorsabout the mean. This novel form of simultaneous color contrastis inconsistent with a variety of models of color appearance,including those based on sensitivity regulation at the receptorlevel, and those in which the effects of complex surrounds oncolor appearance can be reduced to adaptation to the illuminantor induction from a homogeneous 'equivalent surround'. It tendsto normalize the gamut of perceived colors in each visual sceneand may also contribute to color constancy under viewing conditionsthat affect contrast.

D'Zmura, M., P. Colantoni, K. Knoblauch, et al. (1997). "Colortransparency." Perception 26(4): 471-92.

Observation suggests that the chromatic changes which elicitan impression of transparency include translations and convergencesin color space. Neither rotations nor shears in color space leadto perceived transparency. Results of matching experiments showthat equiluminous translations, which cannot be generated by episcotisteror filter models, give rise to the perception of transparency.This implies that systematic luminance change is not needed fortransparency to be perceived. These results were used for thedevelopment of a method for detecting a transparent overlay withina color image and for separating the overlay from the underlyingsurfaces. The method tests for the coherence of chromatic changealong contours through X- junctions to help detect the contourof a transparent region. The algorithm tests locally for translationand convergence to detect a transparent region. It estimates globallythe chromatic parameters of the transparent overlay in order toseparate the overlay from the underlying surfaces.

de Weert, C. M. and N. A. van Kruysbergen (1997). "Assimilation:central and peripheral effects." Perception 26(10): 1217-24.

Assimilation and contrast have opposite effects: Contrastleads to an increase of perceived differences between neighbouringfields, whereas assimilation leads to a reduction. It is relativelyeasy to demonstrate these effects, but the precise localisationof these effects in the perceptual system is not yet possible.In an experiment the strength of assimilation effects was modifiedby adding spatial noise. By varying the localisation in perceivedspace of the added noise (by presentation of the noise patternwith different binocular disparities) the masking effect of thisnoise can be influenced. Masking caused by binocularly disparatenoise is less than masking caused by binocularly non- disparatenoise. It is concluded that the effect at least partly occursbeyond the (binocular) locus of separation in different depthplanes. A similar approach, involving moving noise, is also presented.Finally, several demonstrations show that images that are peripherallysimilar can give rise to differences in the perceived amount ofassimilation. These effects further indicate that a central mechanismis involved in assimilation.

Miyahara, E. and C. M. Cicerone (1997). "Color from motion: separatecontributions of chromaticity and

luminance." Perception 26(11):1381-96.

'Color from motion' describes the perception of a spreadof subjective color over achromatic regions seen as moving. Theeffect is produced with a stimulus display consisting of coloreddots, randomly placed upon a white field, with dots in the testregion differing in both chromaticity and luminance from thosein the surround. Evidence is presented suggesting that color frommotion may be regulated by mechanisms different from those forcontour formation and color contrast. (1) Results based on ratingsshow that, in the absence of luminance differences between thedots in the test and those in the surround regions, chromaticitydifferences alone are sufficient to produce color spread frommotion. As the equiluminance point is approached, subjective colorspread is seen despite a reduction in the strength of the subjectivecontour. Thus, contour formation is not likely to be a prerequisitefor color from motion. (2) Color matches show that the hue andsaturation of the subjective color spread are determined largelyby the chromaticity and the luminance of the dots in the testregion, not by those of the dots in the surround for the valuesexplored. This suggests that color from motion may arise in sitesdistinct from those responsible for the regulation of color contrast.

Sankeralli, M. J. and K. T. Mullen (1997). "Postreceptoral chromaticdetection mechanisms revealed by noise masking in three-dimensionalcone contrast space." J Opt Soc Am A 14(10): 2633-46.

