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Hosted By: Vision Technical Group

26 June 2020, 12:00 - 13:00 EasternTime

OSA Vision Technical Group Workshop Part II: Chromatic Aberrations in Vision

Chromatic aberrations in the eye and their interactions

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Professor of Research

CSIC Consejo Superior de Investigaciones Científicas

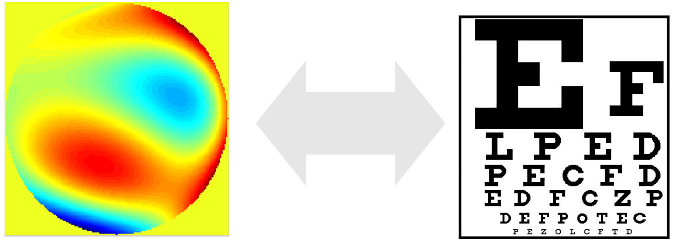
IO Instituto de Óptica

VIOBIO Visual Optics & Biophotonics Lab

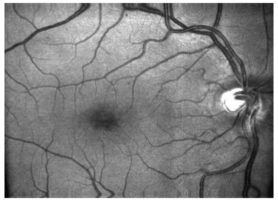
The aberrometers measure monochromatic aberrations but the visual world is polychromatic

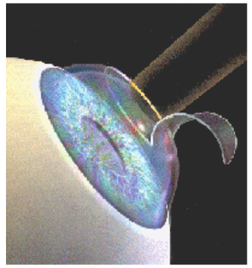
Why is it interesting to investigate chromatic aberrations?

1. To correlate optical & visual performance/perception

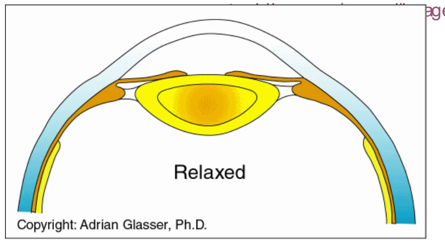


2. To extrapolate aberration measured in IR to other λ





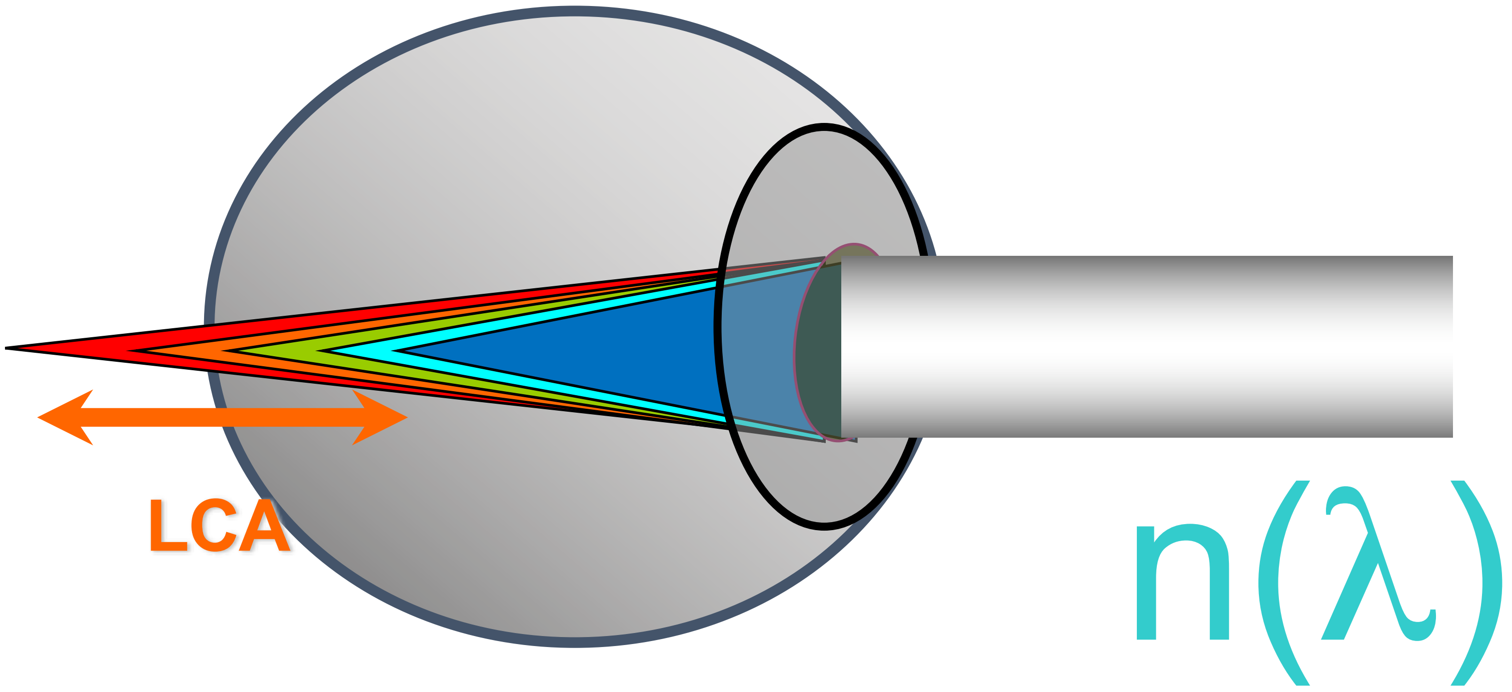
3. As it plays potentially an important role in accommodation & emmetropization



4. As chromatic aberrations depend on IOL materials

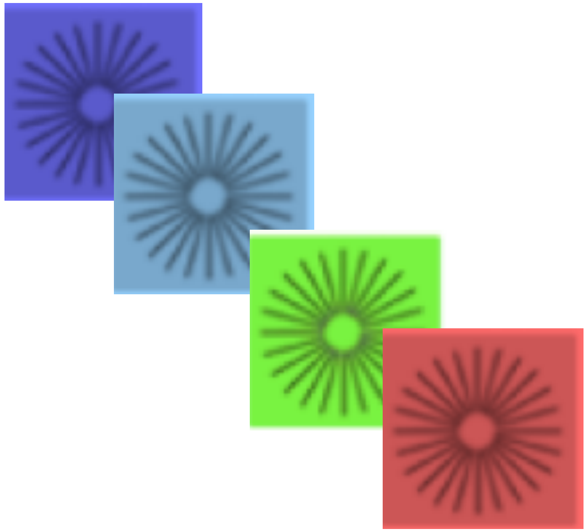
Longitudinal Chromatic Aberration (LCA)

