DALTONIANA

NEWSLETTER

OF THE INTERNATIONAL RESEARCH GROUP ON COLOUR VISION DEFICIENCIES

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THE LAST PAGE OF THIS ISSUE IS THE LAST CALL FOR PAPERS FOR THE SIXTH INTERNATIONAL IRGCVD SYMPOSIUM IN WEST-BERLIN (17th - 19th SEPTEMBER 1981)

LITERATURE SURVEY

Red-green opponent spectral sensitivity : disparity between cancellation and direct matching method, by C.R. INGLING, Ph. W. RUSSELL, M.S. REA and B.H.-P. TSOU, Science 201, No. 4362, 1221-1223, 1978.

The method for directly measuring spectral sensitivities of the colour opponent channels takes advantage of the opponency : the amount e.g. of redness at a given wavelength is measured by how much green is required to cancel it. The cancellation method necessarily desaturates the test light. To test the validity of the cancellation procedure a method was applied of estimating the amount of hue present in an equal luminance (100 trolands) test spectrum in a way that does not desaturate this spectrum, namely to match the amount of hue present by using the same primaries to make a comparison as are used for cancellation. On a 5° bipartite field, the equal-luminance spectrum on the left half, the amount of redness or greenness perceived in the test spectrum was matched by adjusting two primaries mixed on the right half. These primaries were the unique hues for the two subjects : 680 and 480 nm for the spectral region 400 to 480 nm, 480 and 520 nm for 480 to 520 nm, 520 and 580 nm for 520 to 580 nm and 580 and 680 nm for 580 to 680 nm. The brightness of the mixture was adjusted by a neutral density wedge. The amounts of the primaries were set by the subject so that their mixture appeared to contain the same amount of redness or greenness as the test side. To obtain the cancellation curve the subject added either 520 nm or 680 nm to the proper region of the 100 troland test spectrum until it was neither reddish nor greenish. The amounts of the primaries required to cancel the equal-luminance test light were converted to spectral sensitivities by multiplying them by the subjects own flicker spectral sensitivity measured at 100 td. Comparison with the direct hue-matching method shows that cancellation overestimates short wavelength sensitivity since it indicates that in the region from 400 to 480 nm there is about 3o times more redness than by the comparison method. The observation implies that different mechanisms control the perception of short-wavelength and long-wavelength redness. - Ingeborg Schmidt.

Differential thresholds of color from isomeric matching, by E. HITA and E. JIMENEZ (University of Granada, Departamento de Fisica Fundamental Granada, Spain), Atti Fond. G. Ronchi, 35, 511-526, 1980.

Some experimental data obtained from isomeric matching, with spatial and temporal fusion of the primaries, are analyzed in order to clarify the spatial distribution of the thresholds of colour discrimination. In most cases it is observed that the punctual distribution in the chromaticity thresholds differs with respect to what should be expected in a normal distribution. This seems to indicate an increase or diminution of the observer's discrimination capacity in some directions. - Lucia Rositani-Ronchi.

Global colour metrics and color-appearance systems, by T. INDOW (Keio University, Tokyo, Japan), Color, Research and Application 5/1, 5-12, 1980.

The Munsell color system has been constructed primarily on the basis of local perceptual uniformity. When it is used as a criterion for a uniform chromaticity scale, its global structure is important as well and this structure is examined. Chromatic response functions as in opponent-color theories are obtained with object colors by this method. Deviations found in Japanese observers in comparison to the Munsell notations are discussed. - Ingeborg Schmidt.

Chromatic difference steps of moderate size measured along theoretically critical axes, by R.M. BOYNTON and N. KAMBE (Center for Human Information Processing, University of California at San Diego, La Jolla, California 92093, USA), Color, Research and Application 5/1, 13-23, 1980.

When using a new method of measuring chromatic discrimination steps, the observer indicates in which direction a change has occured as well as the fact of its occurence. Tests have been made along (1) the tritan axis, where discriminations depend initially only on variations in blue-cone(B) excitations and (2) the red-green axis where discriminations depend on the substitution of red-cone(R) excitation for that of green-cones(G) or vice versa. Discrimination dependent on blue cones are affected by the level of B-cone excitation but are independent of R/G. An equation $\Delta B/B + B_o = K$ accounts well for the data. Blue cone discrimination is found to be independent of the ratio of red-to-green-cone excitation. About further details see the original paper. - Ingeborg Schmidt.

