OPTICA
Advancing Optics and Photonics Worldwide
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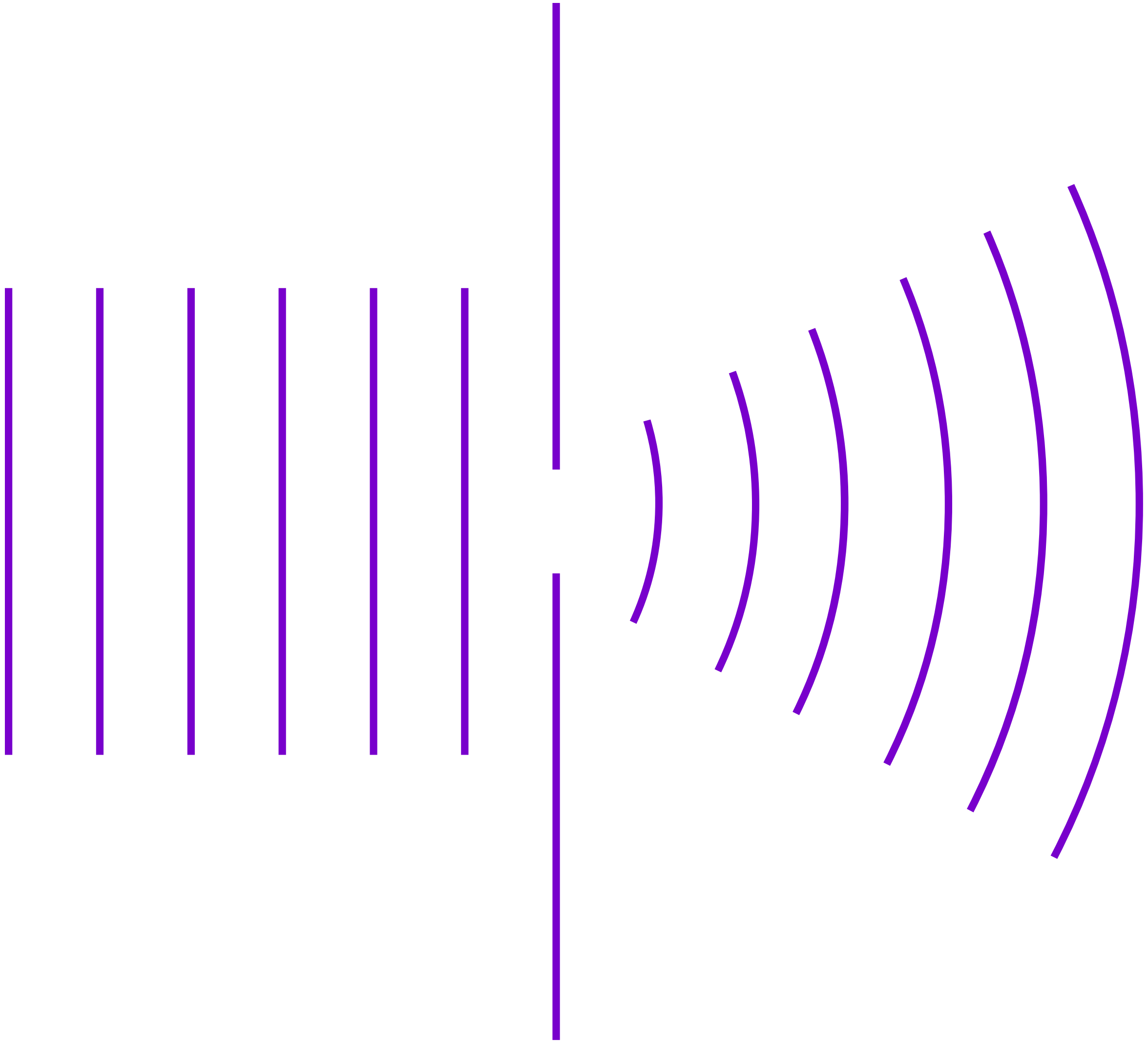
Color Technical Group

Webinar

Quality Assessment for passive aids in color vision deficiency subsets

16 June 2023 | 10:00-11:00 EDT



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Color Technical Group

About the Color Technical Group

Our technical group focuses on all aspects related to the physics, physiology, and psychology of color in biological and machine vision.

Our mission is to connect members of our community through technical events, webinars, networking events, and social media.

Our past activities have included:

- Special webinar on display calibration
- Vision science in times of social distancing coffee breaks
- Incubator meetings

Connect with our Technical Group

Join our online community to stay up to date on our group's activities. You also can share your ideas for technical group events or let us know if you're interested in presenting your research.

Ways to connect with us:

- Our website at www.optica.org/vc
- On Twitter at #ColorTG
- On LinkedIn at www.linkedin.com/groups/13573604
- Email us at TGactivities@optica.org

Next webinar

June 27 2023

OPTICA
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Color

WEBINAR

Color Mechanisms: A Progress Report

27 June 2023 | 11:00 — 12:00 EDT (UTC-04:00)

About the Presenter: Rhea Eskew from Northeastern University

Rhea Eskew did his graduate work at the Georgia Institute of Technology, applying nonlinear systems analysis techniques to human spatial vision. After obtaining his Ph.D., he became a postdoctoral fellow at the Center for Human Information Processing at the University of California at San Diego, where he worked with Robert M. Boynton on color discrimination. He next spent four years as a Research Associate in Biomedical Physics at Harvard University, working on chromatic detection in the lab of Charles Stromeyer and Richard Kronauer. In 1990 he moved to Northeastern University, where he is now Professor of Psychology. Dr. Eskew's research is primarily focused on color vision. An experimentalist, he collects detection and discrimination data and uses it to test quantitative models of early and mid-level vision. He is a Fellow of Optica. His research has been supported by the Air Force Office of Scientific Research, the National Eye Institute, and more.

