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www.icvs.info No. 118 July 2021

ICVS Officers

50-Year Anniversary of ICVS

This summer marks the 50th anniversary of the first meeting of our Society, which was originally named the International Research Group on Colour Vision Deficiencies (IRGCVD). Held in Ghent, in June of 1971, the meeting was attended by at least 70 scientists and clinicians from 16 countries and 3 continents. The Proceedings volume was published the following year by Karger in the series, *Modern Problems in Ophthalmology*. The 35 papers were mostly concerned with congenital and acquired deficiencies of colour vision, clinical screening tests for disease and occupational diagnosis, and genetics. Papers were presented by Yves le Grand, Wolfgang Jaeger, Ronnie Lakowski (see p. 7), Marion and Ernst Marré, Y. Ohta, R.W. Pickford, A.J.L.G. Pinckers, André Dubois-Poulsen, M. Catherine Rittler, Keith Ruddock, Louise Sloan, Lucia Ronchi, Guy Verriest, and W.D. Wright, among others. Current Society member, Jack Moreland, one of our longest-standing current members, presented a paper on "The effect of inert ocular pigments on anomaloscope matches". Jennifer Birch recalls that the meeting was followed by an excursion to a nearby castle and a banquet.

A review of the Proceedings by William Rushton (*Nature*, 1972) concluded that "If the reader has the time and the analytical invention himself to engage in the 'still very mysterious' domain of acquired dyschromatopsia, and will wrest from that confusion some insight into the organization of colour vision, this book describes a great variety of conditions, and may well suggest to the perceptive some promising points of attack" (p. 169).

As the IRGCVD expanded to encompass a larger and more scientifically diverse membership, the name of our Society became the International Colour Vision Society in 1997. Yet, the traditions of our Society have not changed from the description provided by J. François in his opening address to the IRGCVD 50 years ago: "The scientific discussions, which will be conducted by international experts, as well as the human contacts made during this meeting will consolidate and enlarge the ties of friendship between scientists of different countries for the greatest benefit of science, humanity and peace".

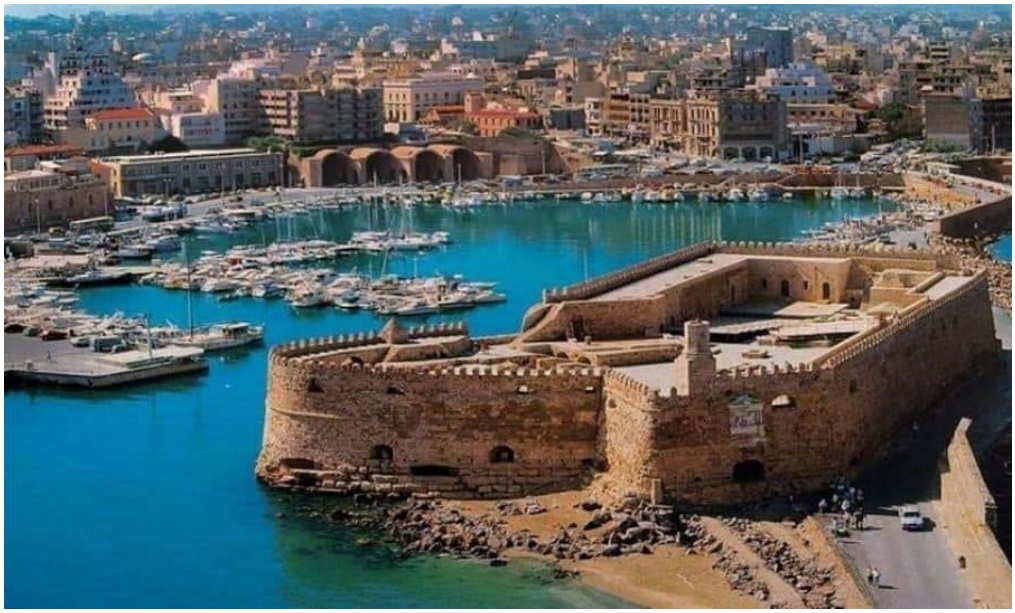
Contents

ICVS 2022 – Crete (Friday, 1 July – Tuesday, 5 July)

After a 1-year delay due to the COVID-19 pandemic, we are pleased to announce that the **26th ICVS Symposium** will be held in Heraklion, Greece, from July 1st to 5th, 2022.

Heraklion is the 4th largest city in Greece and the largest city on the island of Crete, with a population of approximately 200,000. Crete itself is the largest Greek island and the 5th largest island in the Mediterranean Sea, both in population and in area.

Heraklion and Crete have a rich history spanning more than nine millennia. Crete was first inhabited in 7000 BC, and the Minoan civilization appeared in 2200 BC. Knossos is where the Minoans settled, and it is located just 6 km south of Heraklion. It served as its main port and was destroyed by a volcanic tsunami from Santorini. The Knossos palace is the second most visited archeological site in Greece, behind only the Acropolis and Parthenon in Athens. The Disk of Phaistos, a collection of stamped symbols that still await to be deciphered, was found in Phaistos, the second palace of King Minos, located 50 km southwest of Heraklion. The Disk can be viewed in the Archeological Museum of Heraklion that carries prehistoric, neolithic, and later artifacts.