Cube-root color spaces and chromatic adaptation, by K. RICHTER (Bundesanstalt für Materialprüfung, Unter den Eichen 87, D-1000 Berlin 45, B.R.D.), Color, Research and Application 5/1, 25-43, 1980.

Absolute saturation limen as a function of luminance and angular field extent, by P.A. DAVISON (School of Optometry, Indiana University, Bloomington, Indiana). Dr. Thesis, August 1978, 113 pages.

The examination procedure consisted essentially in matching first the brightness of two halves of a circular white bipartite field in a dark surround, then introducing monochromatic light to the left half until a just perceptible difference was noticed between the two sides which could not be removed by increasing the luminance of the right half. Observation was in Maxwellian view. The subjects were 3 young males with normal visual acuity, normal color vision and normal mesopic visual functions. The conclusions from the experiments are that the psychophysically determined saturation limen for a 9°2' (wavelengths 475, 505 or 572 nm) stimulus is strongly dependent on the luminance of the white stimulus to which spectral color is added (throughout 5 to 57.000 trolands). Saturation lines for a 630 nm stimulus were substantially independent of the luminance of white light following direct brightness matching correction though increased with decreasing luminance when limens were calculated without this correction. Saturation limens decreased substantially with increasing field size (41' to 13°45') for all wavelengths (473; 503; 579 and 671 nm) at each luminance tested from upper photopic to mesopic luminances. The data suggest that saturation limens for long wavelength stimuli are not as adversely affected by reduction of either luminance or field size as are those for shorter wavelengths. Certain aspects of the effect of stimulus luminance and field size on saturation limens suggest the possible influence of rod retinal receptors on cone functioning. - Ingeborg Schmidt.

Cone threshold vs. retinal eccentricity : changes with dark adaptation, by B. DRUM (Dept. of Ophthalmology, George Washington University, Washington, D.C. 20037, USA), Invest. Ophthal. 19(4), 432-435, 1980.

Cone thresholds at 2, 5, 20 and 30° in the nasal field were measured during the period of the cone plateau of dark adaptation. Thresholds were obtained with 10' and 66' white, circular test flashes of 1 sec duration. For comparison light adapted cone thresholds were also obtained against a 37.9 cd.m^{-2} background, intense enough to eliminate rods. The results show that spatial summation increases with dark adaptation in the fovea and parafovea, but not in the periphery. Summation in the parafovea may possibly even be greater than in the fovea. - James E. Bailey.

Cone opponency in tonic ganglion cells and its variation with eccentricity in rhesus monkey retina, by E. ZRENNER and P. GOURAS (Max Planck Institute for Physiological and Clinical Research, Bad Nauheim, B.R.D. and Columbia University, New York, N.Y., USA), Invest. Ophthal. 18 (ARVO suppl.), 77, 1979.

Tonic ganglion cells (67% = 254-385 total sample) in rhesus monkey retina were classified according to their cone inputs, defined by action spectra and chromatic adaptation. One group of tonic cells does and another does not receive an obvious input from short-wavelength-sensitive (B-) cones. The former is a small fraction of tonic cells (9%), almost all of which are excited by blue and inhibited by longer wavelength-sensitive cones (B-Y system); in only one (1/23) the sign of interaction was reversed. The strength of this cone opponency is strikingly similar from cell to cell. The latter is a much larger and more heterogeneous group of tonic cells, most of which show opponnency between long (R) and middle (G) wavelength-sensitive cones (R-G system). The strength of this opponency varies considerably, even among neighboring cells. We have scaled this from 1 (strong G dominance) to 5 (strong R dominance). The entire range occurs in each retinal area. In the fovea there is an approximately equal balance of R-G opponency-average dominance index, 2.8 $\pm$ 0.19 (SEM). Perifoveally this index shifts progressively ($p < 0.001$) toward R dominance-average index, 3.4 $\pm$ 0.12 (SEM) at 12° eccentricity. Thus, cone opponency in the R-G system varies regularly with retinal eccentricity, R cones becoming increasingly dominant toward the retinal periphery. A fraction (20%) of tonic ganglion cells does not show cone opponency, perhaps representing extremes in the scale. It is not yet clear whether they reflect the action (center and surround) of only one cone mechanism, either R or G, which would put them in a class of cells not yet reported in primate retina. - The Authors.