We used a noise masking technique to test the hypothesisthat detection is subserved by only two chromatic postreceptoralmechanisms (red-green and blue-yellow) and one achromatic (luminance)mechanism. The task was to detect a 1-c/deg Gaussian envelopedgrating presented in a mask of static, spatially low-passed binaryor Gaussian distributed noise. In the main experiment, the directionof the test stimulus (termed the signal) was constant in conecontrast space, and the direction of the noise was sampled inequally spaced directions within a plane (the noise plane) inthe space. The signal was chosen to coincide with one of the threecardinal directions of three postulated mechanisms. The noiseplane was selected to span two of the cardinal directions, includingthat chosen as the signal direction. As the noise direction wassampled around the noise plane, the signal detection thresholdwas found to vary in accordance with a linear cosine model, whichpredicted noise directions yielding maximum and minimum maskingof the signal. In the direction of minimum masking (termed a nulldirection), the noise was found to have no masking effect on thesignal. Moreover, the null was not orthogonal to the signal directionbut lay instead in one of the cardinal directions. Our findingssuggest that detection is mediated by only three mechanisms. Ina further experiment we found little or no cross masking betweeneach pair of cardinal directions up to the limit of our noisemask contrasts. This further supports the presence of no morethan three independent postreceptoral mechanisms.

Brainard, D. H. (1998). "Color constancy in the nearly naturalimage. 2. Achromatic loci." J Opt Soc Am A Opt Image Sci Vis 15(2):307-25.

Most empirical work on color constancy is based on simplelaboratory models of natural viewing conditions. These typicallyconsist of spots seen against uniform backgrounds or computersimulations of flat surfaces seen under spatially uniform illumination.In this study measurements were made under more natural viewingconditions. Observers used a projection colorimeter to adjustthe appearance of a test patch until it appeared achromatic. Observersmade such achromatic settings under a variety of illuminants andwhen the test surface was viewed against a number of differentbackgrounds. An analysis of the achromatic settings

reveals thatobservers show good color constancy when the illumination is varied.Changing the background surface against which the test patch isseen, on the other hand, has a relatively small effect on theachromatic loci. The results thus indicate that constancy is notachieved by a simple comparison between the test surface and itslocal surround.

Cropper, S. J. (1998). "Detection of chromatic and luminance contrastmodulation by the visual system." J Opt Soc Am A Opt Image SciVis 15(8): 1969-86.

The data presented in this paper examine the ability of observersto detect a modulation in the contrast of chromatic and luminancegratings as a function of the carrier contrast, duration, andspatial frequency. The nature of the signal underlying this abilityis investigated by examining both the paradigm used to make themeasurement and the effect of grating masks on performance inthe tasks. The results show that observers' ability to discriminateamplitude modulation from an unmodulated carrier is dependenton carrier contrast but only up to approximately 5-8 times carrier-detectionthreshold. Discrimination is, however, independent of spatialfrequency [10-1 cycles per degree (cpd) component-frequency range],carrier color, and, most surprisingly, stimulus duration (1000-30ms). This set of experiments compliments data from previous papersand assimilates many of the conclusions drawn from this previousdata. There is absolutely no evidence for the existence of a distortionproduct mediating performance under any of the current conditions,and the data seriously question whether the visual system mightuse such a signal even if it does exist under more extreme conditionsthan those used here. The evidence suggests that the visual systemdetects variations in both chromatic and luminance contrast bymeans of a mechanism operating locally upon the spatial structureof the carrier.

Zaidi, Q. (1998). "Identification of illuminant and objectcolors: heuristic-based algorithms." J Opt Soc Am A Opt ImageSci Vis 15(7): 1767-76.

In everyday scenes, from perceived colors of objects andterrains, observers can simultaneously identify objects acrossilluminants and identify the nature of the light, e.g., as sunlightor cloudy. As a formal problem, identifying objects and illuminantsfrom the color information provided by sensor responses is underdetermined.It is shown how the problem can be simplified considerably bythe empirical result that chromaticities of sets of objects underone illuminant are approximately affine transformations of thechromaticities under spectrally different illuminants. Algorithmsthat use the affine nature of the correlation as a heuristic canidentify objects of identical spectral reflectance across sceneslit simultaneously or successively by different illuminants. Therelative chromaticities of the illuminants are estimated as partof the computation. Because information about objects and illuminantsis useful in many different tasks, it would be more advantageousfor the visual system to use such algorithms to extract both sortsof information from retinal signals than to discount either automaticallyat an early neural stage.