Difference of focus as a function of wavelength



Measuring LCA

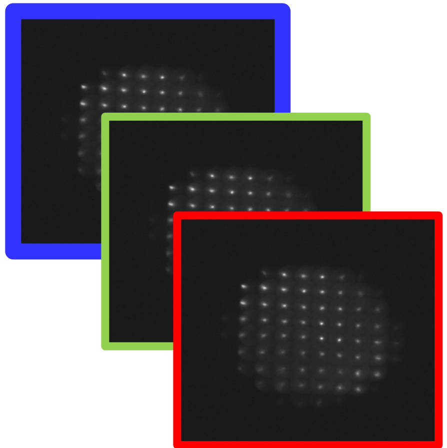
Psychophysical Methods



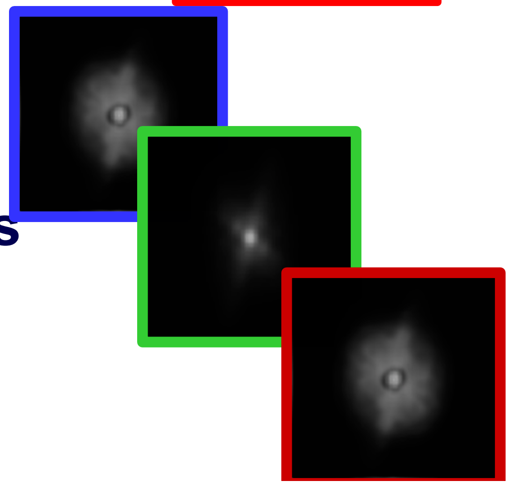
Psychophysical adjustment of best focus

Reflectometric Methods

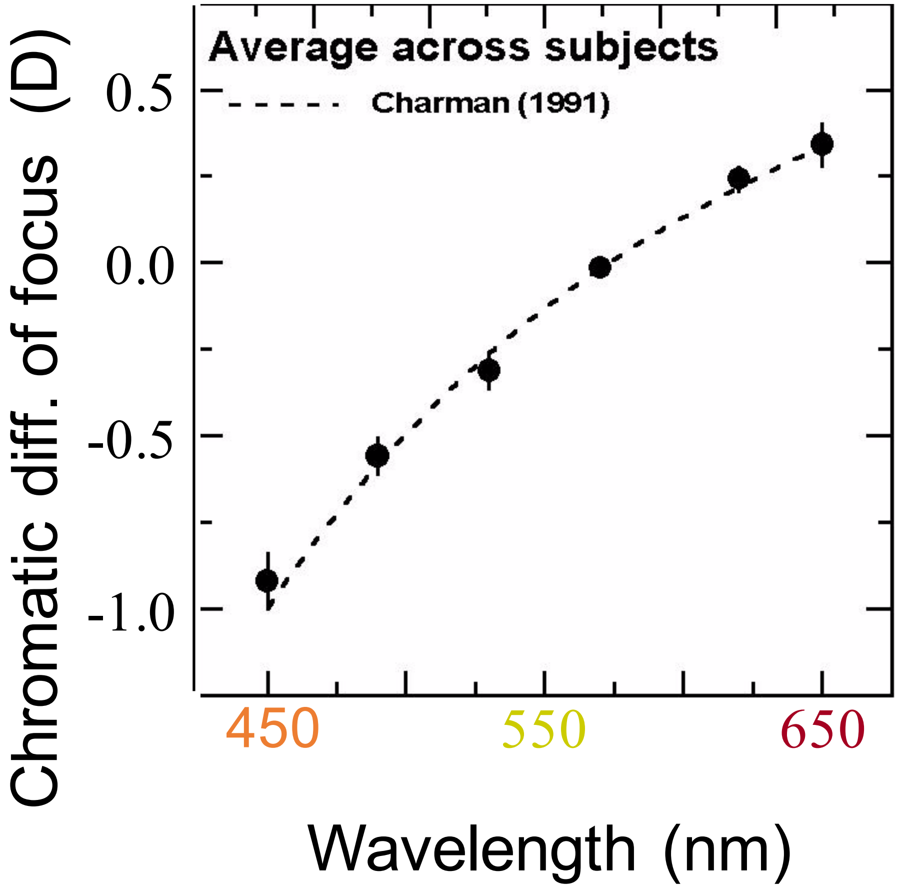
Wave aberrometry at different wavelengths (defocus term)



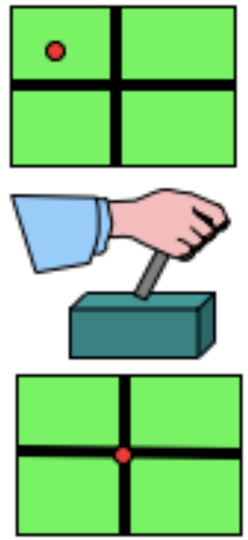
Double pass retinal images (at different wavelengths)