Modulation of blue cone signals by long-wavelength sensitive cones in primate retina, by E. ZRENNER and P. GOURAS, (MPI für physiol. und klin. Forschung, Bad Nauheim and Columbia Univ., New York), Pflügers Arch. Suppl. to 382, R 47, 1979.

About 5% of ganglion cells in macaque retina are excited by blue and inhibited by longer wavelength sensitive cones. In darkness or on neutral backgrounds, such cells continuously discharge but respond weakly to even strong blue light; yellow or red backgrounds eliminate their steady discharge and considerably increase their responsiveness to blue light. Termination of such long-wavelength backgrounds produces a strong off-discharge during which the cell becomes unresponsive to blue light, a refractoriness not due to saturation of the impulse frequency capacity of the cell. This phenomenon is probably responsible for human transient tritanopia, observed after the offset of yellow light.

We suggest the following explanation. The blue cone can be activated (hyperpolarized) either by light (decreasing Na^+ permeability) or by a long-wavelength sensitive hozizontal cell (its depolarization releases a permeability increasing transmitter, probably for K^+). Long-wavelength backgrounds hyperpolarize the horizontal cell which leads to closure of K^+ channels in the blue cone. This decreases the maintained activity of the ganglion cell but enhances the blue cone's response to light, i.e. closing Na^+ channels by light has more effect on the blue cone when K^+ conductance is low. Termination of the long-wavelength adapting light causes a rebound depolarization of long-wavelength cones which depolarizes the horizontal cell which in turn hyperpolarizes the blue cone by opening K^+ channels. This produces an off-discharge in the ganglion cell and makes the blue cone unresponsive to light, i.e. closing Na^+ channels by light has less effect on blue cones when K^+ conductance is high. Thus the color opponent horizontal cell loop would modulate the sensitivity of blue cones by controlling the ratio between Na^+ and K^+ conductances. This can act to enhance the blue cone's response to color contrast as well as to produce transient tritanopia. - The Authors.

Center and surround mechanisms of opponent-color X and Y ganglion cells of retina of macaques, by F.M. de MONASTERIO (Laboratory of Vision Research, National Eye Institute, National Institutes of Health, Bethesda, Maryland, 20014, USA), J. Neurophysiol. 41, 6, 1418-1434, 1978.

Color-sensitive hypercomplex cells in monkey striate cortex, by Ch. R. MICHAEL (Department of Physiology, Yale University School of Medicine, New Haven, Conn. 06510, USA), J. Neurophysiol. 42/3, 726-744, 1979.

The author recorded with tungsten electrodes from single cells in the foveal and parafoveal representation of the rhesus monkey's visual cortex. The hypercomplex cells in the striate cortex respond only to movement either of a specifically oriented monochromatic bar or an edge of light of limited length. The receptive fields consist of an orientation-sensitive central activating area flanked on either side by orientation-sensitive silent antagonistic regions, the activating area and the two flanks of a given cell having the same spectral sensitivity and the same axis orientation. All hypercomplex cells received inputs from red- and green-sensitive cones with peaks at 580 and 540 nm respectively; none was connected with blue-sensitive cones or with rods. The color-sensitive complex units most likely synapse on these hypercomplex units. They represent the fourth stage in the cortical integration of color. - Ingeborg Schmidt.

Spectral selectivity of cells and its dependence on slit lenght in monkey visual cortex, by J. KRÜGER and P. GOURAS Neurologische Universitätsklinik Freiburg i.Br., B.R.D. and Columbia University College of Physicians and Surgeons, Eye Research Division, New York City 10032, USA), Journal of Neurophysiology 43/4, 1055-1069, 1980.

The corneas of anesthetized rhesus monkeys (Macaca mulatta) were covered with zero-power contact lenses, the eyes corrected with appropriate lenses in order to focus the retinas on a rear-projection screen 1.8m away. Three mm artificial pupils were used. A circular piece of bone 1cm in diameter and the underlying dura were removed over the lateral tip of the lunate sulcus, usually on the left side. Responses from single cells, but occasionally from several cells, in the foveal visual cortex (areas 17,18 and V4) were recorded using glass pipette microelectrodes with a 4M sodium chloride solution. The responses were quantitatively measured when stimulating by four slow moving colored (red, yellow, green and blue) slits of approximately equal luminances, separated by 1.75 or 3.5°. The spectral selectivity of most cells in all visual areas studied depended on slit length. Increasing slit length increased the effectiveness of light from the extremes of the visible spectrum (red and blue) relative to light from the middle of the spectrum (yellow, including white). Consequently, increasing stimulus size changes the spectral bandwith and increases the range of spectral differences among cells, subserving the same area of visual space. Using stimuli of similar dimensions, the spectral selectivities of cells in these areas of visual cortex are qualitatively similar, implying that color alone is not the feature that distinguishes them. - Ingeborg Schmidt.