The present city of Heraklion was founded in 824 during the Arab period that was followed by the Byzantine occupation. The Venetians bought the city in 1204 and built an enormous fortification to protect it from the pirates. The fortification is the best preserved around the Mediterranean Sea, and can be seen and enjoyed today, as it is largely intact. The fortress "Roca a Mare" used to protect the harbor and today the Cretans call it "Koule." The Ottomans besieged the city for 21 years, from 1648 to 1669, and occupied it until 1898, when the Great Powers created the Cretan State, and Heraklion became part of the British zone. With the rest of Crete, Heraklion was annexed to Greece in 1913 and became the capital of Crete in 1971, replacing Chania, the second-largest city on the island. Heraklion was the hometown of painter El Greco (or Domenikos Theotokopoulos), novelist Nikos Kazantzakis who wrote *Zorba the Greek*, and poet Odysseas Elytis, a Nobel prize winner.

Today, Heraklion is a modern city with its long history on display, wherever one looks. Apart from several museums, Heraklion hosts two universities (the University of Crete and the Mediterranean University) and the Foundation for Research and Technology - Hellas, which all attract a young population making Heraklion a lively and buzzing city.

Photos of Heraklion, Sotiris Plainis

Call for Papers

Abstracts for either a paper or poster presentation on any aspect of colour vision are invited. Topics of interest include, but are not restricted, to any of the following:

Acquired deficiencies of colour vision
Chromatic mechanisms
Colour cognition
Colour in occupational environments
Colour induction and constancy

Colour in mesopic conditions
Colour naming
Colour vision assessment
Comparative colour vision
Congenital colour vision deficiencies
Digital reproduction of colour information
Ecology of colour vision
Effects of aging on colour vision
Electrophysiology of colour processing
Functional imaging and colour vision
Genetics of colour vision
Object-surface properties, material perception
Peripheral colour vision
Physiology of colour vision
Unique hues
Variability in colour vision

Travelling to Heraklion

Heraklion has an international airport (Nikos Kazantzakis, HER) and a port. More than 60 airlines connect Heraklion with major European cities. There are also several domestic flights to and from Athens and other Greek cities and islands. Therefore, one could fly to Heraklion directly or fly to Athens (AIA) and take a short connecting flight to Heraklion. The airport is located just 3 Km east of the city center.

Several ferries connect Heraklion with Athens daily (at the port of Pireus) or other islands, mainly in the Cyclades, like Santorini, Paros, and Mykonos. One could fly to Athens and then take a ferry to Heraklion. The port is within walking distance from the city center.

Conference Website

The conference website is www.icvs2022.org and will be regularly updated with details about important dates, abstract submission, registration, etc.

Social program

The social program will include:

- Welcome reception on Friday, July 1st, 2022.
- Half-day excursion on Sunday, July 3rd, 2022.
- Banquet on Monday, July 4th, 2022.

A social program for accompanying persons will also be organized for the days and times when the scientific program runs.

Important Dates (subject to change)

January 10th, 2022: Abstract Submission and Early Registration Opens

March 15th, 2022: Abstract Submission Deadline (There will be no deadline extension.)

April 15th, 2022: Abstract Acceptance and Student Award Notification

May 1st, 2022: Early Registration Ends

June 1st, 2022: Late Registration Ends

June 2nd - 20th, 2022: Conference Only Registration (*i.e.*, the registration will include access to the conference, coffee breaks, and two lunches, but not the welcome reception, excursion, and banquet)

July 1st - 5th, 2022: Symposium!

Organizing Committee

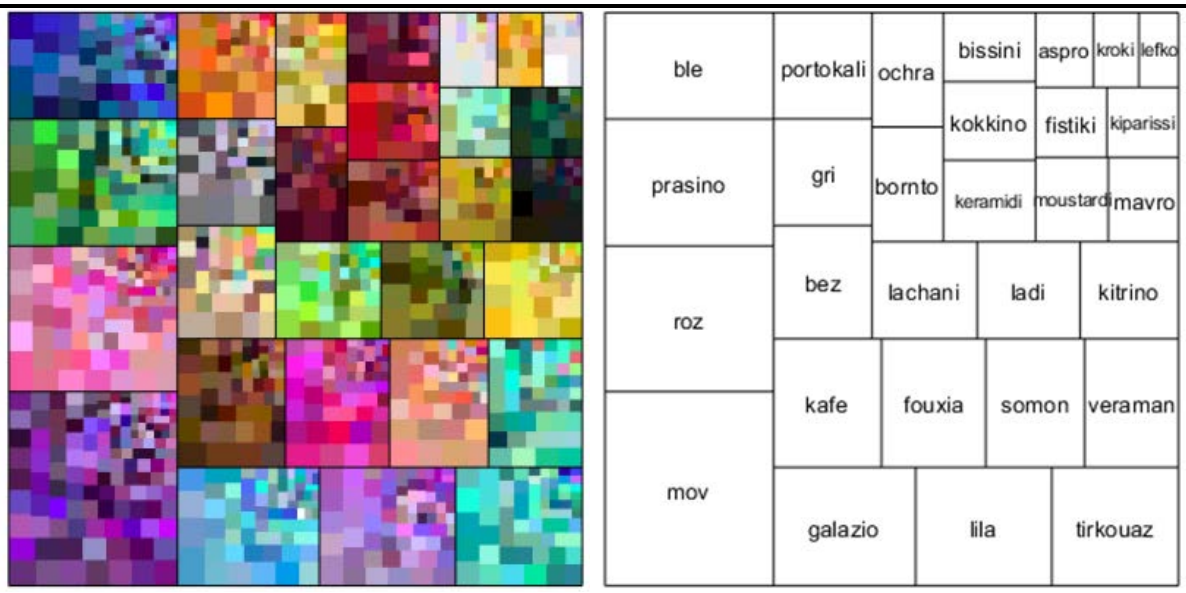
Maria Makridaki, Ph.D., Foundation for Research and Technology Hellas, GR
Dimitris Mylonas, Ph.D., University College London & Goldsmiths, University of London, UK
Thanasis Panorgias, Ph.D., New England College of Optometry, USA
Neil Parry, Ph.D., Manchester Royal Eye Hospital, University of Manchester, UK
Sotiris Plainis, Ph.D., University of Crete, GR
John S. Werner, Ph.D., University of California Davis, USA