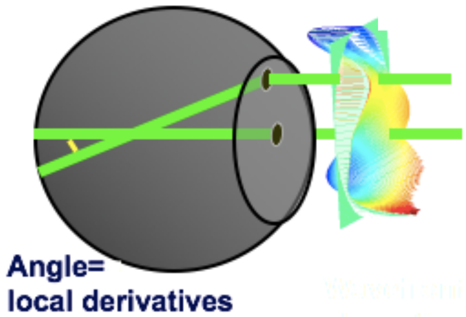


Chromatic difference of focus from defocus term: SRR



Using the Spatially Resolved Refractometer

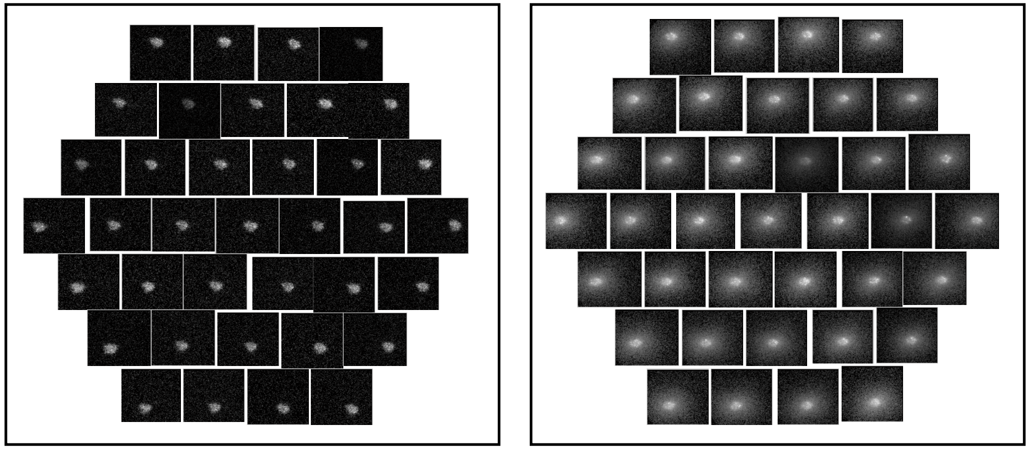




Marcos et al, Vision Res. 1999

Chromatic difference of focus from LRT and HS

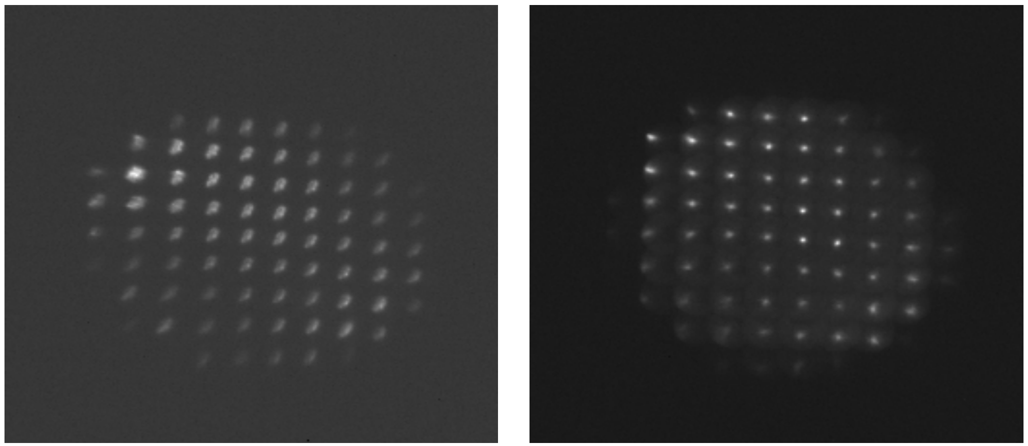
Laser Ray Tracing

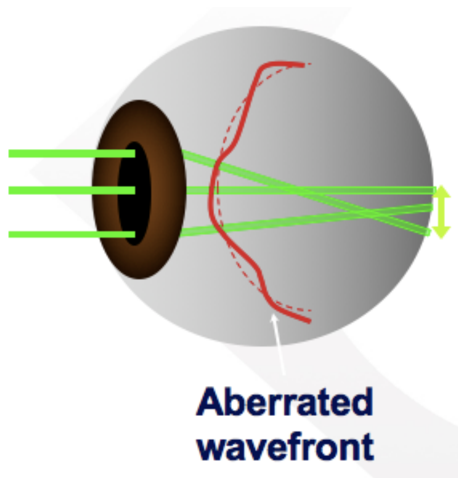


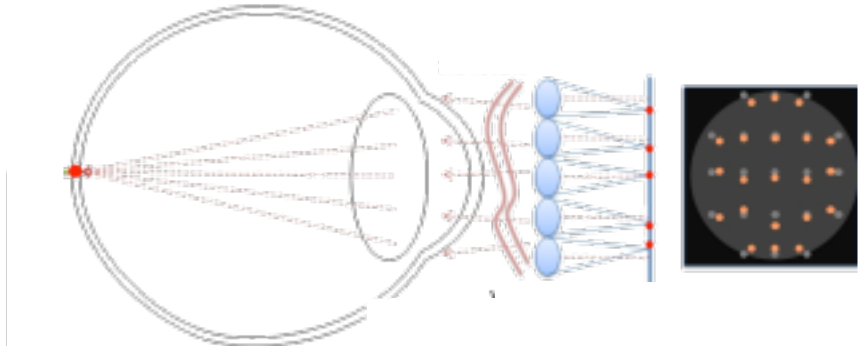
543 nm

786 nm

Hartmann-Shack

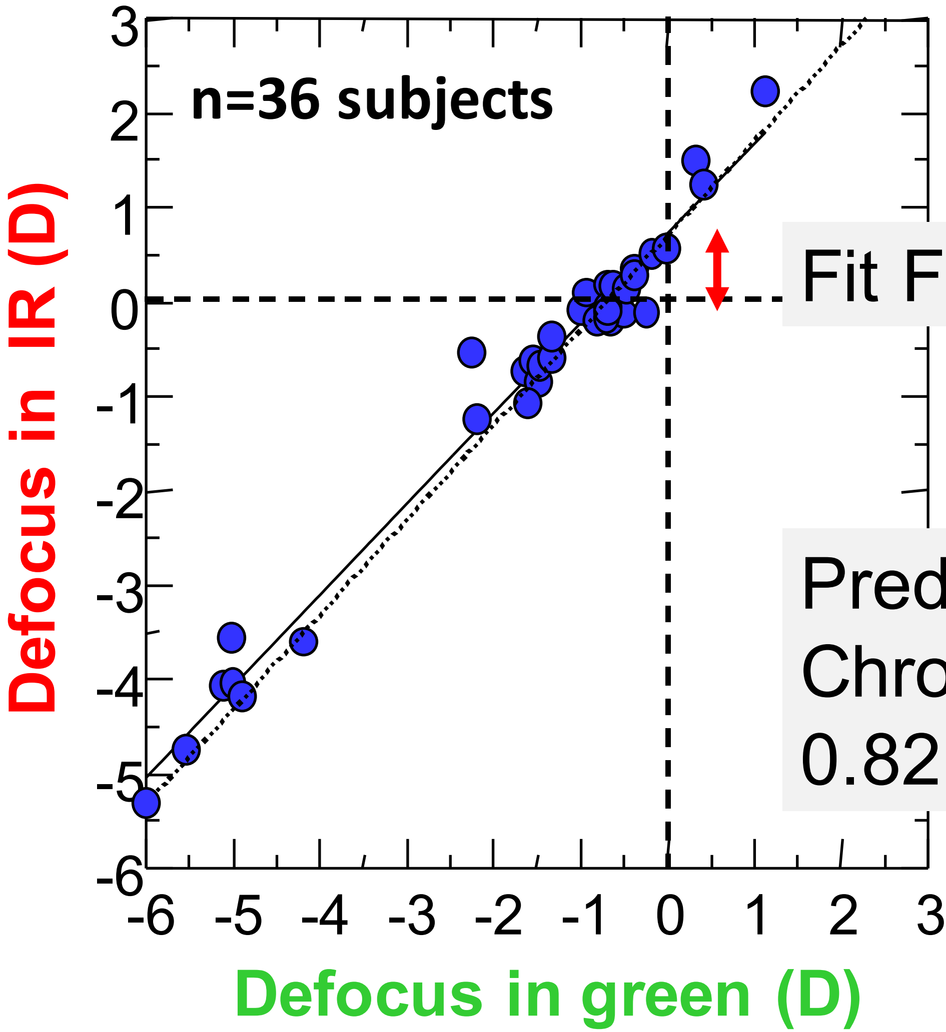






Llorente et al. OVS 2003

Chromatic difference between IR and green light