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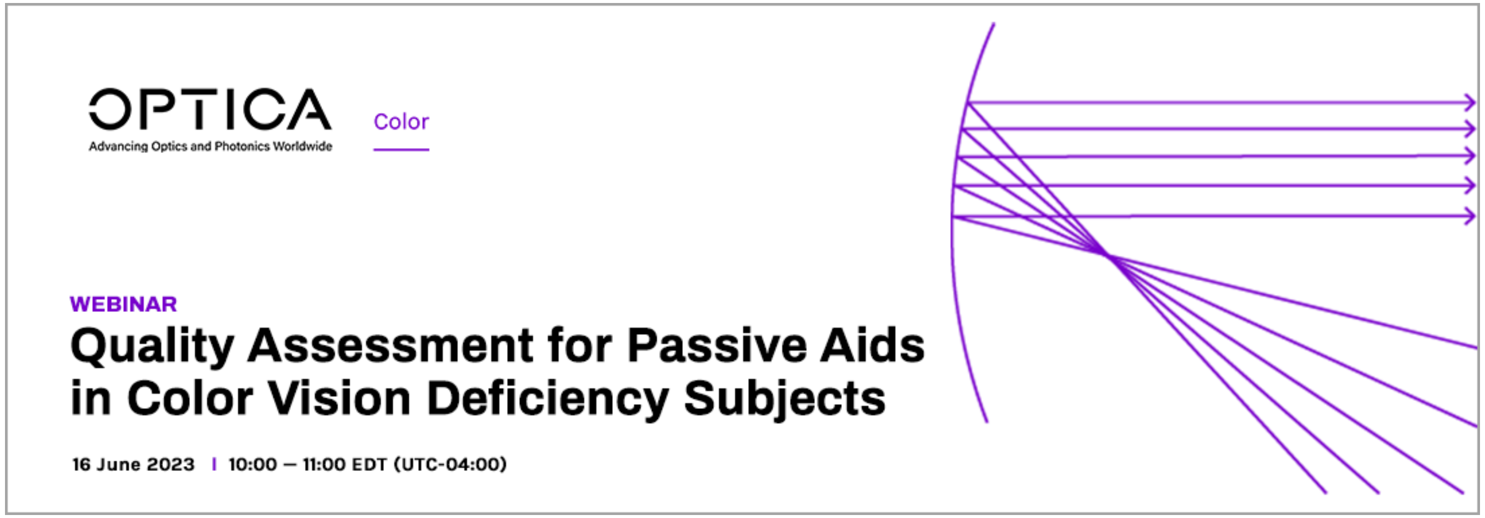
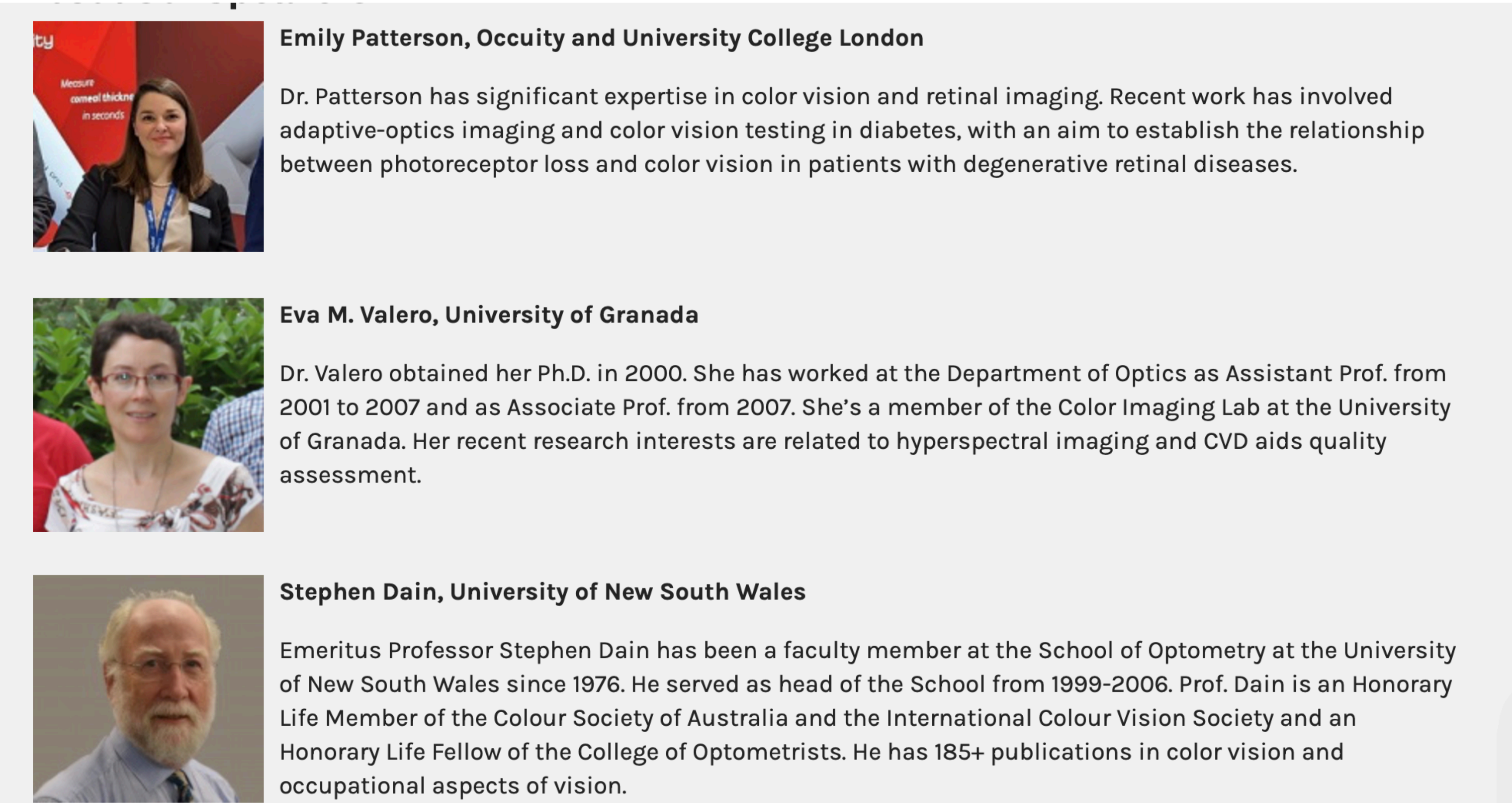
Today’s webinar



WEBINAR

Quality Assessment for Passive Aids in Color Vision Deficiency Subjects

16 June 2023 | 10:00 – 11:00 EDT (UTC-04:00)



Emily Patterson, Occuity and University College London

Dr. Patterson has significant expertise in color vision and retinal imaging. Recent work has involved adaptive-optics imaging and color vision testing in diabetes, with an aim to establish the relationship between photoreceptor loss and color vision in patients with degenerative retinal diseases.

Eva M. Valero, University of Granada

Dr. Valero obtained her Ph.D. in 2000. She has worked at the Department of Optics as Assistant Prof. from 2001 to 2007 and as Associate Prof. from 2007. She’s a member of the Color Imaging Lab at the University of Granada. Her recent research interests are related to hyperspectral imaging and CVD aids quality assessment.

Stephen Dain, University of New South Wales

Emeritus Professor Stephen Dain has been a faculty member at the School of Optometry at the University of New South Wales since 1976. He served as head of the School from 1999-2006. Prof. Dain is an Honorary Life Member of the Colour Society of Australia and the International Colour Vision Society and an Honorary Life Fellow of the College of Optometrists. He has 185+ publications in color vision and occupational aspects of vision.

QUALITY ASSESSMENT FOR PASSIVE AIDS IN CVD SUBJECTS (I)

Eva M. Valero

OPTICA Color Technical Group Webinar

June 16th 2023

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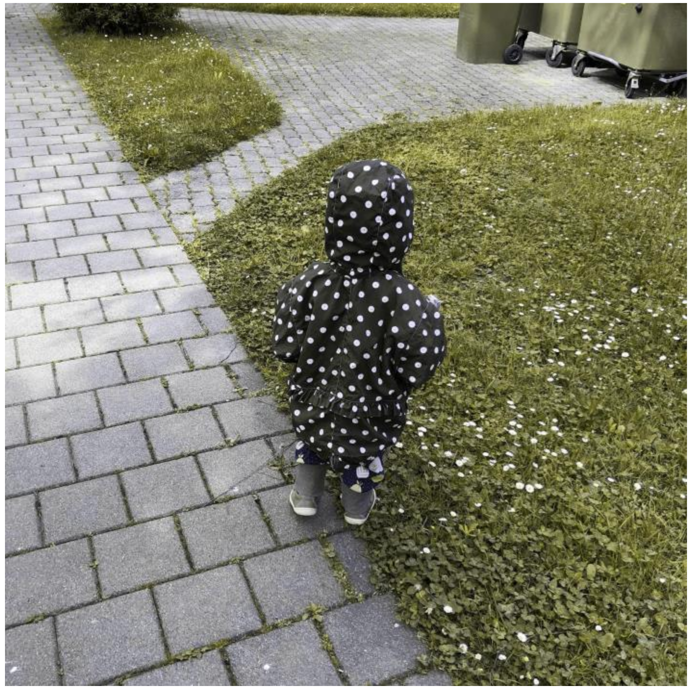
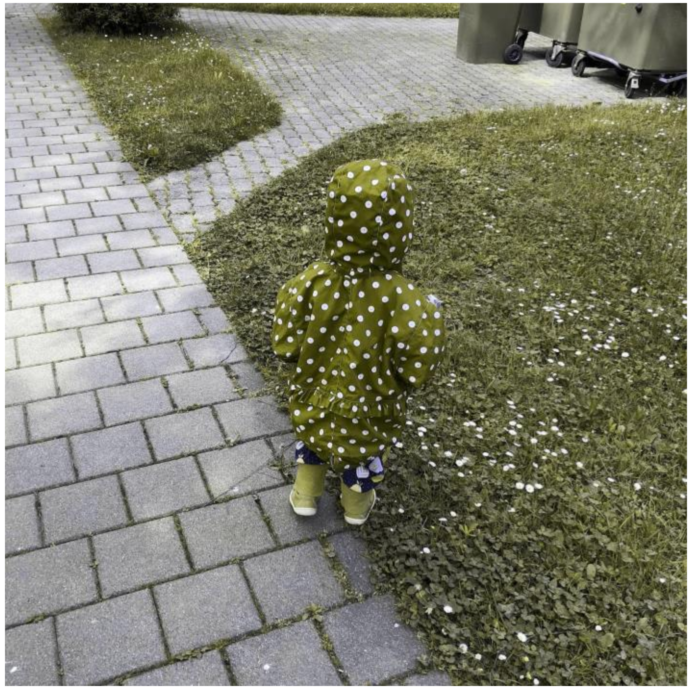
REDDIT POST: WHERE IS MY DAUGHTER?