Scientific Committee

Claudia Feitosa-Santana, Ph.D., Neuroscience for Human Development, Brazil
Jasna Martinovic, Ph.D., University of Aberdeen, UK
Maureen Neitz, Ph.D., University of Washington, USA
Thanasis Panorgias, Ph.D., New England College of Optometry, USA
Miltiadis Tsilibaris, MD, University of Crete, Greece
Michael Webster, Ph.D., University of Nevada Reno, US

Colours that Sound all Greek to Us!

The same colour name is given to many hues that are discriminably different. The number of these labelled colour categories is often large as that makes colour communication easier. Yet, colour names in different languages often sound all Greek to us. To communicate about colour with locals in their native language during the 26th ICVS meeting in Crete, 2022, we need a mapping method between their linguistic and perceptual aspects of colour. You can see below a treemap of common colour terms in Greek scaled by their frequency in an ongoing crowdsourcing colour naming experiment. It is immediately clear that not all colour names share the same status, e.g., some categories are larger than others.



Treemap associated with the size of Greek colour categories in a crowdsourcing colour naming experiment: (left) colour samples of each colour name; (right) Romanised colour names (Mylonas, Koliousis & Uusküla, AIC 2021).

Explanations for the development of colour naming systems often give a special fundamental status to a subset of primary colour categories In a short treatise, Aristotle suggested that five pure colours - *crimson*, *green*, *cyan*, *purple* and possibly *yellow* – arise from the mixture of *white* and *black* and from these categories all the other impure or irregular colours are generated. Aristotle justified this reduction into seven rational categories to simple numerical ratios and offered an analogy with music concords:

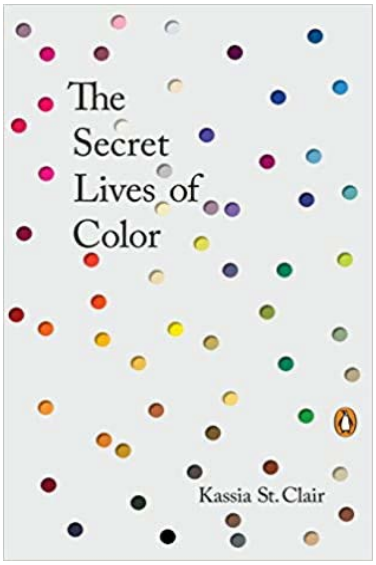
> *"...we may regard all these colours as analogous to the sounds that enter into music, and suppose that those involving simple numerical ratios, like the concords in music, may be those generally regarded as most agreeable; as, for example, purple, crimson, and some few such colours, their fewness being due to the same causes which render the concords few."* (Aristotle 350 BC / trans. by Beare, 2000)

This comparison of abstract colours with the octave division of pitch might have influenced Isaac Newton (1730) in one of the greatest works in the history of colour vision to name initially five principal colours in the spectrum – *red*, *yellow*, *green*, *blue* and *violet* – and subsequenly seven, by adding *orange* and *indigo*. Why Newton named two principally bluish colours similarly to the modern two bluish (*ble* and *galazio*) basic colour terms in Greek, while, in modern English, we have a unitary basic *blue* category, remains an enigma. In the meantime, we can start preparing our abstract for ICVS 2022 in Crete and practise our Greek colour names using Colournamer, a voice web application currently speaking seven colour languages (available at: https://colournaming.org).

Dimitris Mylonas

Dimitris Mylonas is Assistant Professor in Computer Science at New College of the Humanities London at Northeastern University. He is committee member of the Colour Group (GB), Chair of the Study Group on the Language of Colour of the AIC, member of the ICVS and co-organiser of the 26th ICVS meeting in Crete, 2022. His research focuses on the intersection of perceptual, cognitive and linguistic aspects of colour.