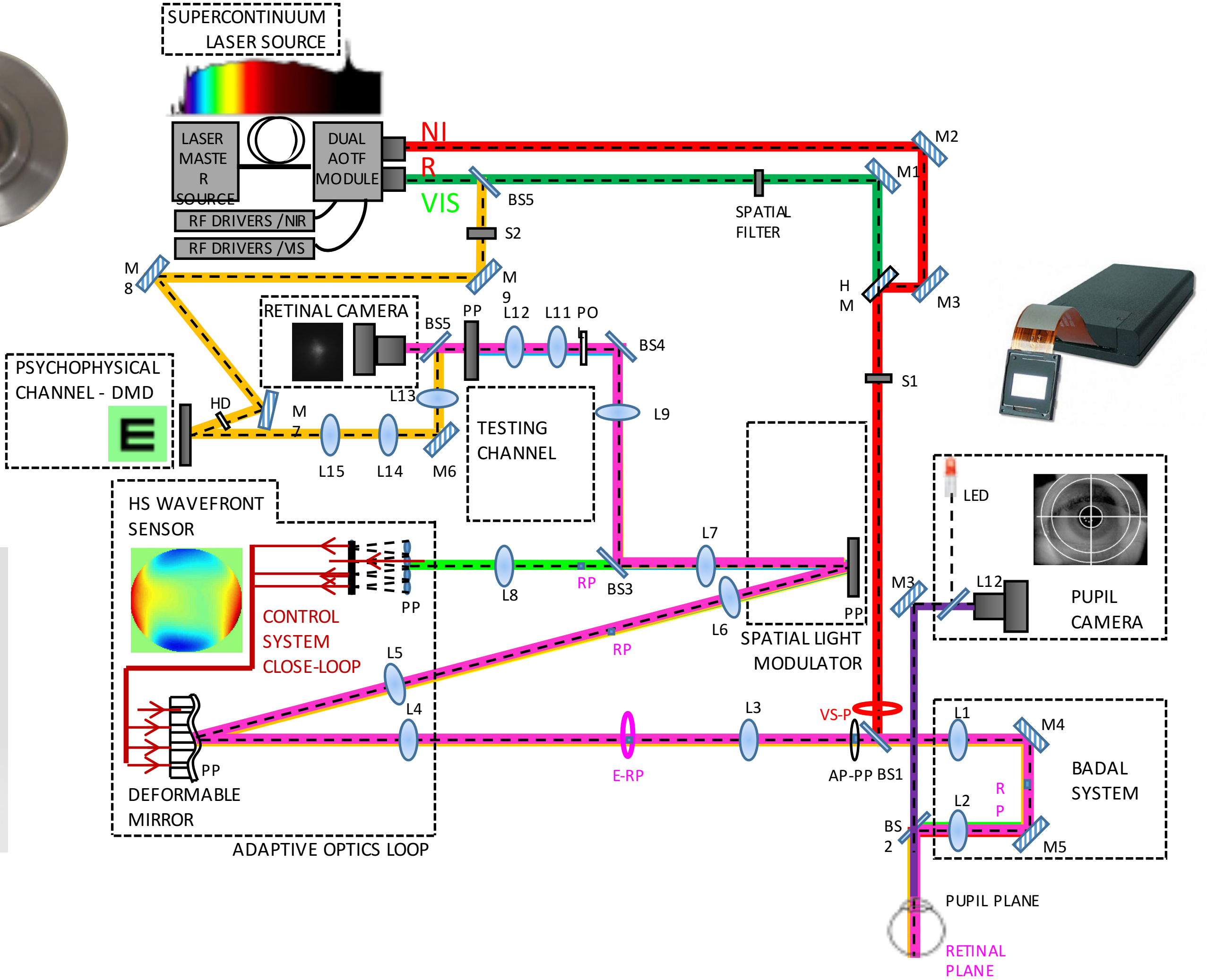


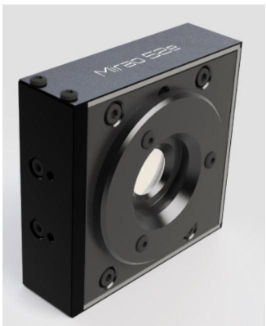
Fit Focus shift= 0.72 D

Prediction from Indiana Chromatic Eye model= 0.82 D

Llorente, Díaz-Santana, Lara-Saucedo & Marcos, OVS 2003

VIOBIO Polychromatic Adaptive Optics II





Supercontiuum laser: Visible-IR

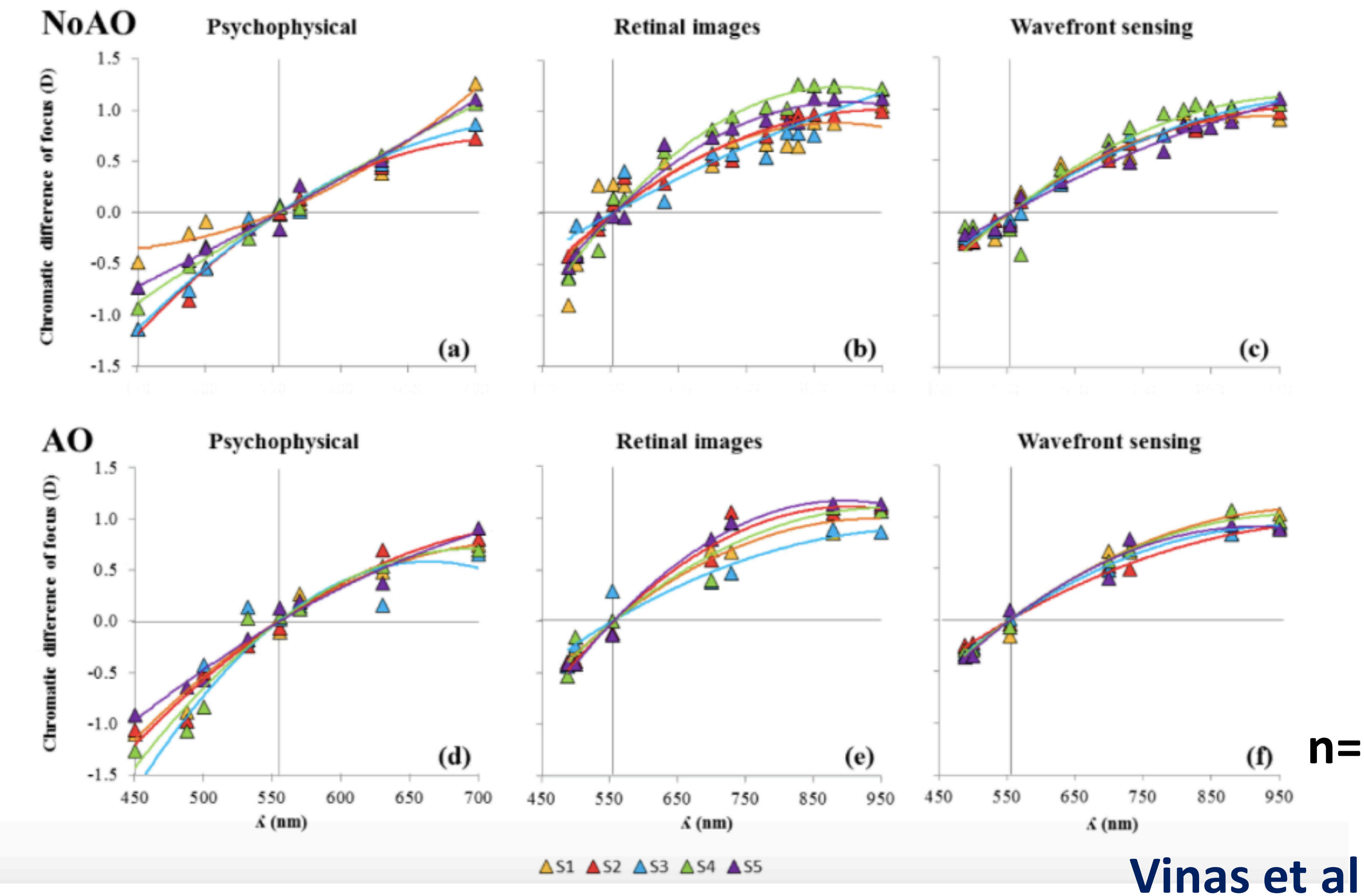
Psychophysical channel

Hartmann-Shack wave aberrations

Double-pass

AO-correction of aberrations

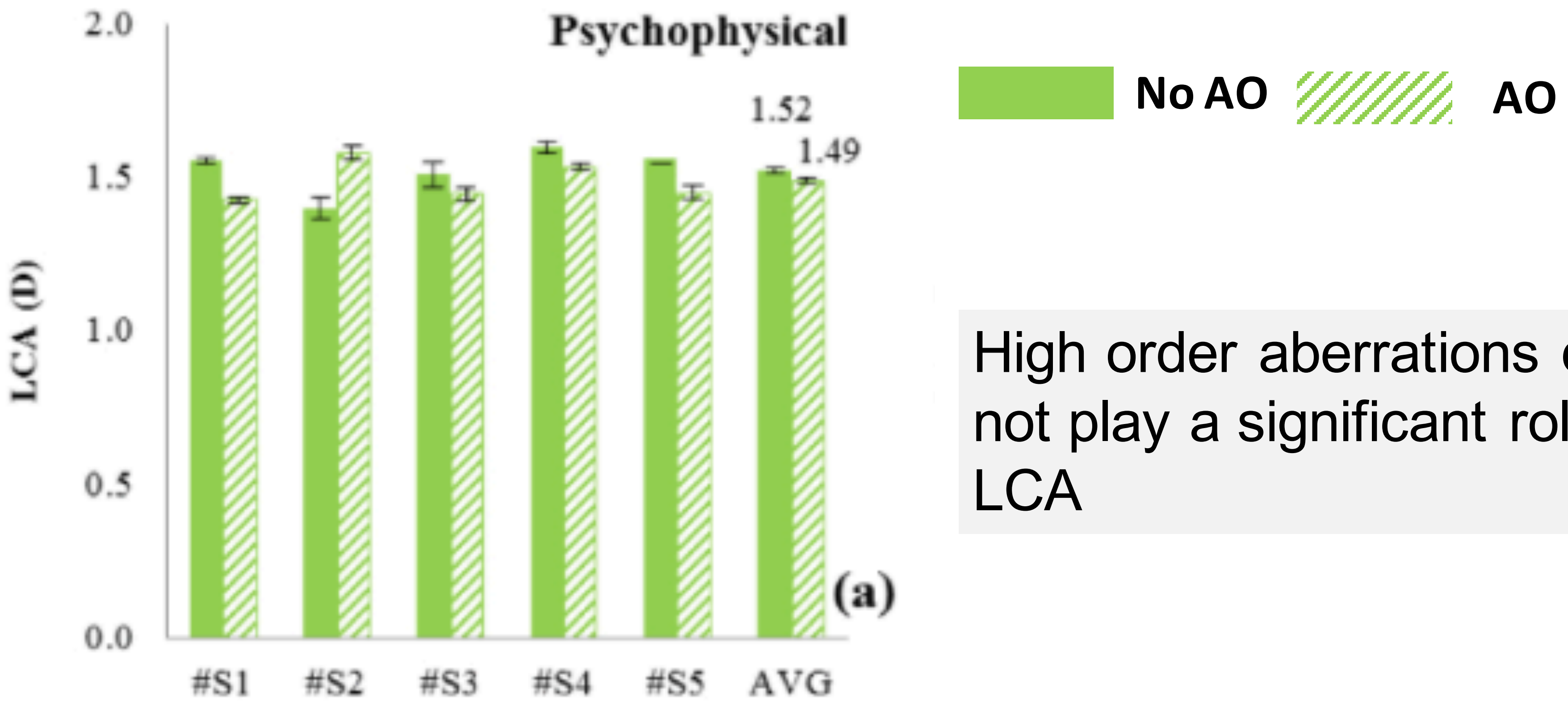
Chromatic Difference of Focus (Psychophysical / Refletometric)