Normal color vision

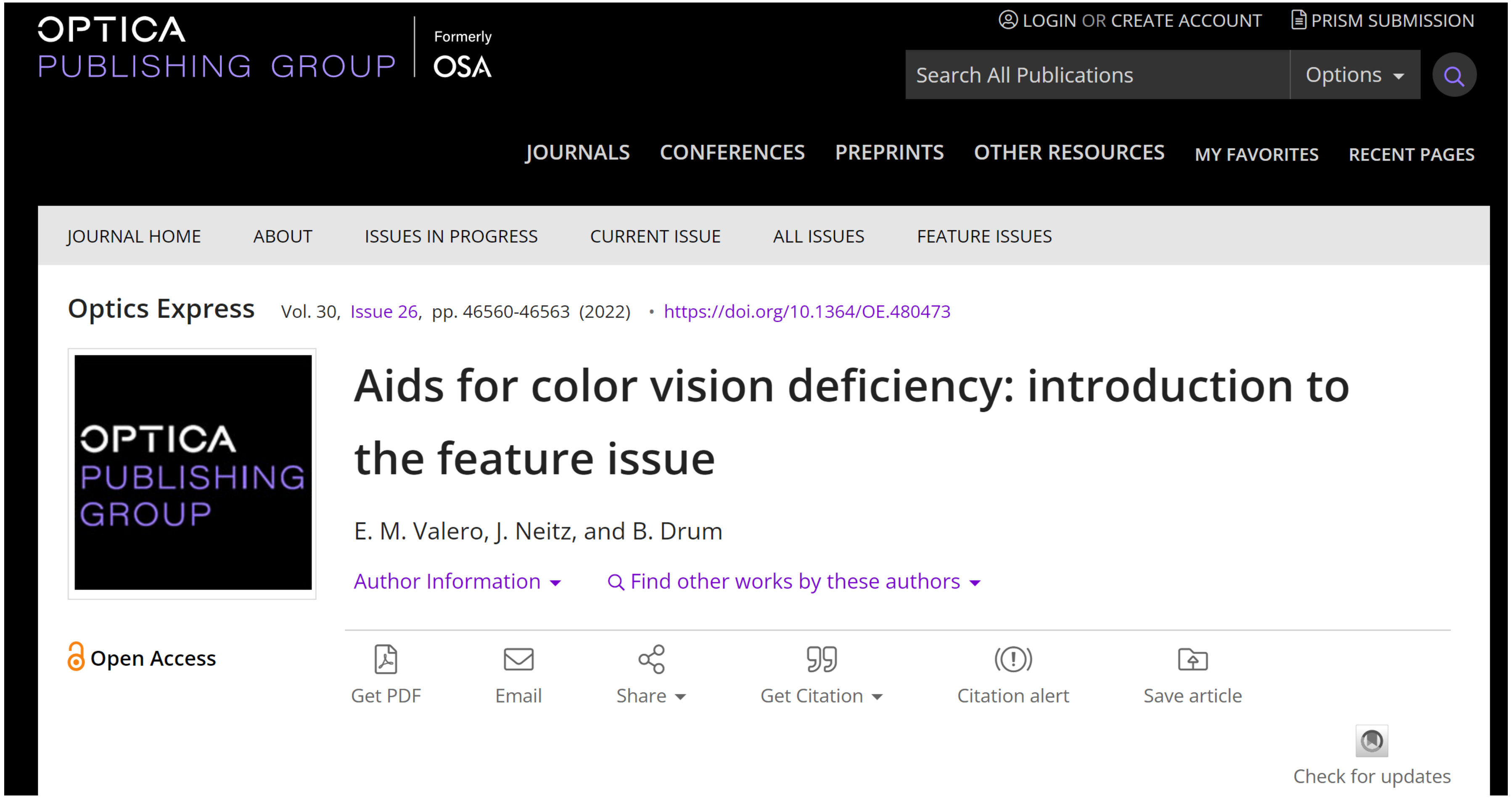


Protanope simulation



Deuteranope simulation

1. OPTICS EXPRESS FEATURE ISSUE



Optics Express Vol. 30, Issue 26, pp. 46560-46563 (2022) • https://doi.org/10.1364/OE.480473

Aids for color vision deficiency: introduction to the feature issue

E. M. Valero, J. Neitz, and B. Drum

https://opg.optica.org/oe/virtual_issue.cfm?vid=527

B. Drum

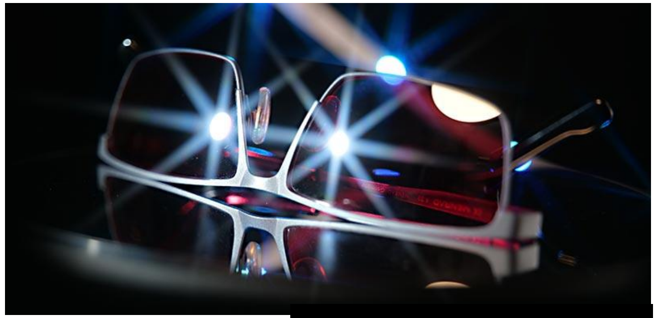
J. Neitz

2. MAIN TYPES OF CVD AIDS

Passive: colored filters

PILESTONE
COLOR BLIND EXPERTS

enchroma.



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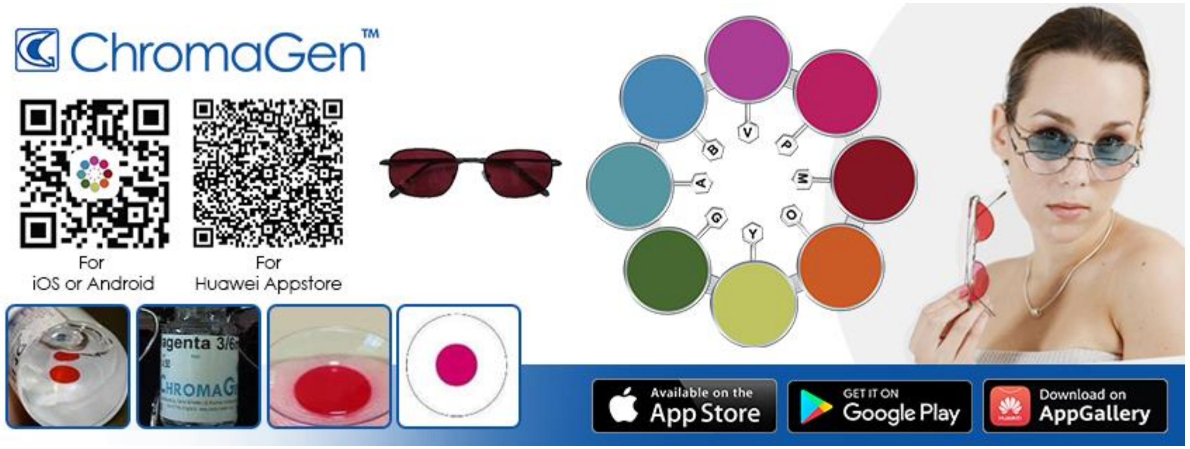