Recent Books on Colour



The Secret Lives of Color

Kassia St. Clair

Penguin Books

Oct 24, 2017 | 320 Pages | 5-5/16 x 8-1/2| ISBN 9780143131144

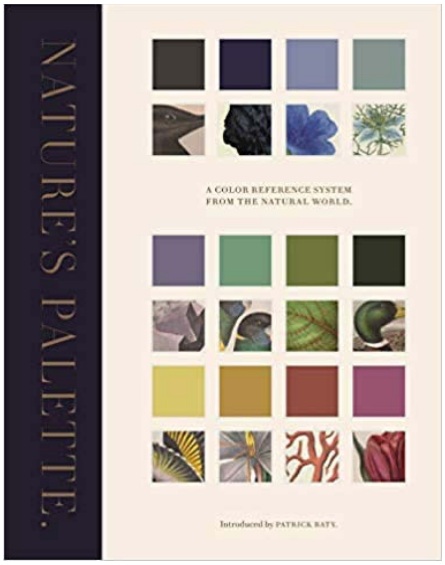
From the Publisher: The Secret Lives of Color tells the unusual stories of seventy-five fascinating shades, dyes, and hues. From blonde to ginger, the brown that changed the way battles were fought to the white that protected against the plague, Picasso's blue period to the charcoal on the cave walls at Lascaux, acid yellow to kelly green, and from scarlet women to imperial purple, these surprising stories run like a bright thread throughout history.

In this book, Kassia St. Clair has turned her lifelong obsession with colors and where they come from (whether Van Gogh's chrome yellow sunflowers or punk's fluorescent pink) into a unique study of human civilization. Across fashion and politics, art and war, the secret lives of color tell the vivid story of our culture.

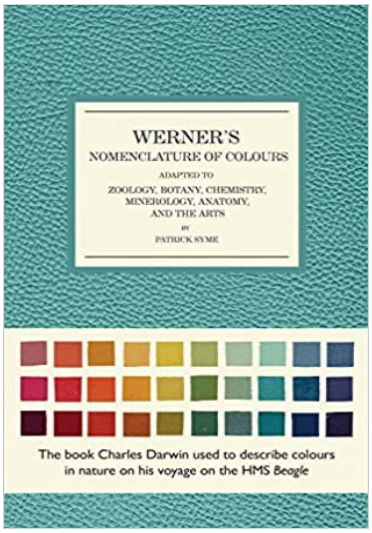
Nature's Palette: A Color Reference System from the Natural World

Patrick Baty (Author), Elaine Charwat, Peter Davidson, André Karliczek, Giulia Simonini (Contributors)

Princeton University Press., 2021, Pages:288, Size: 8.13 x 10.5 in.



From the Publisher: A gorgeous expanded edition of *Werner's Nomenclature of Colours*. First published in 1814, *Werner's Nomenclature of Colours* is a taxonomically organized guide to color in the natural world. Compiled by German geologist Abraham Gottlob Werner, the book was expanded and enhanced in 1821 by Patrick Syme, who added color swatches and further color descriptions, bringing the total number of classified hues to 110. The resulting resource has been invaluable not only to artists and designers but also to zoologists, botanists, mineralogists, anatomists, and explorers, including Charles Darwin on the famous voyage of the *Beagle*.



Werner's Nomenclature of Colours: Adapted to Zoology, Botany, Chemistry, Mineralogy, Anatomy, and the Arts

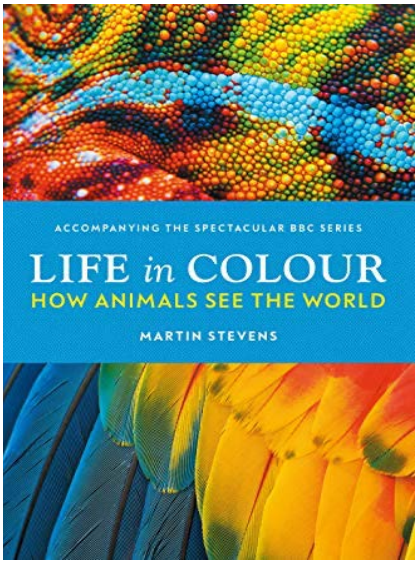
Patrick Syme (Author), Abraham Gottlob Werner (Illustrator)

Smithsonian Books; Illustrated edition (February 6, 2018), 80 pp

First published in 1814, *Werner's Nomenclature of Colours* is a taxonomic guide to the colors of the natural world that has been cherished by artists and scientists for more than two centuries. This beautiful **pocket-size facsimile** is certain to delight and inform a new generation of artists and scientists. *Werner's Nomenclature of Colours* is a charming artifact from the golden age of natural history and global exploration.

Book Title **「色のふしぎ」と不思議な社会**
2020 年代の「色覚」原論
Mystery of Colour and Mysterious Society
川端裕人 Mr Hiroto Kawabata
Chikuma Shobo Publishing Co Ltd., Tokyo, Japan.