CLINICAL STUDIES AND TESTING

Craven, B. J. (1997). "A method for increasing the scoringefficiency of the Farnsworth- Munsell 100-Hue test." OphthalmicPhysiol Opt 17(2): 153-7.

This paper describes a method for scoring the Farnsworth-Munsell100- Hue test, based on maximum-likelihood estimation, which intheory reduces test-to-test variability in scores and which istherefore better able to discriminate between different levelsof overall colour discrimination than is the original Farnsworthscoring system. Error scores produced by the method are directlycomparable to error scores produced by the traditional scoringsystem. It is hoped that this work will provoke further considerationof the efficiency of the scoring system as far as test-to-testvariability is concerned, including the efficient detection ofpolarity in the subject's hue discrimination function.

Geller, A. M. and H. K. Hudnell (1997). "Critical issues in theuse and analysis of the Lanthony Desaturate Color Vision test."Neurotoxicol Teratol 19(6): 455-65.

The Lanthony Desaturate Color Vision test (D-15d) has beenused to demonstrate the incidence of acquired color vision defectsresulting from toxic exposure. The D-15d is a sensitive test designedto grade color deficiencies, but results can be difficult to interpretbeyond the qualitative level, and the high incidence of errorsreported for controls in some toxicology studies raises questionsabout how to effectively use this test. This article reviews standardadministration of the test, physical determinants of performance,classification of acquired color vision defects, and methods ofanalysis that have been used to quantify results. The basis fora new method of analysis is discussed, illustrating the sourceof some characteristic errors, and recommendations are made fortest protocols to attempt to more closely identify the type ofcolor vision loss with the goal of identifying the site of toxicologicalinsult.

Morland, A. B. and K. H. Ruddock (1997). "Retinotopic organisationof cortical mechanisms responsive to colour: evidence from patientstudies." Acta Psychol (Amst) 97(1): 7-24.

This paper deals with the visual responses of three patientswho have impaired colour vision consequent on cortical dysfunctionwhich, in two of them, is associated with demonstrable neuronaldamage. The studies to be described are concerned particularlywith the spatial attributes of their chromatic response mechanisms.Data are presented which establish that a hemianope GY has coarsechromatic discrimination for large stimuli located within his'blind' hemifield. GY responds to stimuli containing differentlycoloured equiluminant components as if the coloured componentswere averaged over the whole field and it is speculated that suchspatial averaging may correspond to the process which, in normalvision, provides compensation for change of illuminant in orderto achieve colour constancy. Colour constancy is impaired in asecond patient, BL, who has cortical lesions involving the lingualand fusiform gyri, areas which are partially spared in GY. Itis shown that movement, but not colour, presented to GY's normalhemifield generates a response localised in his blind hemifieldand disinhibitory interaction between movement and colour is illustratedfor a patient MW, in whom colour chromatic stimuli generate spreadinginhibition of visual responses. This inhibitory interaction ispropagated between widely separated stimuli, including those whichare located on opposite sides of the vertical meridian. We discussthese experimental results in relation to anatomical and physiologicalmechanisms of the primate visual cortex.

Schneck, M. E. and G. Haegerstrom-Portnoy (1997). "Color visiondefect type and spatial vision in the optic neuritis treatmenttrial." Invest Ophthalmol Vis Sci 38(11): 2278-89.