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Covisn
COLOR BLIND EXPERTS

ZIIZZ
Focus on color blind

2. MAIN TYPES OF CVD AIDS

Active: recoloration algorithms

Color Blind Pal

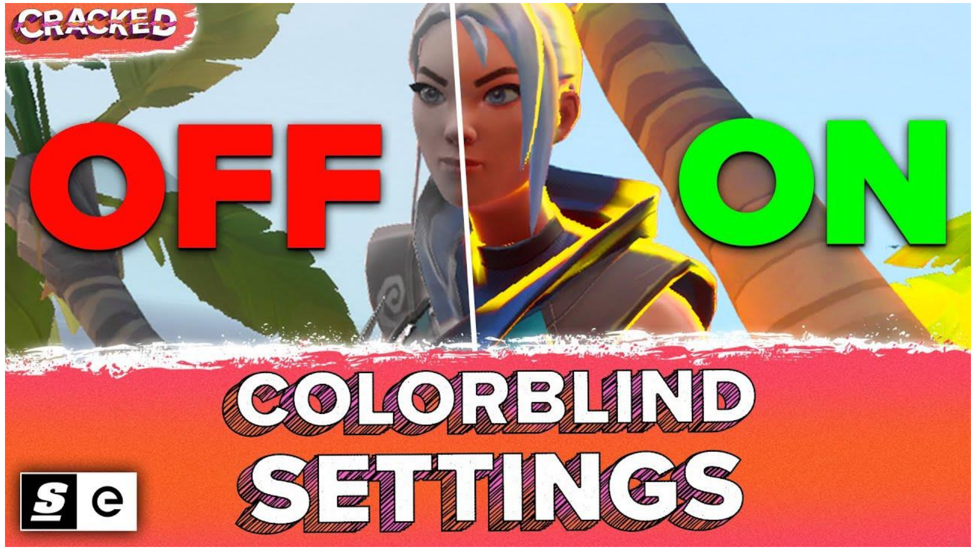
Need for auxiliary display

Selective color change in some parts of the images

Ribeiro and Gomes, ACM Comput. Survey 2020

2. MAIN TYPES OF CVD AIDS

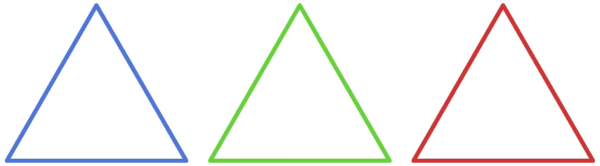
Active: recoloration algorithms



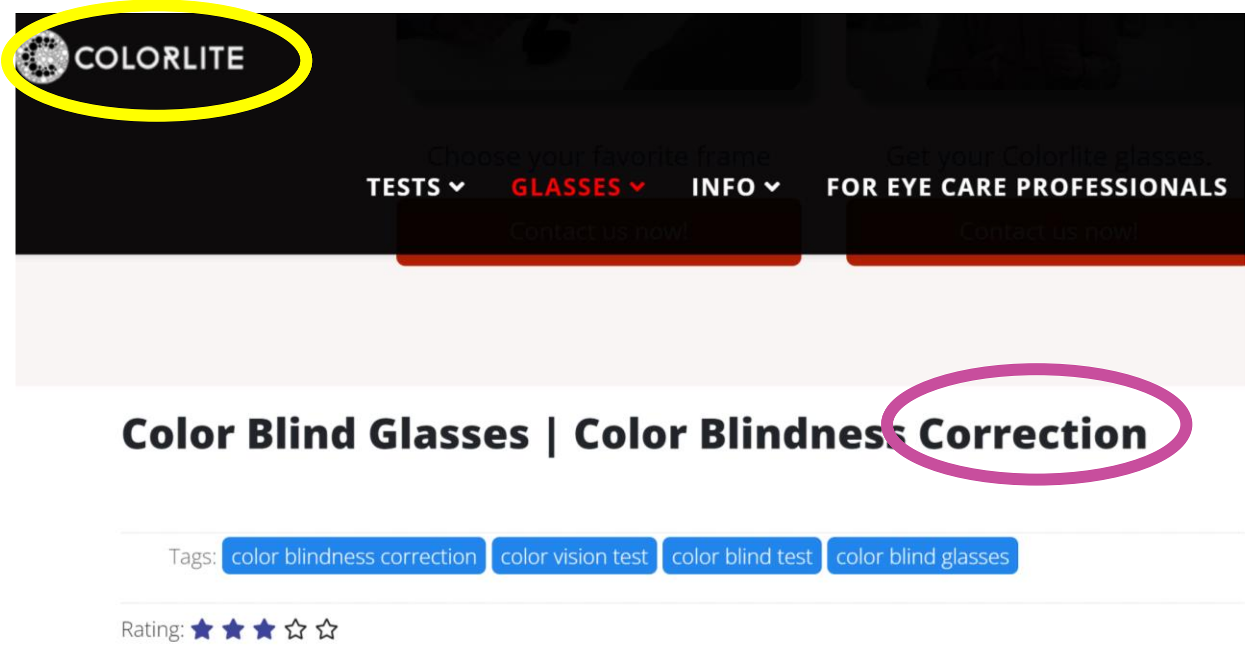
Ribeiro and Gomes, ACM Comput. Survey 2020

2. MAIN TYPES OF CVD AIDS

Passive: colored filters. What the ads say



Normal Color Vision

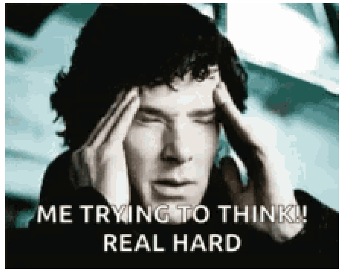


Color Blind Glasses | Color Blindness Correction

Tags: color blindness correction | color vision test | color blind test | color blind glasses

Rating: ★★★☆☆

3. PROSPECTIVE PROBLEMS FOR CVD EVALUATION



…. So do the passive aids improve CVD vision, or not?

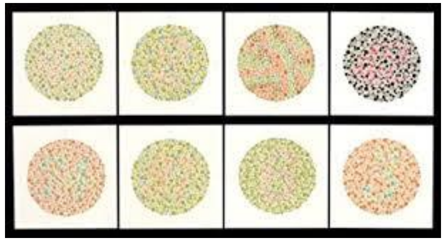
Ask the CVD subjects?

Gómez-Robledo et al. Opt. Exp. 2018; Patterson et al. Opt. Exp. 2020; Alvaro et al. Sci. Rep. 2022; Pattie et al. Opt. Exp. 2022

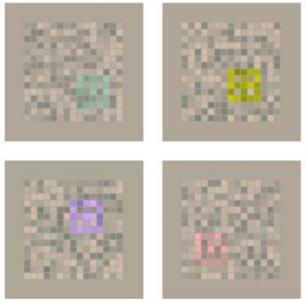
Quantitative quality assessment is important

How do we measure improvements in color vision?

Birch 2001; Ishihara, 1976; Vingrys and King-Smith, 1988; Valero et al. Col. Tech. 2021



There is no standard color space specific for CVD



4. CVD-MET: EXAMPLE OF EVALUATION METRIC

Workflow

Fuzzy C-means clustering in L*a*b* space

Find confusing clusters

Efficiency

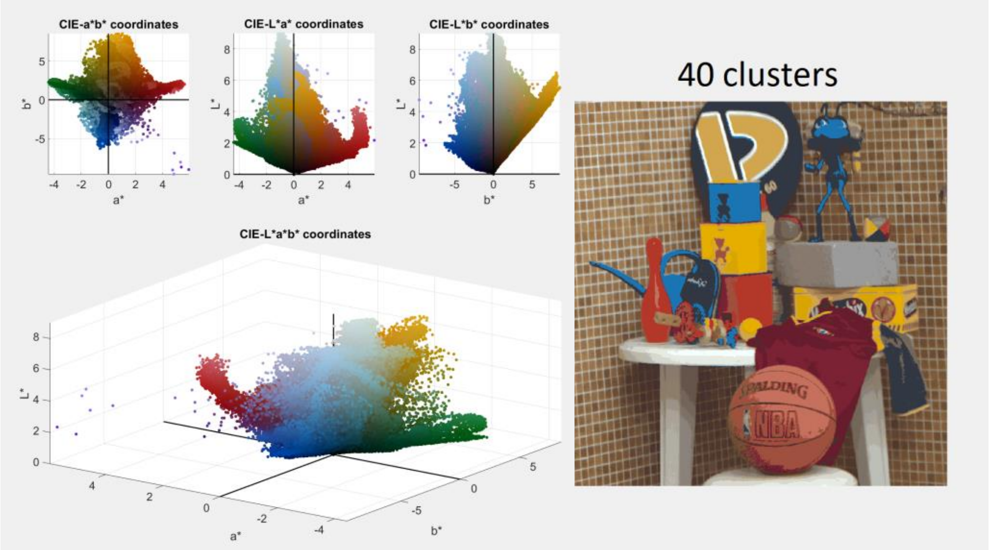
$$E = \sqrt{\left(Normal - CVD_{rec/fil}\right)^2}$$