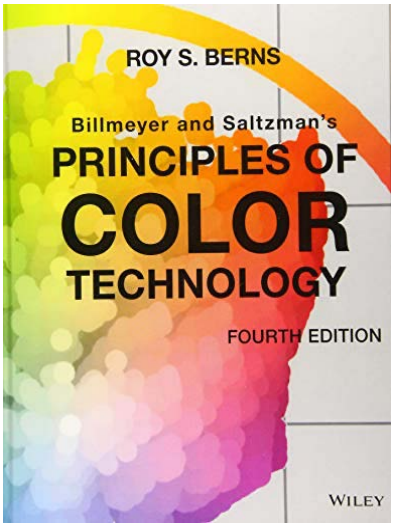
Dr Chie Takahashi summarises: The author, a science writer, was diagnosed with "dyserythrochloropsia" or "incomplete red-green blindness" in the early 1970s after a medical examination at an elementary school. In Japan, such colour vision tests at school medical examinations were practically abolished; however, this exam seems to be have been reinstated around 2016. Why did it happen? How did it come about? Starting from such questions, the author intensively conducted interviews with a wide range of people from ophthalmologists to colour vision researchers. The author focuses on some of the problems that the colour vision perspectives of the last century have brought to our society and illustrates these problems from scientific aspects. Through numerous interviews and surveys over the course of 5 years, the author reached a new horizon of colour vision: that is, human colour vision is more diverse than we expected and there is no clear border between "normal" and "abnormal".



Life in Colour
Martin Stevens

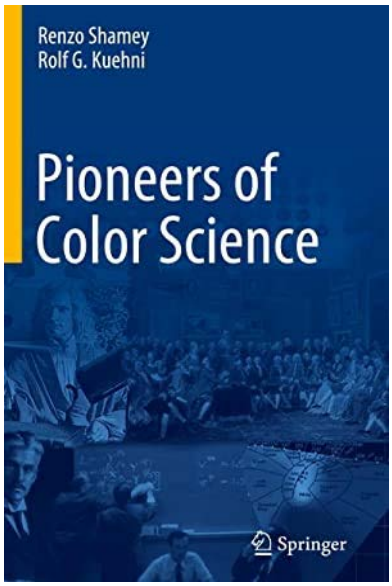
Ebury Publishing, United Kingdom.
About this Book: 'The natural world is awash with colour, but we are only seeing half the story. If we could see things as animals do, our world would become unimaginably brighter. Depending on the situation, colour says different things - it can be an expression of power or seduction, warning or deceit - and it can even, occasionally, save your life. Accompanying a major new BBC series with David Attenborough, *Life in Colour* explores the fascinating story of how colour works in the natural world. From the 'trichromatic' vision of Silver Leaf Langurs, which allows them to see orange and red against forest foliage - the colours not only of ripe fruit, but of their young - to African Mandrills who use their colouration to do battle, Professor Martin Stevens reveals a complex system of messaging visible only to those who know the code. Based on the latest scientific research in the field, and illustrated with stunning photography throughout, Life in Colour reveals a world previously unknown to us.

Principles of Color Technology
Roy S. Berns
Published by John Wiley and Sons Ltd, United States (2019)
ISBN 10: 1119367220 ISBN 13: 9781119367222



About this Item: 4th Edition. This book offers detailed coverage of color, colorants, the coloring of materials, and reproducing the color of materials through imaging. It combines the clarity and ease of earlier editions with significant updates about the advancement in color theory and technology. Provides guidance for how to use color measurement instrumentation, make a visual assessment, set a visual tolerance, and select a formulation. Supplementary material is included with numerical examples, graphs, and illustrations that clarify and explain complex subjects. Expands coverage of topics including spatial vision, solid-state lighting, cameras and spectrophotometers, and translucent materials.

Recent Books on Colour, continued from Page 6



Pioneers of Color Science

Renzo Shamey and Rolf G. Kuehni

Springer International Publishing (2020), 468 pp

This book provides a comprehensive overview of the historical development of color science. Grouped by historical period, each part is prefaced with a short introduction that sets the essays into context. Beginning with classical Greece and the works of Plato and Aristotle, the book goes on in the second part to describe the advances made by Islamic scholars such as Ibn al-Haytham between the 10th and 15th centuries. The third part covers contributions from Roger Bacon and Theodoric of Freiberg in the same period. Part four includes discussions on color formation and visual perception for a time period from about the 16th to the 18th centuries encompassing the Age of Enlightenment. This part addresses the works of nineteen pioneers including Descartes, Boyle, Newton, Goethe, Lambert, Purkynje, Runge, Dalton, Young and Chevreul. The final part is the largest section of the book and covers the most recent discoveries and contributions from pioneers born after 1800 and includes over 60 essays. Among the pioneers listed in this chapter are Nobel laureates, vision scientists including Helmholtz, and Hering, and many other notable color pioneers such as Munsell and Land. This part of the book also includes essays on color science including Adams, Boynton, Crawford, Hardy, MacAdam, Ostwald and Wyszecki and reviews their contributions to this dynamic field. A useful reference for color scientists, science historians, artists and others, Pioneers of Color Science offers a fascinating insight into the development of color science and the nature of scientific advancement.