Assessment of the visual acuity of human color mechanisms with the visually evoked cortical potential, by R.L. KLINGAMAN and A. MOSKOWITZ-COOK (Dept. of Ophthal., Univ. of Illinois Eye and Ear Infirmary, 1855 W. Taylor St., Chicago, Ill. 60612, USA), Invest. Ophthal. 18(12), 1273-1277, 1979.

The method of the visually evoked cortical potential (VECP) is used to measure the visual acuity of the blue and red-green color mechanisms isolated by selective chromatic adaptation. Checkerboard acuity for the blue mechanism is 7 minutes and that of the red-green is 0.7 minutes. The blue mechanism also showed a longer response latency. These spatial and temporal differences agree with the results of psychophysical experiments with similar stimulus conditions. - James E. Bailey.

MFT of the defocused optical system of the human eye for incoherent monochromatic light, by L.J. BOUR (State University of Utrecht, Department of Medical and Physiological physics, Princetonplein 5, 3584 CC Utrecht, The Netherlands), J. opt. Soc. Amer. 70/3, 321-328, 1980.

The method used to measure the modulation transfer function (MTF) of the defocused optical system of the human eye for incoherent monochromatic light (514 nm) and for various pupil diameters was the one applied by E.W. Campbell and D.G. Green (J. Physiol. 181, 576-593, 1965) and by A. Arnulf and O. Dupuy (C.R. Acad. Sci. 250, 2757-2760, 1960). With their subjective method the contrast degradation of the human eye was measured for defocused incoherent polychromatic sine-wave targets for different spatial frequencies and a single pupil diameter. The conclusions from the experiments are as follows : for the lower spatial frequencies (= 10cpd) and all pupil sizes up to 5mm the optical system of the eye suffers from a small amount of spherical aberration. At higher spatial frequencies and all measured pupil sizes the quality of the eye will be determined by irregular and axial asymmetric monochromatic aberrations. There is strong indication that the human crystalline lens has a segmented character resulting in more than one focus for the larger pupil sizes (≥ 3mm). In poly chromatic light this leads to a broadening of the depth of focus. Monochromatic MTF's are generally no better than MTF's in white light. - Ingeborg Schmidt.

Spectral sensitivity function measured by a rapid scan flicker photometric procedure, by R.K. KAISER (Dept. of Psych., York University, Downsview, Ontario, M3J 1P3, Canada), Invest. Ophthal. 18(12), 1264-1272, 1979.

von Bekesy's tracking method of audiometry is adapted to measurements of the flicker photometric luminosity curve. The results compare favorably with curves obtained with slower conventional methods. The speed of obtaining results with this method removes a major obstacle for consideration of spectral sensitivity measurements to evaluate pathological conditions in a clinical setting. - James E. Bailey.

A century of pseudoisochromatic plates, by S.P. TAYLOR (Department of Optometry, UWIST, Cardiff, U.K.), Atti Fond. G. Ronchi, 35, 323-332, 1980.

After an historical survey of the attempts to understand the mechanisms of faulty colour discrimination, pseudoisochromatic plates are described and analyzed in detail. The conclusion is drawn that such tools have a valuable place in colour vision testing. Little has changed regarding their design since the early days of the Stilling plates, but the theoretical understanding of the fundamental principles has improved with the continuing understanding of colour perception. It would seem that

Restoration of color perception after deadapting flashes, by V.I. SHOSTAK and V.V. KOLBANOW (Translation from Kosmicheskaya biologiya i aviakosmicheskaya meditsina, Moscow, No. 2, pp. 61-63, 1979) Space biology and aerospace medicine No. 2, 84-87, 1979. (National Technical Information Service U.S. Department of Commerce, Springfield Va. 22161, USA).