Naturalness

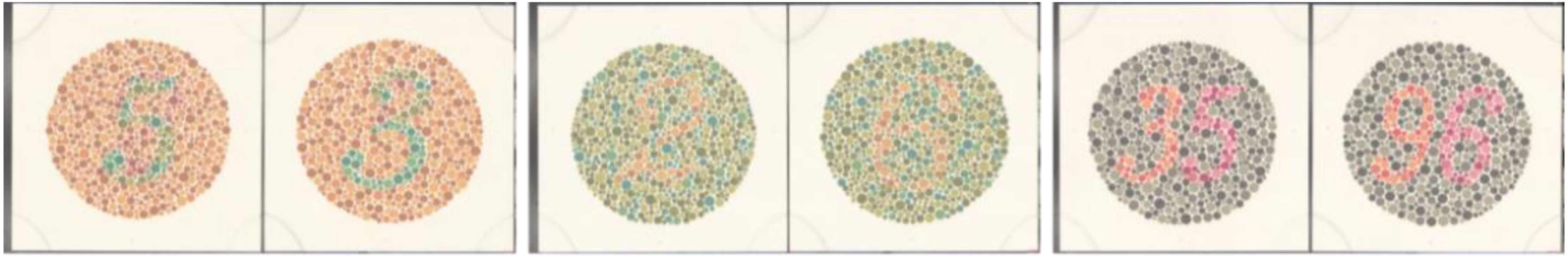
$$N = \sqrt{\left(CVD - CVD_{rec/fil}\right)^2}$$

CVD-MET

$$CVD\text{-}MET = E + N$$



4. CVD-MET: EXAMPLE OF EVALUATION METRIC

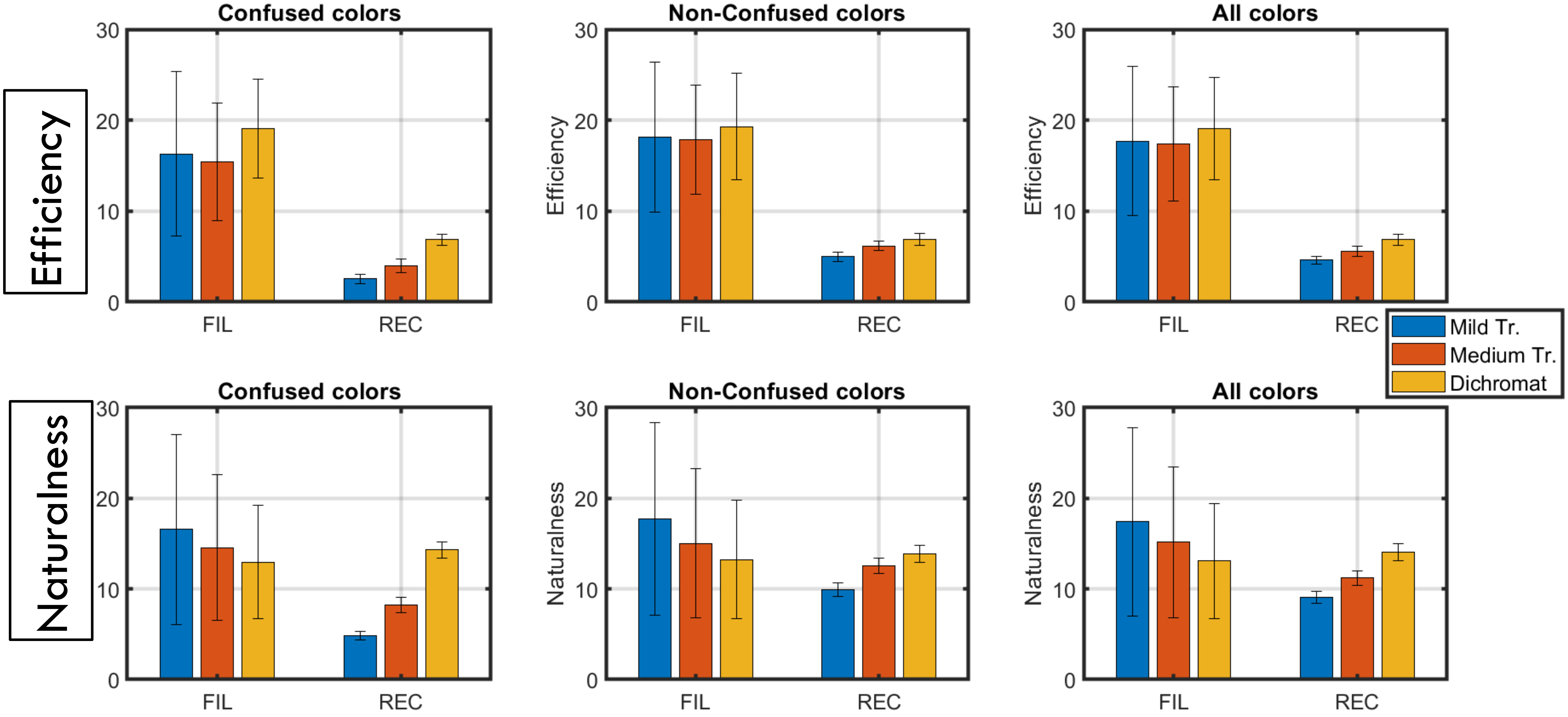


Scenes used

Aids evaluated: Enchroma, VINO (passive); Fidaner, Hassan (active)

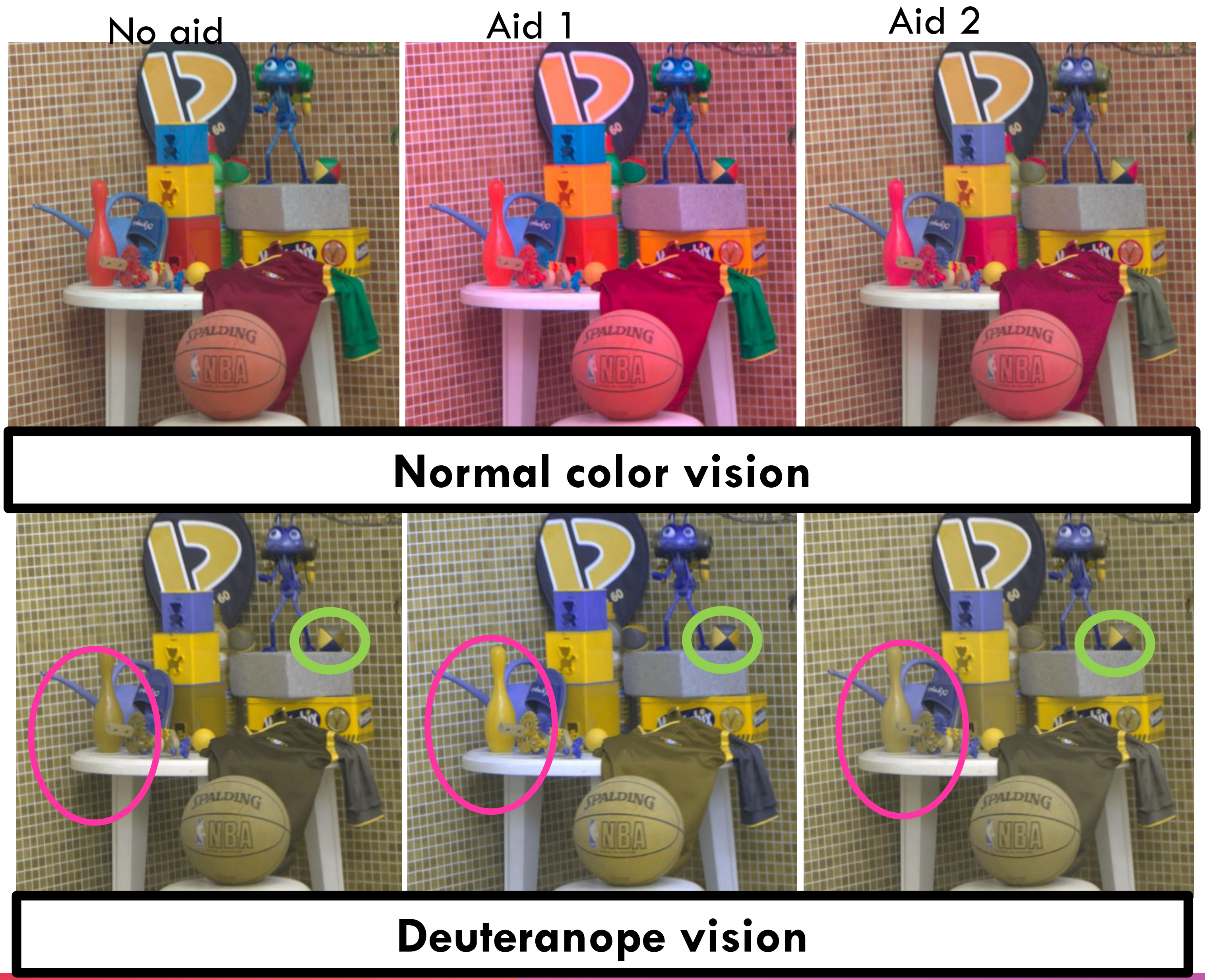
Hassan and Paramesran, 2017; Fidaner et al. 2015