Obituary for Romuald (Ronnie) Lakowski

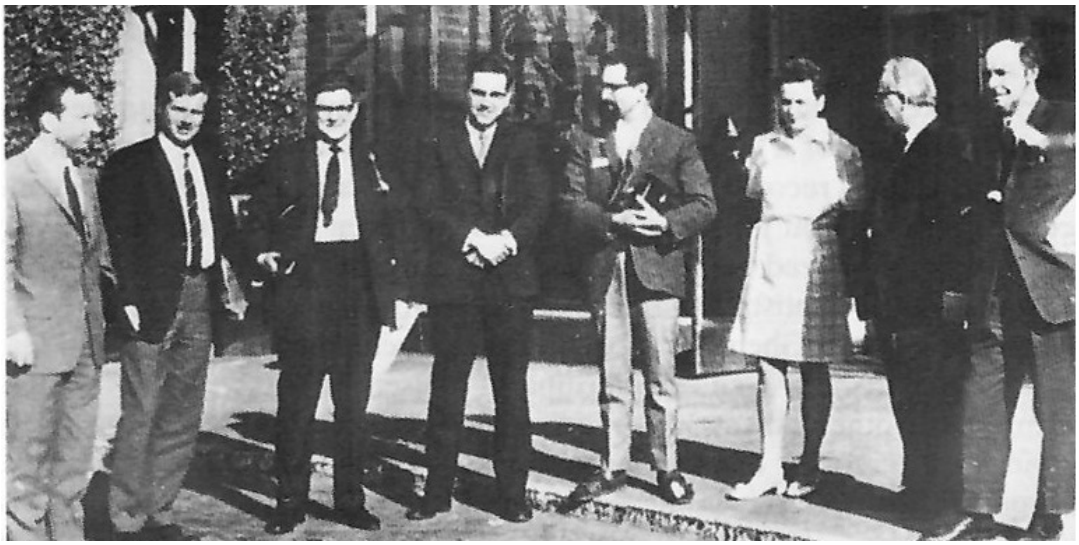
5 July 1926 - 1 November 2013

Ronnie, as everyone knew him, was born in Swiecie, Poland. During the Second World War he was a member of the Polish Free Forces and eventually travelled to Great Britain where his knowledge of Polish, Russian, German and English made him a valuable translator for the British Army. He took out UK citizenship on 28 March 1953. After the war he studied at the University of Glasgow where he met his wife, Isabel. He completed a PhD , "Age and colour vision", in 1965 at the University of Edinburgh under the supervision of Professor R.W. Pickford. His publications covered the design and evaluation of colour vision tests, the effect of aging on colour perception, and the study of acquired colour vision deficiencies, particularly in diabetes. His two-part paper in Occupational and Environmental Medicine, in 1969 provided the basis to the understanding of colour vision tests through knowledge of their colorimetric design. By 1970 he was a reader in the Department of Psychology, University of Edinburgh.

In 1965 he presented a paper at the International Colour Meeting in Lucerne, Switzerland. "Colorimetric and photometric data for the 10th edition of the Ishihara plates". This meeting was the forerunner of the Association Internationale de la Couleur which first met in Stockholm in June 1969. Here Ronnie presented "Psychological variables in colour vision testing". At this first AIC meeting, a number of clinical colour vision researchers were disappointed at the poor coverage of colour vision deficiencies. They resolved to create a group that would pay more attention to this topic and would meet around the same time as and geographically close to the AIC.

Obituary for Ronnie Lakowski , continued from Page 7

So was born the International Research Group on Colour Vision Vision Deficiencies. Ronnie was the Foundation Treasurer for the Western Hemisphere until 1983. Marion Marré was Treasurer for the Eastern Hemisphere, given that moving money from behind the Iron Curtain was difficult. Guy Verriest was General Secretary, and driving force, and Jules François the President. André Roth was later President. Ronnie organised the assistance to students to attend, but Jenny Birch says that the bed in Edinburgh was the hardest she has ever encountered. The link to the AIC has gradually dissolved as the IRGCVD/ICVS became, as John Mollon once, so aptly, put it "a meeting of friends rather than a big conference" that travelled around to members'own institutions. That was the ethos that Guy Verriest introduced in the very first symposium and Ronnie maintained in the second.