Impairment of color perception by intense photic stimuli and quantitative characteristics of restoration of colour perception were studied on 10 subjects, 21 to 34 years of age. An IFK-120 pulsed lamp generated the deadapting flashes of 2 ms which appeared on a completely dark background. An ADM adaptometer was used to examine the recovery of colour perception. The size of the test object was 1°. Observation was in central fixation. Distortion of color perception e.g. perception of a white test object as being pink, orange and less frequently, yellow was observed rather distinctly with maximum intensity of flashes at 2.56×10^{-4} cal/cm^2, at 106°, and was insignificant at 0.77×10^{-4} cal/cm^2. Curves of recovery of red, green and blue sensitivity are shown. If the recovery curves are smoothed according to their final level, then it becomes apparent that red sensitivity decreases least and is restored fastest and blue sensitivity restored slowest. This confirms a previously expounded hypothesis that the color receptor for red is most resistant. - Ingeborg Schmidt.

Colour vision, by R. HERTZBERG, Australian J. Ophthal. 7/3, 232, 1979.

A short survey on color vision and color deficiency stimulated by the publication of the Standard Pseudoisochromatic Plates by H. Ichikawa (Igaku Shoin, New York 1978) (see also Daltoniana Nr. 38, p. 9). - Ingeborg Schmidt.

Some abstracts from the SYMPOSIUM ON DAYLIGHT, organized by the CIE (Berlin-West, July 9-10, 1980)

STANDARDIZATION OF DAYLIGHT AND ITS APPLICATION FOR COLORIMETRY, by D. Gundlach (Germany).

Sunlight and daylight are important light sources for colorimetry and colour matching. But natural light sources are changing their spectral power distribution and correlated colour temperature in dependence on time of day, year and weather. Therefore in 1964 the CIE defined spectral power distributions of typical daylight as a function of correlated colour temperature between 4000 K, which means yellowish sunlight and 25000 K, corresponding to radiation of a clear blue sky incident to the ground. These spectral distributions are called phases of daylight "D". The one with a correlated colour temperature of 6500 K is the standard illuminant D 65. It is needed for colorimetry of luminescent materials, like daylight fluorescent colours and brightening agents. However, there are no artifical radiation sources available which match directly with the spectral distribution of D 65. Until now the most promising basic source is the high-pressure xenon arc lamp. We modified its spectral distribution by expensive filtering. Standard illuminant D 65, as tabulated today, should be revised by the CIE as soon as possible. On the one hand, we need a smoother distribution for easier filtering of xenon lamps. On the other, the content of UV-radiation with standard illuminant D-65 is too low and the spectral power distribution above 830 nm, which can cause quenching effects to luminescent materials, is not defined. A proposal for a more realistic distribution for colorimetric purposes will be submitted.

VISUAL PERFORMANCE WHEN DAYLIGHT BECOMES INSUFFICIENT, by L.R. Ronchi, A. Serra and G. Passigli (Italy).

The criteria adopted to assess when daylight is no longer sufficient are traditionally based on contrast sensitivity and/or visual acuity. From the ergonomical point of view, however, it seems worthwhile to take into account the visual performance as a whole.

After a review of data taken from the available literature, we describe some results obtained by us during the course of an experiment dealing with colour discrimination (F-M 100 Hue Test) and refraction (Badal Optometer) for both far and near points. The appearance of a tritan-like defect (related to spatial vision through Liebman effect), when passing from photopic to mesopic vision, is found to be related to incoming twilight myopia and presbyopia. The level at which the said deterioration of visual performance starts to occur, is found to depend on the age of the subject. The occurence of "visual twilight" is thus quantified. In addition, visual effects due to the specular spectral distribution of daylight during sunset are described and compared with visual performance recorded under decreasing illuminance for a set of commercially available light sources. - Collected by Lucia Rositani-Ronchi.

Some abstracts from the

THIRD EUROPEAN CONFERENCE ON VISUAL PERCEPTION

(University of Sussex, Brighton, England, September 3-6, 1980)

BICUCULLINE (A GABA-ANTAGONIST) ACTS DIFFERENTLY ON SPECTRALLY DIFFERENT CONE MECHANISMS
R. Schuurmans and E. Zrenner (Max-Planck-Institute for Physiol. and Clin. Research, Bad Nauheim, F.R.G.).