n=5 subjects

Vinas et al BOE 2015

Psychophysical LCA: Effect of AO-correction

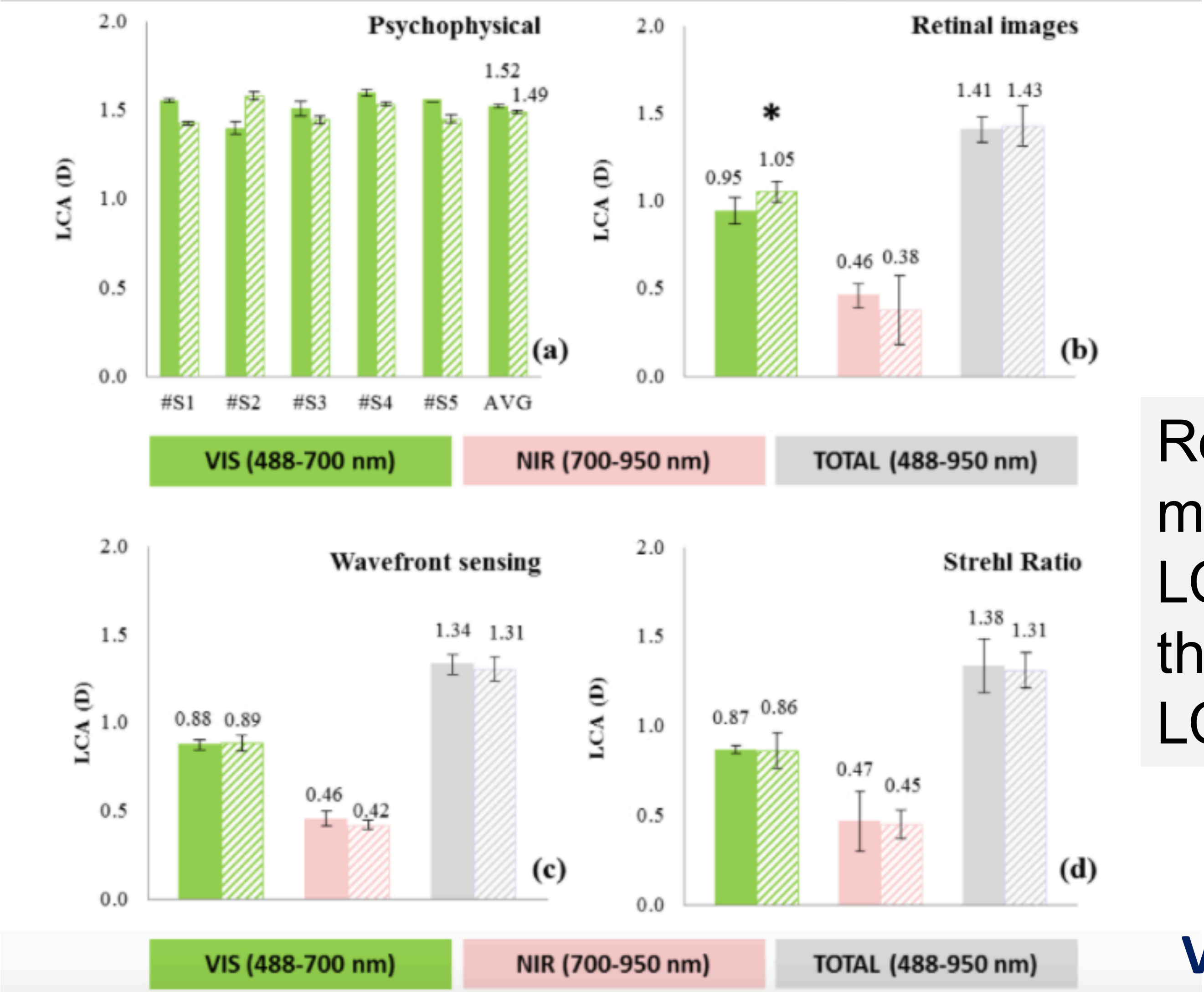


488-700 nm

High order aberrations do not play a significant role in LCA

Vinas et al BOE 2015

Psychophysical vs reflectrometric LCA

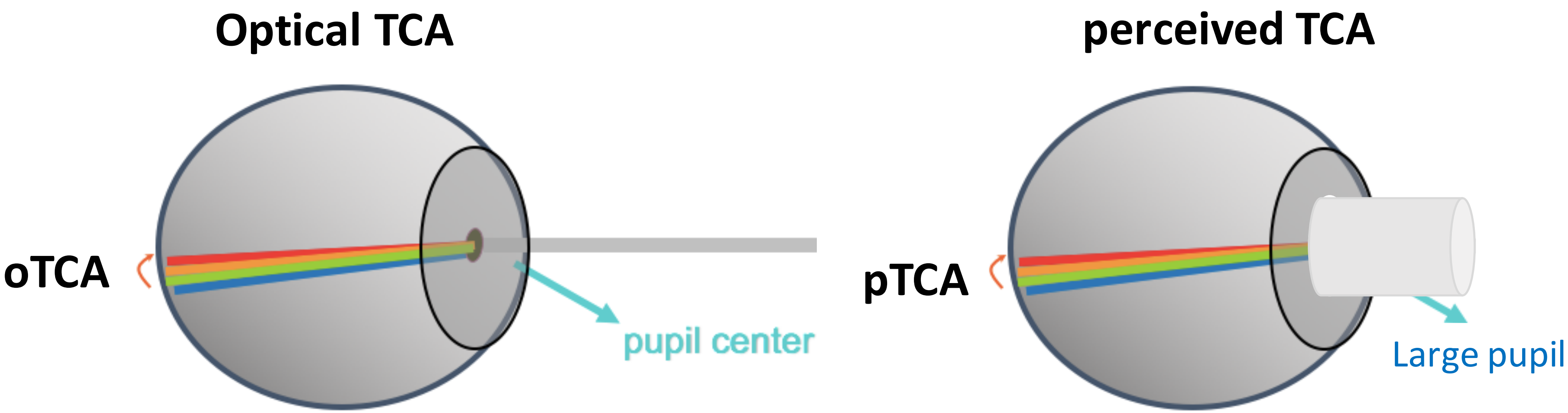


Reflectometric measurements of LCA underestimate the psychophysical LCA