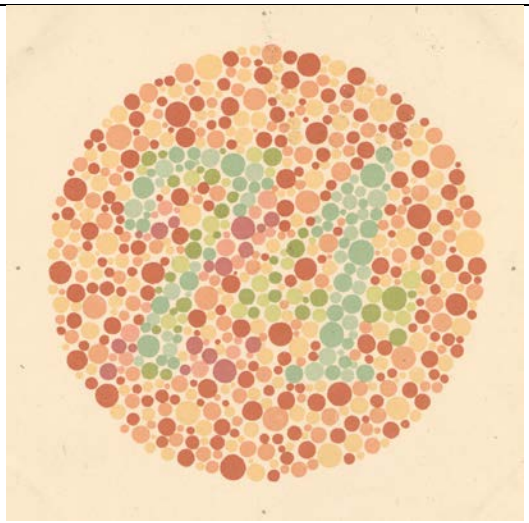


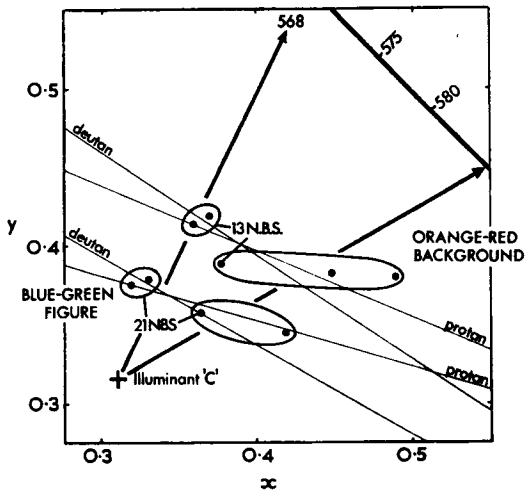
Left to Right: André Roth*, Switzerland, Carl Rendahl, Sweden, Ronnie Lakowski*, UK, Max Kalberer, Switzerland, Jack Moreland*, UK, Marion Marré*, Germany, Oskar Neubauer, Austria and Guy Verriest, Belgium.
*Honorary Life Member IRGCVD/ICVS

Ronnie was also an active part of the Colour Group of Great Britain. In those days the membership also included such well-known names (still) as W.D. Wright, B.H. Crawford and W.S. Stiles.

In 1970 , Ronnie and family emigrated to Vancouver where he taught in both the Psychology and Ophthalmology departments at the University of British Columbia. His research in colour vision established the link between changes in colour vision and the onset of diabetic retinopathy. He continued his contribution to the IRGCVD with a total of 14 papers between 1971 and 1981 and then four at Annapolis in 1987. At the Annapolis meeting he presented an invited paper "Uses and abuses of the Farnsworth-Munsell 100-Hue test." This should be compulsory reading for anyone using the FM100 Hue test. He was also made an honorary life member of the group, the fifth person to be given this honour after Louise Sloan, WD Wright, Ingeborg Schmidt and WS Stiles. He had, by his own admission, lost the drive to travel across time zones and that meeting was his last. He retired from the University of British Columbia in 1991.

Ronnie always had a smile and a mischievous look on his face. He was a happy person. People always speak of his sense of humour. Joel Pokorny remembers him from IRCGCVD meetings and the NRC Working Group 41 which in 1981 produced the document "Procedures for Testing Color Vision". He recounts the following story "Ronnie had a marvellous droll sense of humour. Spending time with him was delightful. I remember once when he was visiting us in Chicago he expressed interest in taking some sausage back to Vancouver, so we took him to a Polish delicatessen. After Warsaw, Chicago has the largest Polish population in the world. There are parts of the city where no English was spoken. So, we go into this large deli and Ronnie starts speaking Polish to the attractive young woman behind the counter. She listens for a brief time, gets a bemused look on her face and then starts laughing. Well, Ronnie was speaking 1940s Polish to a modern lady! As far as we could tell, he began with something like "Most honored lady...". He knew exactly what he was doing - it was great fun!"





Lakowski (1969) was the first to undertake a detailed colorimetric analysis of pseudoisochromatic plates, such as the Ishihara; and he insightfully used his measurements to show how the plates worked (or failed to work). In this figure he shows, in a section of the CIE *x,y* diagram, the chromaticities used in one of Ishihara's transformation plates (No 5 of the 5th Edition). The normal observer links together the four chromaticities enclosed in the two small circles and identifies a greenish '74' on a reddish-orange background. But the confusion lines of protans and deutans allow each of the two small circles to be linked to a different subset of background chromaticities; and now the perceptual organisation has rotated by almost 90° in the *x,y* diagram and the dichromat reads '21'. (Lakowski, R. (1969) Theory and practice of colour vision testing: A review. Part 2. *British J. industrial Medicine*, **26,** 265-288.)

One of Ronnie's PhD students at Edinburgh, Peter Aspinall, recalls that "Ronnie was always entertaining and was trained under the psychologist Prof Pickford in Glasgow (Pickford of the anomaloscope fame) and we always had lots of laughs in the lab. I think Pickford was a Freudian and Ronnie enjoyed using Freudian ideas (with their connotations) to explain behaviour. Coffee times led to discussions about anything other than colour vision. Ronnie didn't get involved in the details of statistical analysis but he made up for this in his enthusiasm and interpretation of statistical findings, I remember Ronnie being surprised and delighted at the implications from a regression model on some age-related visual field changes. He was both supportive and inspirational as a supervisor. Ronnie was a good lecturer but also entertaining. In addition to deliberately mis-spelling words such as 'blew' (imagine someone working in colour vision who couldn't spell blue) he would also write on the blackboard and deliberately turn it upside down to keep the students' attention.. Of course, students regularly shouted out "You've got it wrong!" or "It's upside down!". He also added to this by deliberately tripping over stairs or things on the lecture stage, for the same reason. Years later I came across a number of students who had taken a year-long psychology course at Edinburgh and experienced Ronnie's lectures. While, in general, not remembering much about their undergraduate lectures, they did remember Ronnie's colourful (in many ways) ones."