In the arterially perfused cat eye and under photopic conditions, summed action potentials of the optic nerve (ONR) reveal two clearly distinct types of cone responses : A slow, predominantly tonic one which has flat V-log I functions, lacks a positive off-effect and shows a peak sensitivity near 460 nm; it can be easily differentiated from a fast phasic one, which has steep V-log I functions, a distinct off-response and originates from longer wavelength-sensitive receptors which have a peak sensitivity at 510 and 560 nm. The 460 nm-cone mechanism exhibits two paradoxical phenomena : A gradual *increase* of its sensitivity (sensitization) after the *onset* and a transient sensitivity *decrease* (desensitization) after the offset of a yellow adapting light. The latter phenomenon might be an electrophysiological correlate of transient tritanopia (Mollon and Polden, 1977). The sensitivity of the 460 nm-cone mechanism is probably controlled by the longer wavelength sensitive cones which might modulate the horizontal cells' transmitter release (Zrenner and Gouras, 1979). Horizontal cells take up ^{3}H-GABA, known to act as a neurotransmitter (Graham, 1974). Addition of 1-2µM bicuculline to the perfusion medium resulted in a loss of the transient desensitization of the 460 nm-cone mechanism after the offset, but did not affect its sensitization during the onset of the adapting light. These results indicate that GABA might be involved in a neuronal circuitry which modulates the short wavelength cone's sensitivity through the action of longer wavelength sensitive cones, differently however, for the sensitization and desensitization of the 460 nm-cone mechanism.

IS π_5 A UNITARY MECHANISM?, by A. Reeves (Institut für Arbeitsphysiologie, Postfach 1508, D-4600 Dortmund 1, BRD.

Much recent evidence suggests that it is (Sigel and Pugh, JOSA 70, 71-81). However, Sternhiem et al (Vis. Res. 17, 45-49) showed that the threshold of a red test may rise by 0.4 log units just after a green background has been substituted for a red background, when the intensities of the backgrounds were equated for their effects on the steady-state threshold of the same red test. They concluded that the "long wavelength photopic mechanism", shown to be similar to π_5, was not a unitary mechanism. Possibly the dynamic alteration generated by substituting one background for another provides a more sensitive test of the hypothesis that π_5 is a unitary mechanism than to the steady-state tests undertaken by Sigel and Pugh. Present research shows, however, that 1) substitution has no effect on the threshold of a tiny, brief test (20 msec, 24 min arc); and 2) substitution only raises the threshold of a large, longerlasting test (200 msec, 30) when background intensity is high enough for detection to be mediated by π_5'. These results confirm Pugh's claim that π_5 is a unitary mechanism, but that π_5, is not.

IMPOSED MOVEMENTS TO PERCEIVE COLOUR WITH A STABILIZED RETINAL IMAGE, by J.A. Foley-Fisher and R.W. Ditchburn (Dept. of Engineering, University of Reading, England).

By imposing controlled movements on a stabilized retinal image, the movements necessary for the perception of hue and saturation are being investigated. Whilst the movements required to perceive chromaticity are large compared with those required to perceive only luminance differences, the variation of movement needed for different hues is usually small. Results of experiments will be given in which step and pulsed movements have been used. The pulse movements show that both temporal and spatial integration occurs and that, within certain limits, the product of displacement and time is constant at the detection threshold of hue.

POST-RECEPTORAL COLOUR VISION MECHANISMS IN NORMAL AND DEFECTIVE COLOUR VISION, by I. Hendricks, K.H. Ruddock and V.A. Waterfield (Departments of Physics and Zoology, Imperial College, London, U.K.).

A new method for the determination of post-receptoral colour vision mechanisms in human vision has been described briefly by Ruddock and Waterfield (1980). This method relies on the inhibitory inter-ocular interaction which occurs when each eye is adapted simultaneously to a different spatial structure. If both adaptation patterns are one-dimensional gratings, the inhibitory interaction is not wavelength-selective, but if one of the patterns is a two-dimensional spot matrix, the effect is markedly dependent on the matrix wavelength. The nature of this wavelength selectivity depends on the geometry of the matrix and, by suitable choice of matrix pattern, three different spectral mechanisms have been revealed. In the poster, data for three normal subjects and for a number of subjects with red-green congenital colour vision defects are displayed. The spectral sensitivity functions derived for the normal subjects are shown to be similar to those described in studies of primate apes and the mechanisms responsible for the generation of these responses are discussed. The modification of the normal spectral mechanisms in congenital red-green colour vision defects is examined in terms of current analyses of these defects.