4. CVD-MET: EXAMPLE OF EVALUATION METRIC



FIL: Passive REC: Active

4. CVD-MET: EXAMPLE OF EVALUATION METRIC



Muñoz-Postigo et al. Opt. Exp. 2022

5. CONCLUSIONS AND OPEN QUESTIONS

Design principle and economy: two reasons supporting Active vs Passive Aids

Still far from a totally satisfactory evaluation (working on it!).

CVD Aids cannot correct/compensate effectively. Genetic therapy?

Mancuso et al. 2009

Who does really need CVD Aids? Severity of CVD

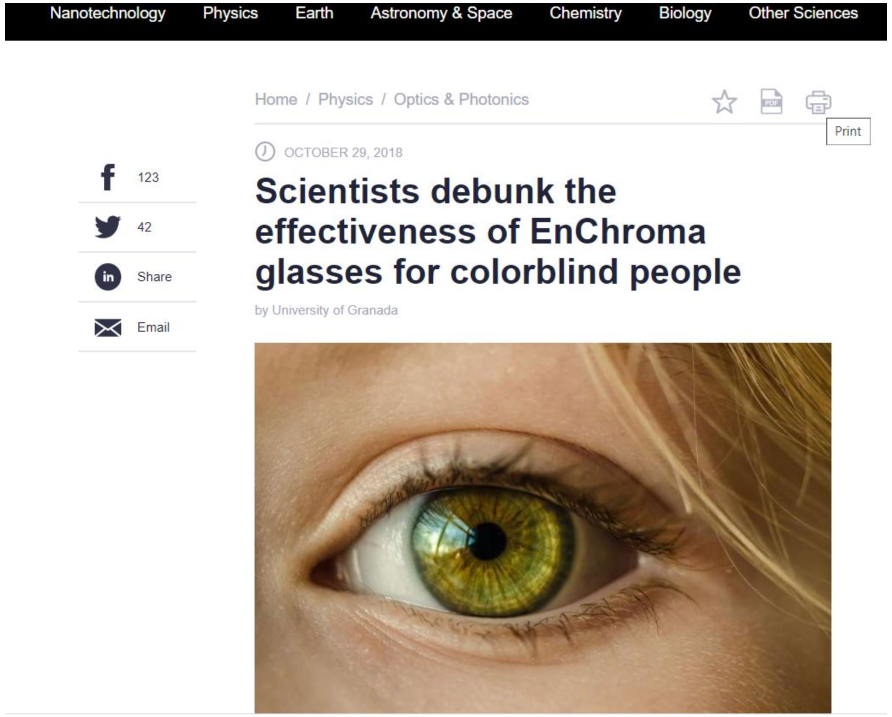
Linhares et al. 2008; Pastilha et al. 2019, Rezeanu et al. 2022

….. What did we not take into account? Full long-term chromatic adaptation, compensatory neural mechanisms

Werner; et al. 2020, Neitz et al. 2002; Tregillus and Engels, 2019

5. CONCLUSIONS AND OPEN QUESTIONS

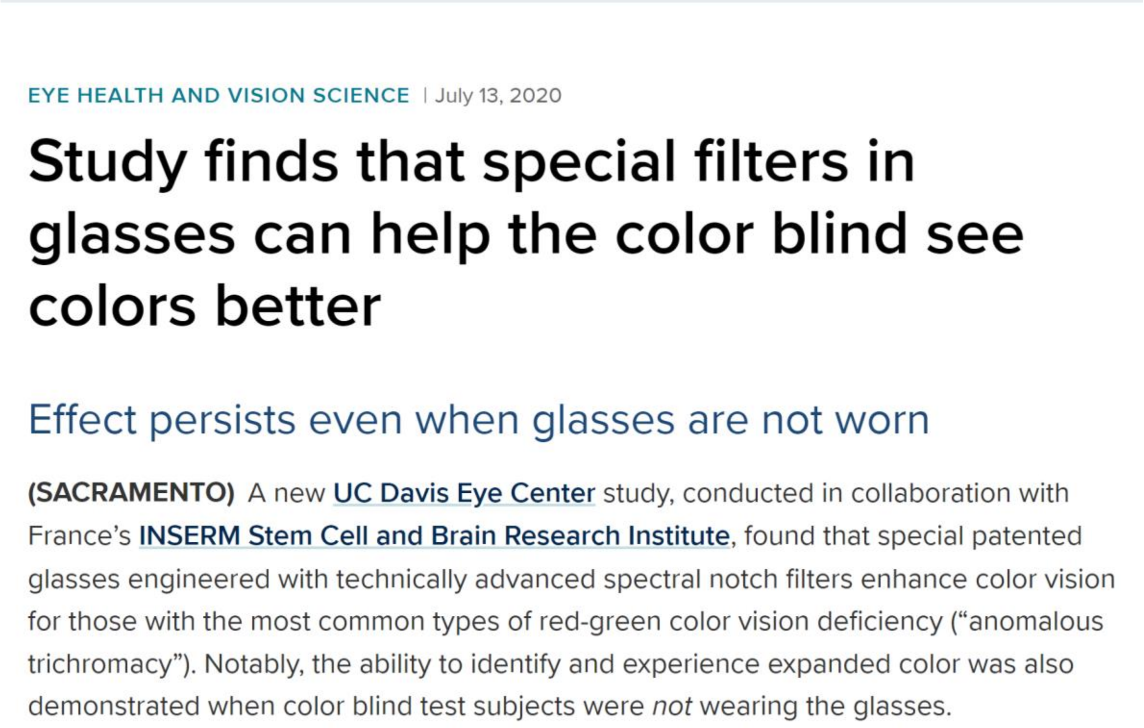
This research has **undeniable** social impact, is controversial….



OCTOBER 29, 2018

Scientists debunk the effectiveness of EnChroma glasses for colorblind people

by University of Granada



EYE HEALTH AND VISION SCIENCE | July 13, 2020

Study finds that special filters in glasses can help the color blind see colors better

Effect persists even when glasses are not worn

(SACRAMENTO) A new UC Davis Eye Center study, conducted in collaboration with France's INSERM Stem Cell and Brain Research Institute, found that special patented glasses engineered with technically advanced spectral notch filters enhance color vision for those with the most common types of red-green color vision deficiency ("anomalous trichromacy"). Notably, the ability to identify and experience expanded color was also demonstrated when color blind test subjects were *not* wearing the glasses.