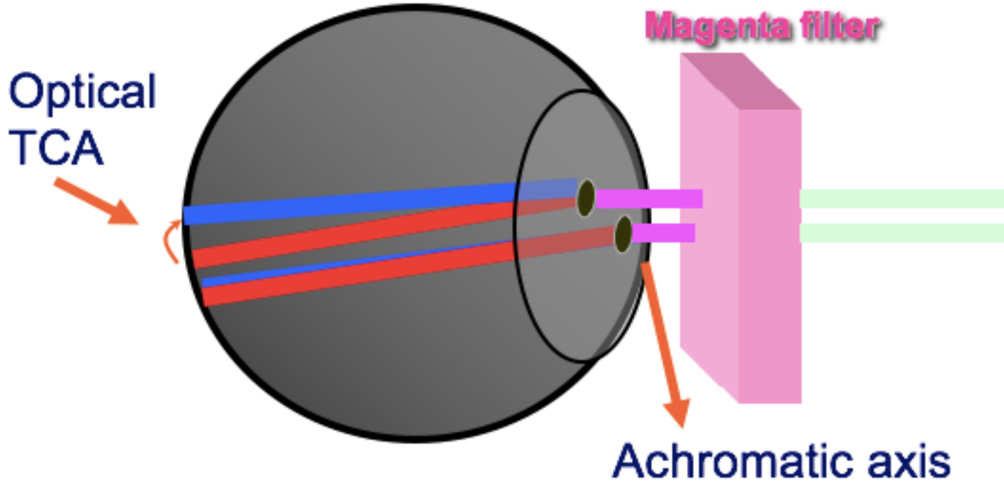
Vinas et al BOE 2015

Transverse Chromatic Aberration (TCA)

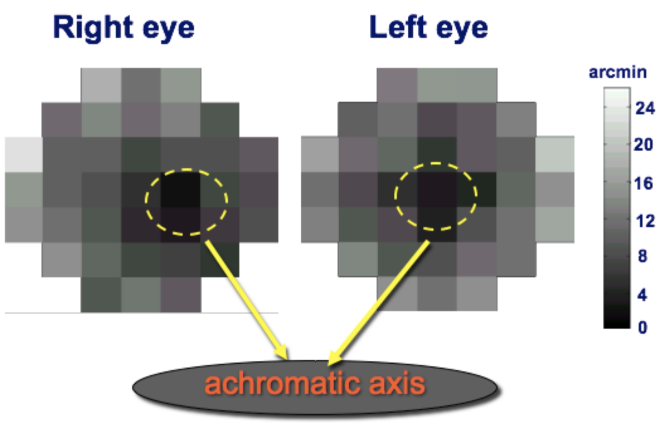
Lateral separation between between red & blue spots

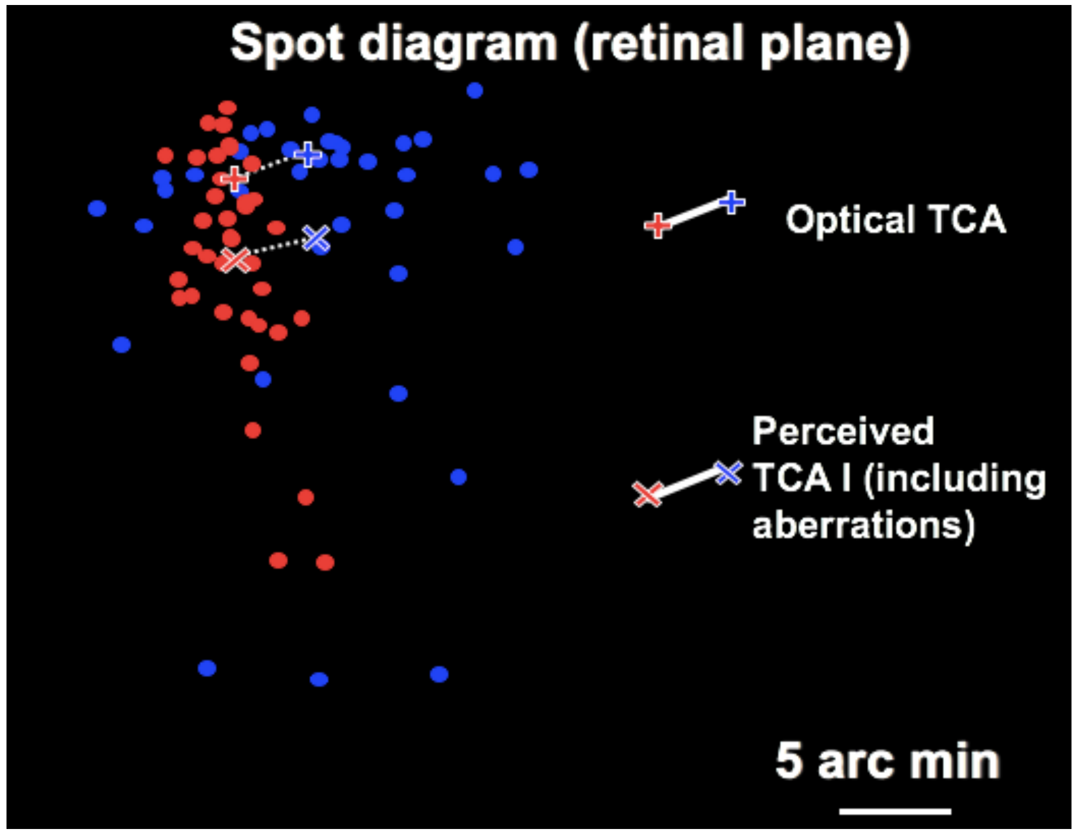


TCA & achromatic axis using SRR



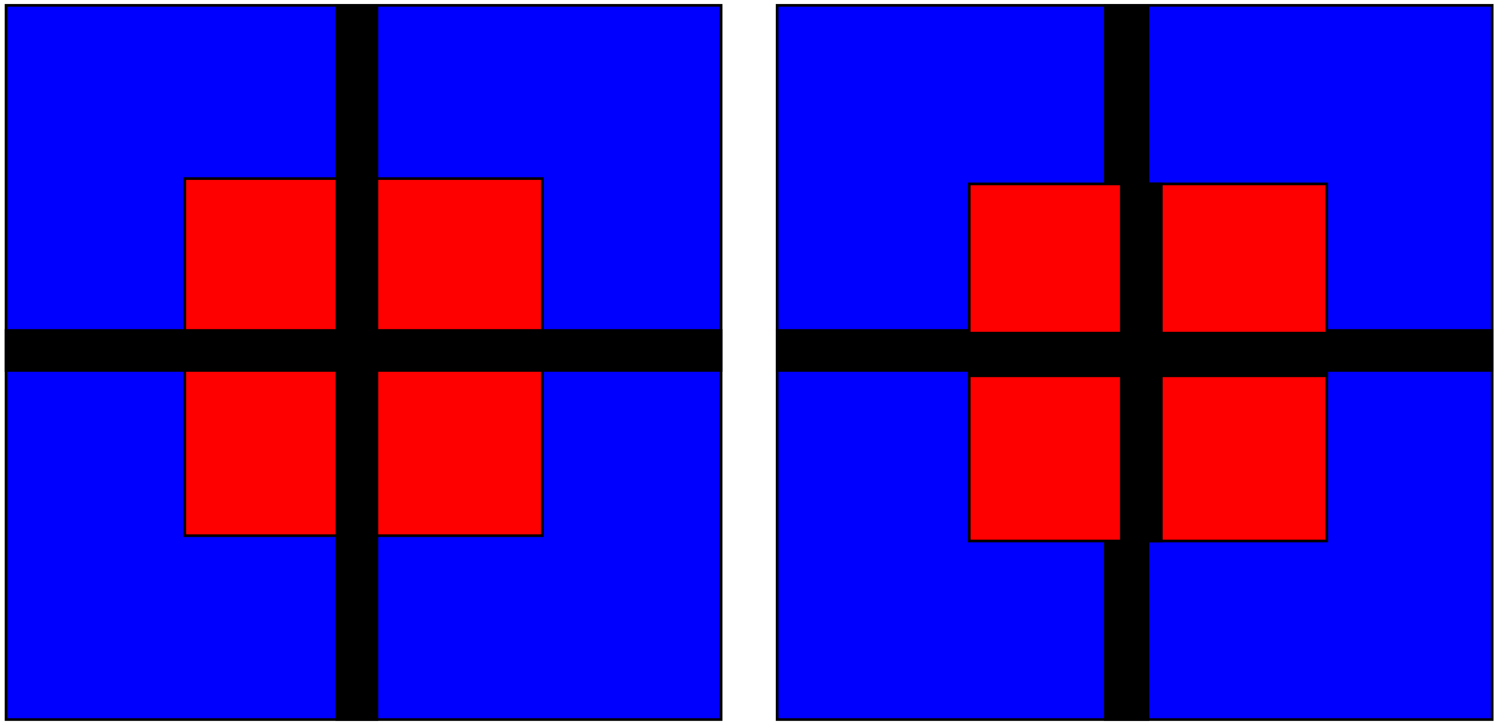
Parallax functions (pupil plane)