EVIDENCE THAT OPTIC NERVE PATHOLOGY MAY BE ASSOCIATED WITH A LOSS OF TONIC GANGLION CELLS, by S.L. Alvarez, P.E. King-Smith, S.K. Bhargava, L. Burnett, F. Zisman and J.G. Rosten (Ophthalmic Optics Dept. UMIST, Manchester Royal Eye Hospital, Oxford Road, Manchester, England).

Electrophysiological experiments in rhesus monkey retina have demonstrated two categories of ganglion cell, Gouras, 1968; non colour-opponent phasic cells with fast conduction velocity and large receptive fields v. tonic colour-opponent cells with relatively slow conduction velocity and smaller receptive fields. The fast conducting phasic cells may be presumed to have larger diameter axons. Here we review earlier and recent evidence that optic nerve pathology can involve selective damage to the small axons of tonic cells. The characteristic psychophysical changes include poor colour discrimination, a reduction in acuity and in contrast sensitivity at high spatial frequencies, and a replacement of the normal three peaks of spectral sensitivity on a white background by a single peak near 555 nm, similar to that in phasic cells. Foveal fixation and sensitivity to high frequency flicker are usually normal. The ERG shows no retinal malfunction. Cases include retrobulbar neuritis and demyelinating diseases, tobacco amblyopia, optic atrophy associated with diabetes (DIDMOAD syndrome), and five members of a family with hereditary optic atrophy. Damage to the small tonic fibres or neurons may be the focus of these optic nerve pathologies.

BEHAVIORAL STUDIES OF STIMULUS DEPRIVATION AMBLYOPIA IN MONKEYS, by R.S. Harwerth, M.L.J. Crawford, E.L. Smith and Roger L. Boltz (University of Houston and University of Texas, Houston, Texas, USA).

Contrast sensitivity and increment-threshold data have been studied for three rhesus monkeys with stimulus deprivation amblyopia. The monkeys right eyelids had been sutured at age 1 month for periods of two weeks, 19 months and 23 months. The refractive errors of the previously sutured eyes were larger than those of the unsutured eyes with the deprived eye of the monkey sutured for 19 months being more myopic and the deprived eyes of the other two monkeys more hyperopic. Contrast sensitivity functions were determined for all three monkeys and showed greatly reduced visual function with a high spatial frequency cut-off 5 octaves lower in the deprived than nondeprived eyes. The increment-threshold data were collected for the two long-term lid sutured monkeys. The spectral sensitivity data for the deprived eye were well fit by the scotopic luminosity curves for adapting field luminances of zero, 188, 750 and 3000 trolands, while the nondeprived eye showed normal photopic function for all the three light adapted conditions. However, even with complete dark adaptation, the sensitivity for the deprived eye was approximately 4 log units lower than the nondeprived eye. The increment threshold function for achromatic stimuli showed normal rod-cone functions in the nondeprived eye, but was a monotonic function for the deprived eye over a 1.9 log unit range of background luminances. Spectral sensitivity measurements in the presence of intense blue backgrounds showed functions that were best described as showing scotopic function over the short wavelengths and photopic function at longer wavelengths. Therefore, the results of these experiments show that stimulus deprivation causes profound defects for visual resolution, rod saturation and the rate of change of sensitivity with light adaptation.

PHOTOPIC AND SCOTOPIC FLICKER SENSITIVITY OF A ROD MONOCHROMAT, by D.C. Skottun (Neurobiological Laboratory, University of Trondheim, Norway), K. Nordby and S. Magnussen (Institute of Psychology, University of Oslo, Norway).

The sensitivity to sine wave flicker of a rod monochromat was compared to that of a control at photopic (38 cd/m^2 ph. = 102 cd/m^2 sc.) and scotopic (3.9×10^{-5} cd/m^2 sc.) levels of luminance. The sensitivity of the rod monochromat in the low frequency region (below 3 Hz at scotopic and below 12-14 Hz at photopic levels) was found to be superior to that of the control. This superiority was most pronounced at photopic levels, where the monochromat frequently showed a two-peak sensitivity curve.