PURPOSE: To describe the types of color vision defects presentin the acute phase of the disease and 6 months into recovery inthe 438 participants of the Optic Neuritis Treatment Trial. METHODS:Patients meeting strict eligibility criteria were seen within8 days of the onset of symptoms and then at regular follow-upvisits. At the first and 6-month visits (and subsequent annualvisits), spatial vision (acuity, contrast sensitivity), visualfields, and color vision were measured. Farnsworth-Munsell 100-huetests were scored by a variant of the method of quadrant analysisdescribed by Smith et al (Am J Ophthalmol. 1985; 100:176-182).RESULTS: Most persons show mixed red- green (RG) and blue-yellow(BY) color defects (one type predominating, accompanied by a lesserdefect of the other type). BY defects tend to be slightly morecommon in the acute phase of the disease, with slightly more RGdefects at 6 months. Persons may shift defect type over time.Defect type was not related to any of the spatial vision measuresat either test time or to treatment group; however, severity ofcolor defect was related to both spatial vision measures and treatmentgroup. CONCLUSIONS: Contrary to common clinical wisdom, opticneuritis is not characterized by selective RG defects. Color defecttype cannot be used for differential diagnosis of optic neuritis.

Toyoguchi, A., H. Kudo, T. Rokugo, et al. (1998). "[Cone sensitivitymeasurements in diabetic retinopathy]." Nippon Ganka Gakkai Zasshi102(2): 117-22.

We made cone sensitivity measurements and hue discriminationmeasurements in 58 eyes of 34 diabetic patients with and withoutdiabetic retinopathy including preproliferative retinopathy. Thesame measurements were performed in 8 eyes of 8 subjects to comparethem. In this study, we were able to make the measurements ina short time and comfortably for the patients because we onlyneeded to measure peak sensitivities of spectral sensitivity curvesin three cones. There was significant correlation between shortwave length sensitive-cone pathway sensitivity and retinopathylevels determined by fluorescein angiography. The cone sensitivitymeasurements that we used in this study were simple and sensitive.Our results suggested that the measurements were useful for detectionof visual functional disturbances, determination of retinopathylevels, and prognosis.

TOXICITIES

Muttray, A., U. Wolff, D. Jung, et al. (1997). "Blue-yellowdeficiency in workers exposed to low concentrations of organicsolvents." Int Arch Occup Environ Health 70(6): 407-12.

OBJECTIVES: To evaluate the effects of low concentrationsof organic solvents on color vision. METHODS: Color vision wasexamined in 24 workers exposed to mixtures of solvents and in24 control subjects. Exposure to mixtures was below the threshold-limitvalues. Color vision ability was assessed using the Ishihara plates(to screen for congenital dyschromatopsia), the Farnsworth panelD-15 test, the Lanthony desaturated panel D-15 test, and the StandardPseudoisochromatic Plates part 2 (SPP2 test). RESULTS: The comparativelyless sensitive Farnsworth panel D-15 test failed to show any differencebetween the groups, but the Lanthony panel D-15 desaturated testas well as the SPP2 test showed a significant impairment in theexposed group. Errors were of the blue-yellow type. CONCLUSION:This study gives further evidence that even mixtures of organicsolvents at concentrations below the threshold-limit values mayimpair color vision.

Cavalleri, A. and F. Gobba (1998). "Reversible color vision lossin occupational exposure to metallic mercury." Environ Res 77(2):173-7.

Color vision was evaluated in twenty-one mercury exposedworkers and referents matched for sex, age, tobacco smoking, andalcohol habits. The Lanthony 15 Hue desaturated panel (D-15 d)was applied. In the workers, mean urinary Hg (HgU) was 115+/-61.5microg/g creatinine; in all but one the values exceeded the biologicallimit (BEI) proposed by the American Conference of GovernmentalIndustrial Hygienists. A dose-related subclinical color visionimpairment was observed in Hg-exposed workers compared to thereferents. Just after the survey, working conditions were improved.Twelve months later the workers were reexamined. Mean HgU was10.0 microg/g creatinine and in no subjects was the BEI exceeded.Color perception was significantly improved compared to the firstexamination and, furthermore, no differences were observed betweenexposed workers and referents. The results add evidence that thecolor vision loss observed during the first part of the studywas related to Hg exposure and, moreover, show that this effectis reversible. These data indicate that metallic Hg can inducea reversible impairment in color perception. This suggests thatcolor vision testing should be included in studies on the earlyeffects of Hg. The possibility of applying the D-15 d as an earlyeffect index in the biological monitoring of Hg exposed workersshould also be entertained.