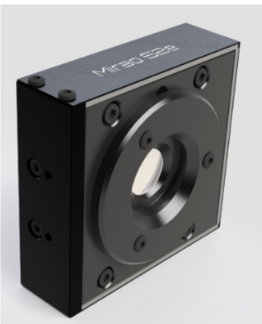
Marcos et al. Vision Res 2000

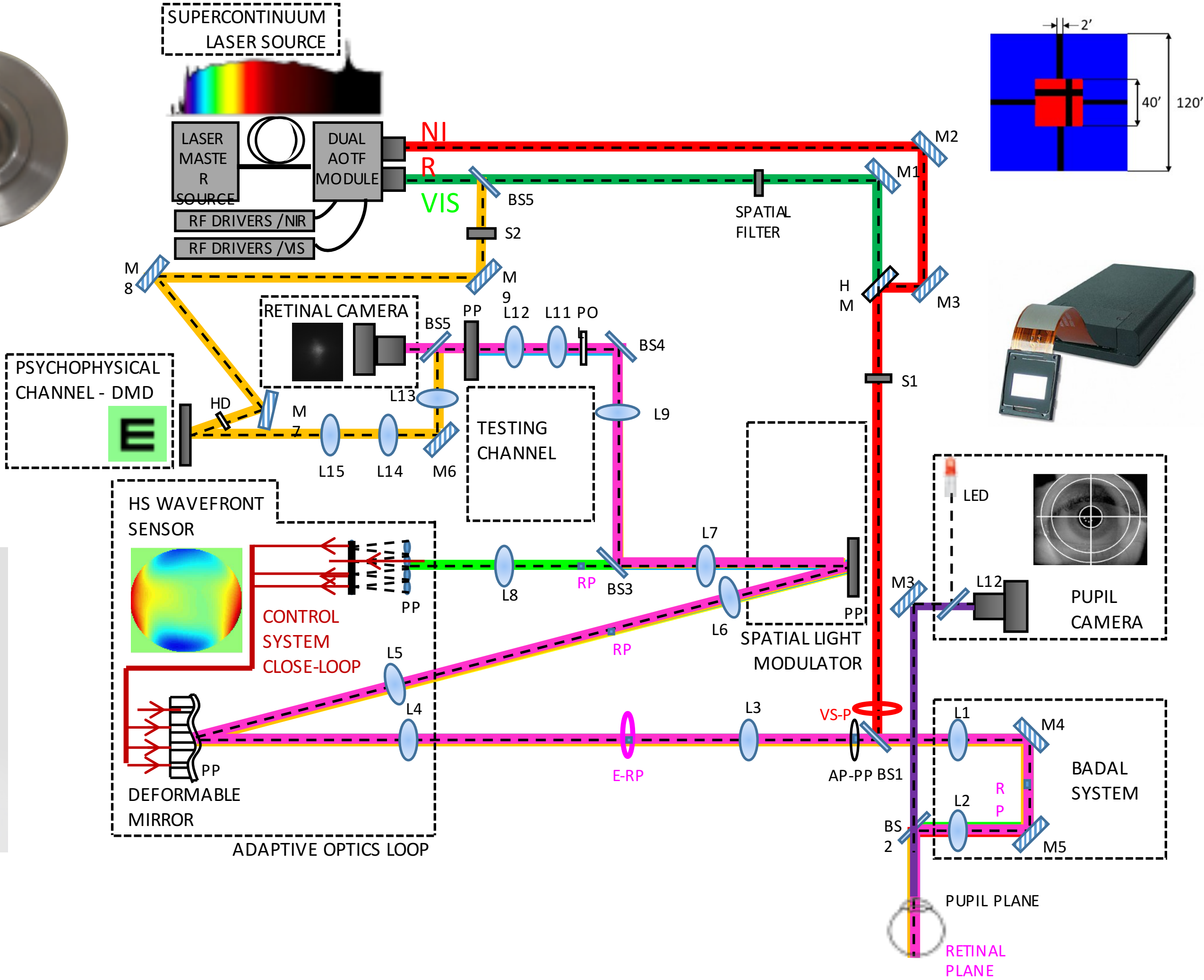
TCA (Vernier Alignment Test)