FLICKER FUSION EXPERIMENTS AND HUMAN VISION MECHANISM, by C.W. Burckhardt and V. Van Toi (Institut de Microtechnique de l'EPF, Lausanne, Switzerland).

In agreement with Kelly (1962), using a sinusoidal waveform timulus and a 60° field size, we found that when 3 channels Red, Green and Blue sensitive of the color vision mechanism are excited together, the sensitive characteristic (De Lange curve) has 3 peaks at 20, 10 and 5 Hz. By using a spectral compensation method developed by Estévez and Spekrijse (1974) for isolating each channel of the color vision mechanism, we found that the De Lange curve of the blue sensitive channel has a peak at 18 Hz and the De Lange curve of the red channel had a peak at 22 Hz. It appears that the peak which characterizes one channel moves when another channel is excited too. This phenomenon may be explained by a resonance mechanism which is probably controlled by the lateral inhibition mechanism, so that the resonance frequencies of the green and blue sensitive channel are the harmonic frequencies of the red sensitive channel frequency. A theoretical model of the retina is presented to sum op these experimental results and these reflections.

A CASE OF ACQUIRED UNILATERAL ACHROMATISM, by S.P. Taylor and J.M. Woodhouse (Optometry, UWIST, Cardiff.).

Studies have been carried out with a patient who has no apparent colour vision, and who experiences difficulties in form perception, in her aphakic eye, despite a corrected acuity of 6/9. We hope to describe her perceptual problems in terms of colour responses and contrast sensitivity measures. Since the defect is unilateral this case allows immediate comparison of normal and abnormal responses and may be useful in providing further insight into normal colour and form processes.

A PROTANOMALOUS COLOUR SPACE, by E. Wolf and H. Scheibner
(Physiologisches Institut II, Universität Düsseldorf, 4000 Düsseldorf, B.R.D.).

The blind fundamentals of the three types of dichromats are usually regarded as being the basic sensations in colour vision of normal trichromats. In normal trichromatic colour space these blind fundamentals specify three distinct base vectors (fundamental primaries) with the property that spectral tristimulus values associated with a particular fundamental primary can be compared with the spectral absorption curves of the corresponding cone pigment. No equivalent description of anomalous trichromatic colour systems is available. Taking protanomaly as an example, we show how the fundamental primaries can be defined within a protanomalous colour space and determined experimentally. The results indicate that the red fundamental is nearly the same blind fundamental of a protanopic observer, but the green fundamental is changed. The blue fundamental is shown to lie within a restricted region in colour space which includes the location of that of normal trichromats. Knowledge of these primaries permits calculation of the fundamental tristimulus functions of the anomalous observer from his own measured colour matching functions. The calculated red tristimulus function is shifted considerably towards shorter wavelengths, while the calculated green functions are not significantly different from those of normal trichromats. This result leads support to the single-shift hypothesis of anomalous trichromacy. There still remains the fact that protanopes do not accept protanomalous matches. This will be explained with reference to the individual isolychnes of these types of observers.

Collected by G. Verriest.

Last call for papers!

SIXTH INT. SYMPOSIUM OF THE INTERNATIONAL RESEARCH GROUP ON COLOUR VISION DEFICIENCIES

(WEST)BERLIN-STEGLITZ, 17th - 19th SEPTEMBER 1981
just before the AIC-Congress COLOR 81 in Berlin

PRELIMINARY INSCRIPTION FORM

(to be detached from one of the 1980 issues of Daltoniana and to be returned before 1st february 1981 to Dr. G. VERRIEST, Dienst Oogheelkunde, Akademisch Ziekenhuis, De Pintelaan 135, B-9000 Ghent, Belgium).

The special themes of this symposium will be :
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3. Pathology of the higher optic centers and colour vision
4. Why is the blue mechanism more liable to acquired damage?

Free papers will be accepted (methods of examination of central and peripheral colour vision, congenital and acquired defects, genetics of colour vision, practical aspects etc.)

The (principal) authors have to be members of the IRGCVD and are asked :
a) to send before 1st April 1981 two copies of a summary of at most 200 words to Dr. G. VERRIEST;
b) to insert for their oral presentation slides with (English) text intended to render the subject more understandable for the non-English-speaking people;
c) to remit before the end of the symposium the manuscript (in good english) to be printed in the Proceedings.

PAPER

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THEME 1
2
3
4
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