And *open* for new perspectives

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Muñoz-Postigo et al., Opt. Express, 30, 4665-34683 (2022). [https://doi.org/10.1364/OE.456346]

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Thank you

A model for assessing the efficacy of colour vision aids

Jack D. Moreland	Keele University, UK
Stephen J. Dain	University of New South Wales, Australia
Vien Cheung	University of Leeds, UK
Stephen Westland	University of Leeds, UK

Background

- Topic generating much controversy
  - Groundhog day phenomenon
- Occupational colour vision standards and circumventions
  - Used to pass pseudoisochromatic (PIC) plate tests – therefore cured?
    - Will they be used?
    - Do they actually help with the practical tasks?
    - What secondary problems do they introduce?
  - The clinic guards against such attempts to circumvent
- Passing a PIC test is not the same as facilitating practical colour discriminations
  - Discrimination vs recognition
    - Seeing that two colours are different is not the same as accurate naming of colours
    - Lenses induce a vey significant brightness difference between figure and ground in a PIC test
    - Anecdotally, I can report that performance on the FALANT test is not improved

Background

- Universal panacea or horses for courses?
  - c1970 Rhodesian tobacco grower
    - self-selected a magenta filter for grading tobacco.
      - Fletcher & Voke, Defective Colur Vision. Bristol. Adam Hilger. 1985
  - c1970 BBC vision controller – when BBC changed to colour – extreme deuteranomal
    - self-selected a magenta filter for interpreting studio lighting diagram.
  - 1988 Geologist – using landsat imagery - protanope
      - Pye & Dain, 1988. The X-Chrom lens: a case study. Aust J Optom, 71(3), 91-93.

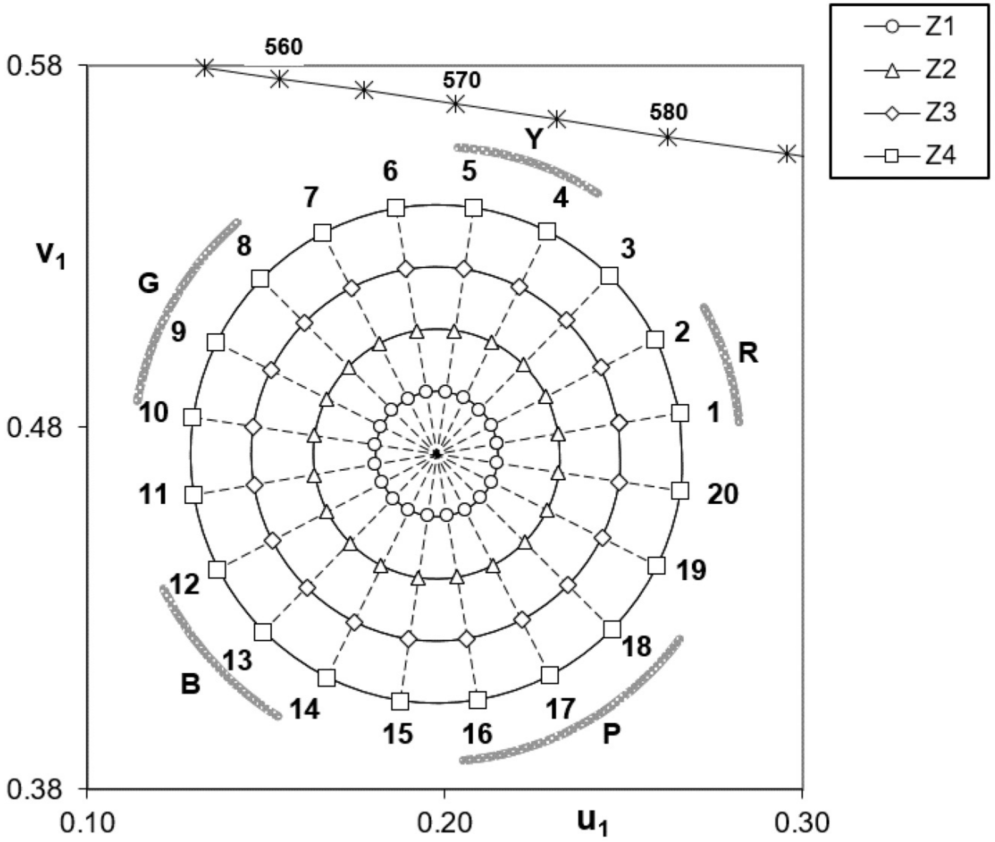
Background

- Anomalous trichromats distinct from dichromats
  - Anomalous trichromats
    - optimise what red-green discrimination that they have
      - true red-green discrimination
    - **“notch filters”**
  - Dichromats
    - rotate the colour difference vector off the confusion line
      - convert to a blue-yellow discrimination task
    - induce a brightness difference
      - pseudo colour discrimination
    - These will also work for anomalous
    - **Long or short wavelength pass or band pass filters**
    - How these, then, relate to colour naming is complex and unpredictable

This study

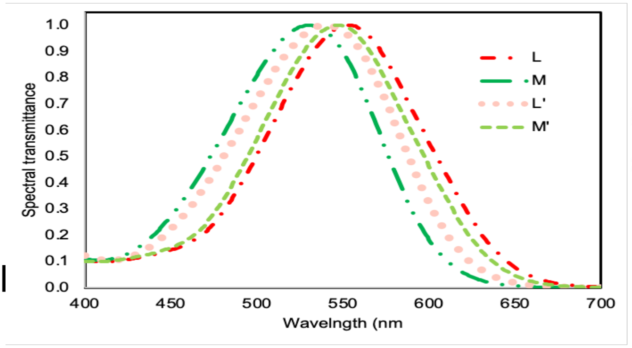
- As a consequence, this study deals with
  - Colour in general not colour vision tests (unlike our earlier study)
  - Anomalous trichromats and not dichromats
- In my experience much of the confusion and controversy arises because these distinctions are not made

- The colours
  - representative colour set of 80 defined in the UCS diagram, 4 equi-spaced saturation levels with 20 equi-spaced samples.
  - Adjacent Munsell colours
    - https://sites.uef.fi/spectral/munsell-colors-matt-spectrofotometer-measured/

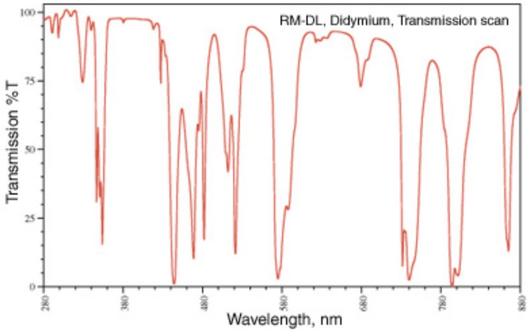


This study

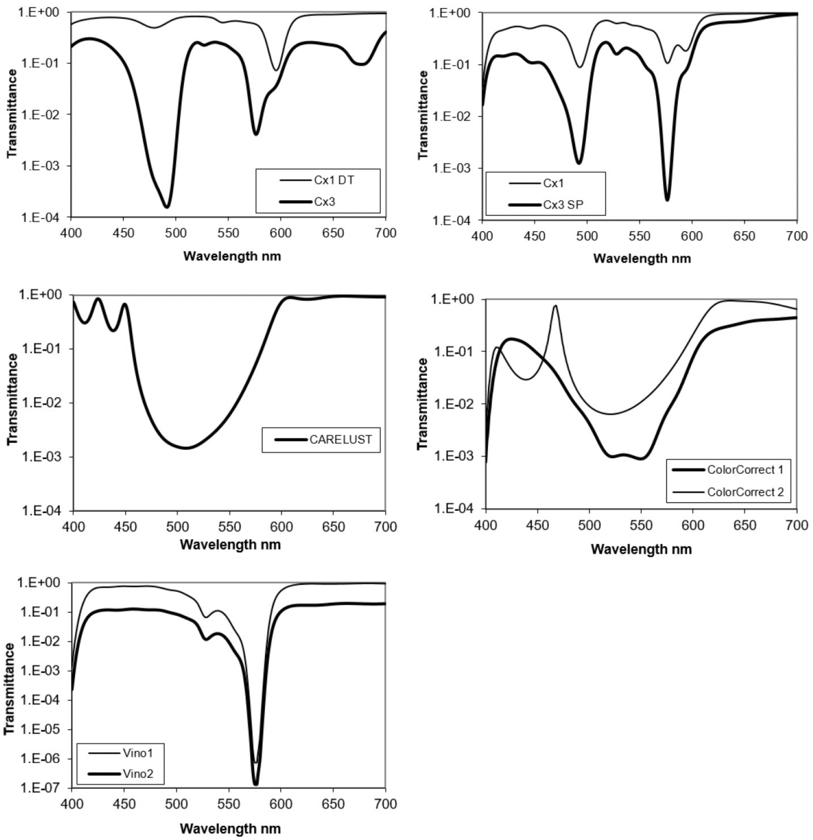
- The subjects
  - De Marco fundamentals
    - De Marco P, Pokorny J, Smitl VC.
      J Opt Soc Am A 1992; 9: 1465-1476.
- The lenses
  - 8 currently available
  - Enchroma (Cx series), Vino, Carelust, Color Correct.
  - Transmittances measured on two Varian Cary 500 dual beam, double monochromator spectrophotometers.