Jack Moreland remembers Ronnie as "a ball of energy providing an early lesson in drinking vodka, moderated (inadequately) with rye bread." I remember him as being unstinting in his time to help a mere graduate student.

Ronnie died at the age of 87. He was married to Isabel for 61 years. He was predeceased by one son and two great-grandsons. He left 15 children, 41 grandchildren, 9 great- grandchildren and numerous nieces and nephews in the UK and Australia.

As a founding member and early office bearer in the IRGCVD and a great colour vision researcher, the ICVS owes a debt of gratitude for its existence to Ronnie and the like-minded people who wanted to get together to share their colour vision research.

Stephen Dain

With the assistance of Romuald Lakowski jnr, Peter Aspinall, Jenny Birch, Jack Moreland, Joel Pokorny, André Roth.
https://www.findagrave.com/memorial/127213748/romuald-lakowski

Mikhail Bongard (1924 – 1971)

August 5th, 2021 marks the fiftieth anniversary of the accident that prematurely took the life of the Russian physicist and colour scientist, Mikhail Moiseevich Bongard. The manner of his death recalls that of an earlier colour theorist, Leonard Troland. Until that awful August day in 1971, Bongard was a member of the flourishing Moscow laboratory for 'information processing in sensory organs'. The group included the colour scientists N. D. Nyuberg and V. V. Maximov, as well as M. S. Smirnov (pioneer of adaptive optics), A. L. Yarbus (celebrated for his work on eye movements) and the electrophysiologist A. L. Byzov [1].

Figure 1. M. M. Bongard

A photograph supplied for the 1957 NPL symposium on colour vision. Bongard was not able to attend in person, perhaps because he was not a member of the Communist Party.

In 1956 Bongard and Smirnov described how the human parafovea is tetrachromatic in a special sense [2]. If two metameric, trichromatic, matches are made for this region, a transient is typically perceived when one of the two fields is replaced by the other. It is, however, possible to make tetrachromatic matches that can be interchanged imperceptibly. Moreover, unlike trichromatic matches, the tetrachromatic matches are stable with changes in light level and with changes in the state of chromatic adaptation.

During the present century, the phenomenological dimensionality of peripheral vision has gained fresh interest owing to the discovery of a fifth class of photoreceptor – the melanopsin-containing ganglion cells – and so we are currently preparing for publication an English translation of Bongard and Smirnov's classic paper. However, Bongard's most important contribution to colour science was probably the superordinate one: the exploitation of what Donner and Rushton were later to call 'silent substitution'. There had been occasional applications of silent substitution previously [3], but these were limited to the case where one monochromatic light was substituted for another. The value of Bongard's 'colorimetric' use of silent substitution lay in its extension to the case where there were two, three or even four primaries. The method could be applied to whole organisms or to single nerves, in order to establish the dimensionality of vision and to derive colour-matching functions [4].

In an early paper that definitely has not enjoyed the recognition it deserves, Bongard and Smirnov used a microelectrode to record action potentials from single ganglion cells in frog retina [5]. They identified single, chromatically sensitive, cells for which no silent substitution could be made between two monochromatic lights, a result implying that the cell was connected to more than one type of receptor. However, a silent substitution was possible when two primaries and a variable test light were available; and dichromatic 'colour-matching functions' could be measured rather precisely for a single nerve

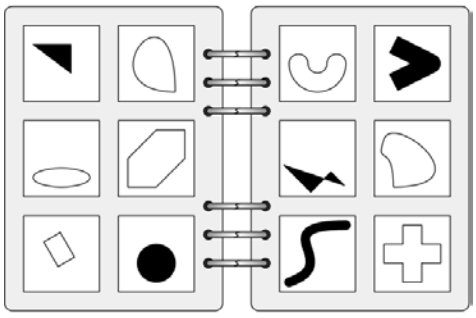


Figure 2. An example of a Bongard problem.

The program, or the observer, must identify the property in which the righthand figures differ from those on the left.

In the 1960's, Bongard turned to problems of machine vision and his pioneering 1967 book *Pattern Recognition* was translated into English in 1971. In computer science he is celebrated for 'Bongard problems', developed as challenges for AI (see Figure 2). However, he maintained his interest in vision and colour, publishing papers on colour constancy, on the dominance of contours in binocular combination, and on the controversial Rosa Kuleshova, who claimed to identify colours by touch.

Bongard and Smirnov were long-term friends. In the lab, they were known as *dva Mishki* (see *Sensornye Sistemy* 2021, vol 35, p 175). The phrase means both 'the two Michaels' and 'the two bears'. In 1971 they still shared an office and in an interview late in life Smirnov recounted how in the spring of 1971 he had discussed summer holiday plans with Bongard [6]. Bongard was a keen alpinist – and indeed held the soviet qualification of 'Master of Sport'. He annually enjoyed a summer climbing holiday. But in 1971, in conversation with his office mate, he expressed a strange reluctance to go that year and proposed to withdraw his application for holiday leave. In

the end, he did not withdraw his application. During a descent high in the Pamir mountains, he was roped to a companion, when they slid a distance on an icy and rocky slope and then fell 800 metres vertically into a gorge [7]. Their bodies are still buried close by.

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