De Marco fundamentals



Didymium filter



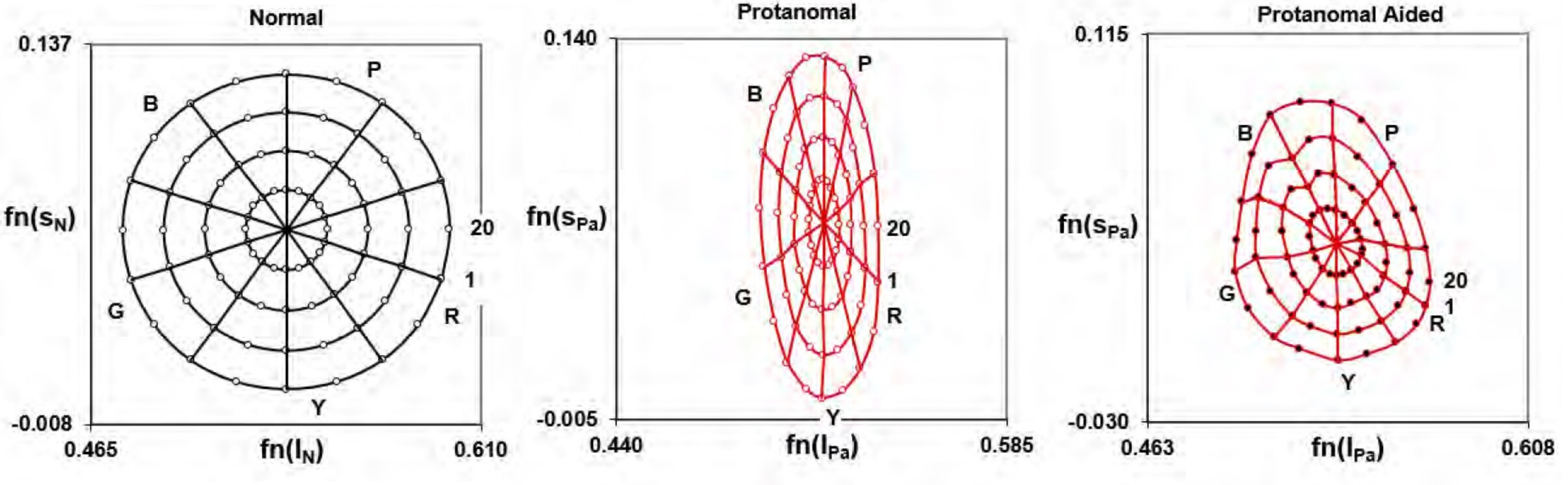
Calculation

- Source Spectral power CIE standard illuminant D65. ISO 11664-
- Objects Spectral reflectances Synthesized colours
- Observer Cone Fundamentals De Marco et al

- MacLeod-Boynton colour space Plot

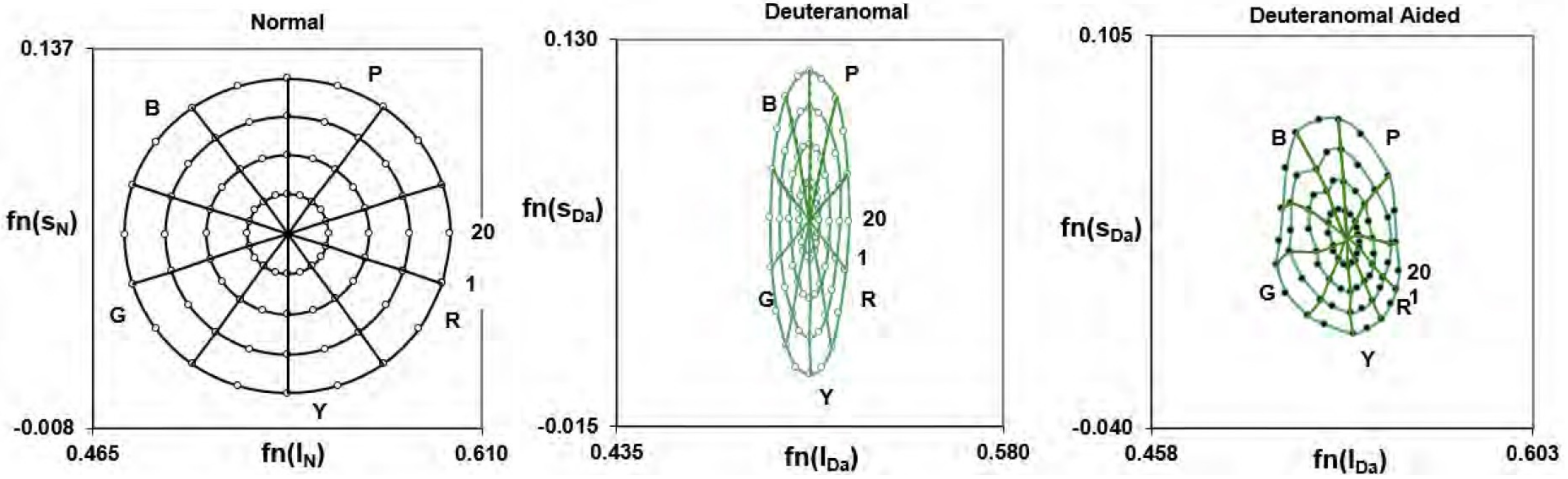
- Enhancement factors E_l and E_s aided/unaided

Results - EnChroma Cx3 SP as an example



Fuller details - https://doi.org/10.1364/OE.461215

Results - EnChroma Cx3 SP as an example



Results Enhancement factors, E_l and E_s, for zone 4 as an example

	Aid	**EnChroma**				**Care lust**	**Color Correct**		**Vino**	
		Cx1	Cx1 DT	Cx3	Cx3 SP	Colo specs	1	2	1	2
Pa	E_l	1.23	1.01	1.23	1.74	0.50	0.88	1.04	1.38	1.44
	E_s	0.98	1.05	1.01	0.72	1.39	1.60	1.24	1.35	1.34
Da	E_l	1.34	1.18	1.34	1.64	0.61	0.99	1.08	1.27	1.29
	E_s	0.96	1.04	1.00	0.67	1.47	1.66	1.26	1.36	1.35
D65 Luminous Transmittance	Pa	0.46	0.65	0.14	0.13	0.09	0.02	0.06	0.22	0.04
	Da	0.49	0.62	0.14	0.19	0.24	0.06	0.16	0.28	0.05

Previously proposed a minimum enhancement factor of 2. https://doi.org/10.1111/j.1475-1313.2010.00761.x

Conclusions

Of the 9 lenses assessed

- only Cx3 SP has an E_l close to our recommended utility value of 2
- 1.7 for Pa and 1.6 for Da
- at the expense of reduced Blue-Yellow discrimination (E_s = 0.72 Pa, 0.67 Da)

This metric maybe useful in assessing aids for true red-green discrimination enhancement more rapidly and at less cost

For fuller results and reference list see https://doi.org/10.1364/OE.461215