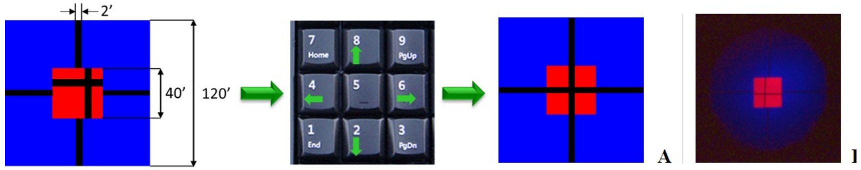


Thibos et al.1990

VIOBIO Polychromatic Adaptive Optics II



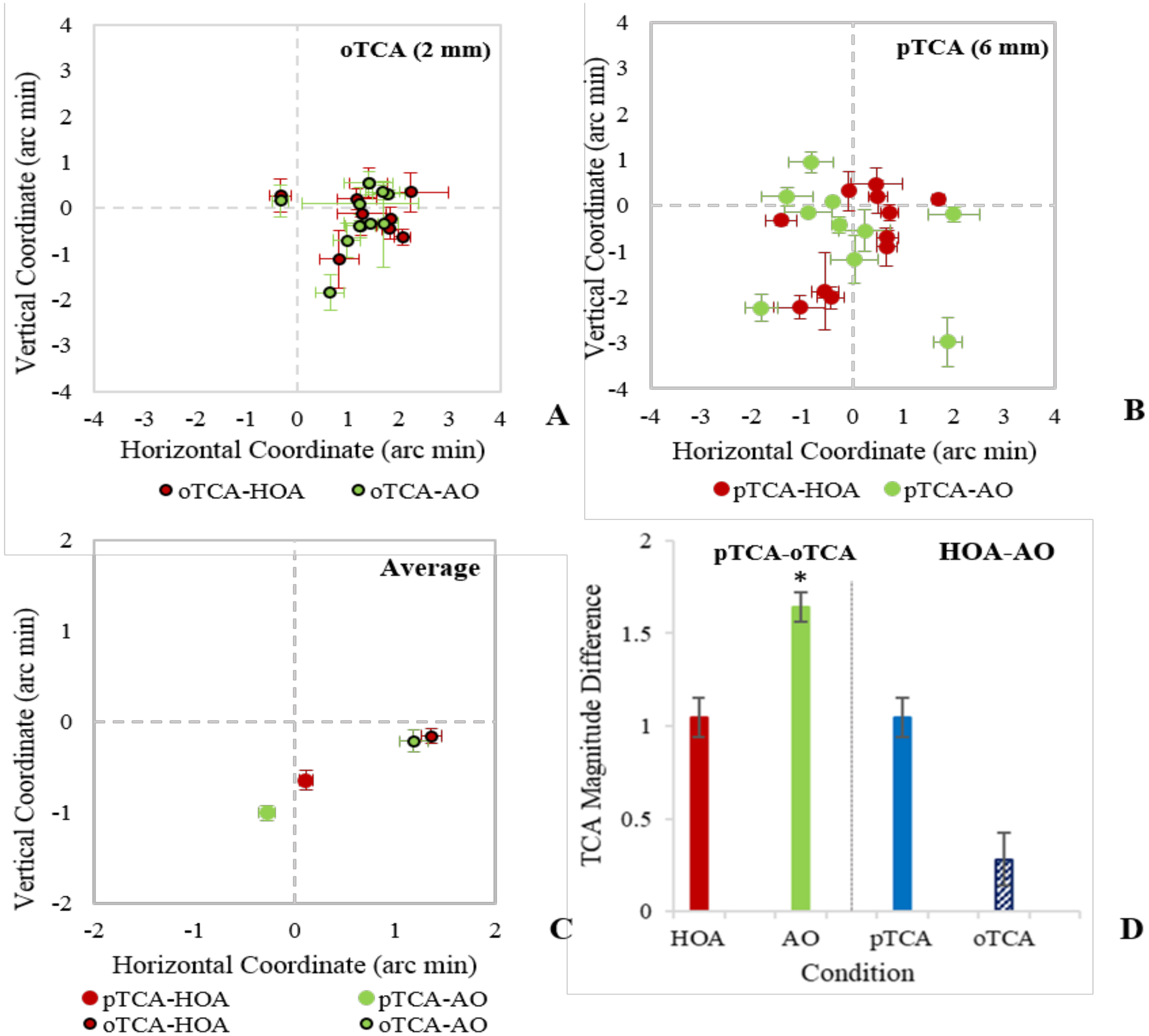




TCA channel

Aissati et al. BOE 2020

Optical & Perceived TCA (with/without aberrations)



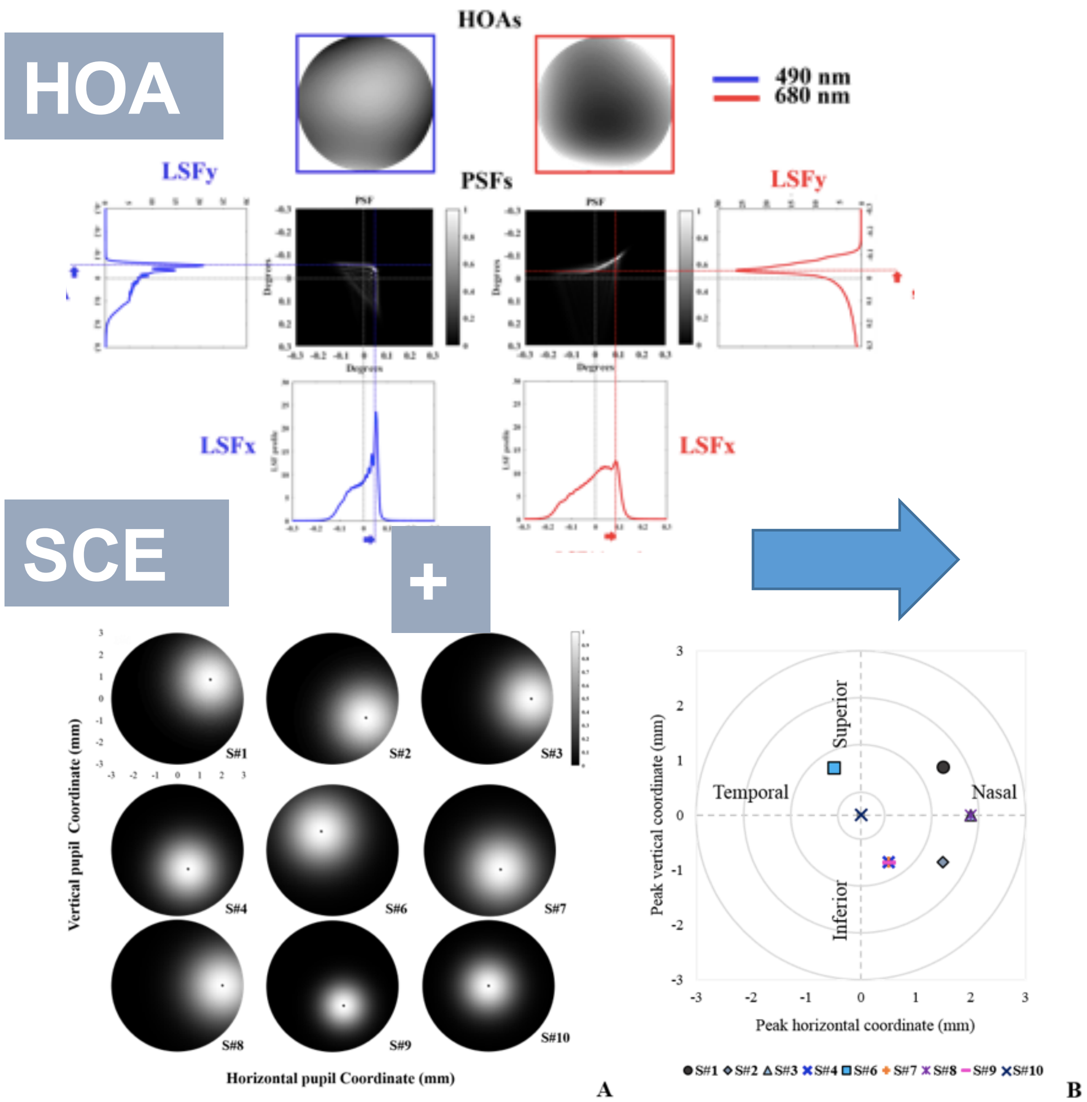
Increasing pupil diameter shifts TCA direction

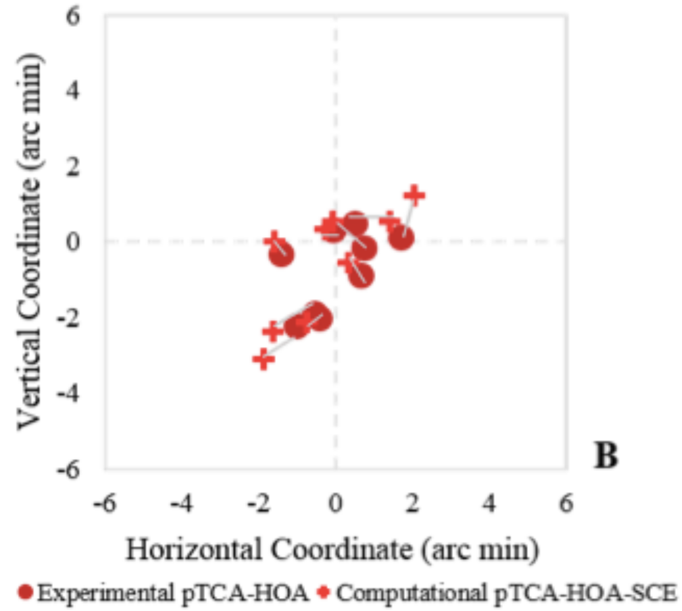
Correcting HOA increases perceived TCA

n=11 subjects

Aissati et al. BOE 2020

Predicted and simulated perceived TCA

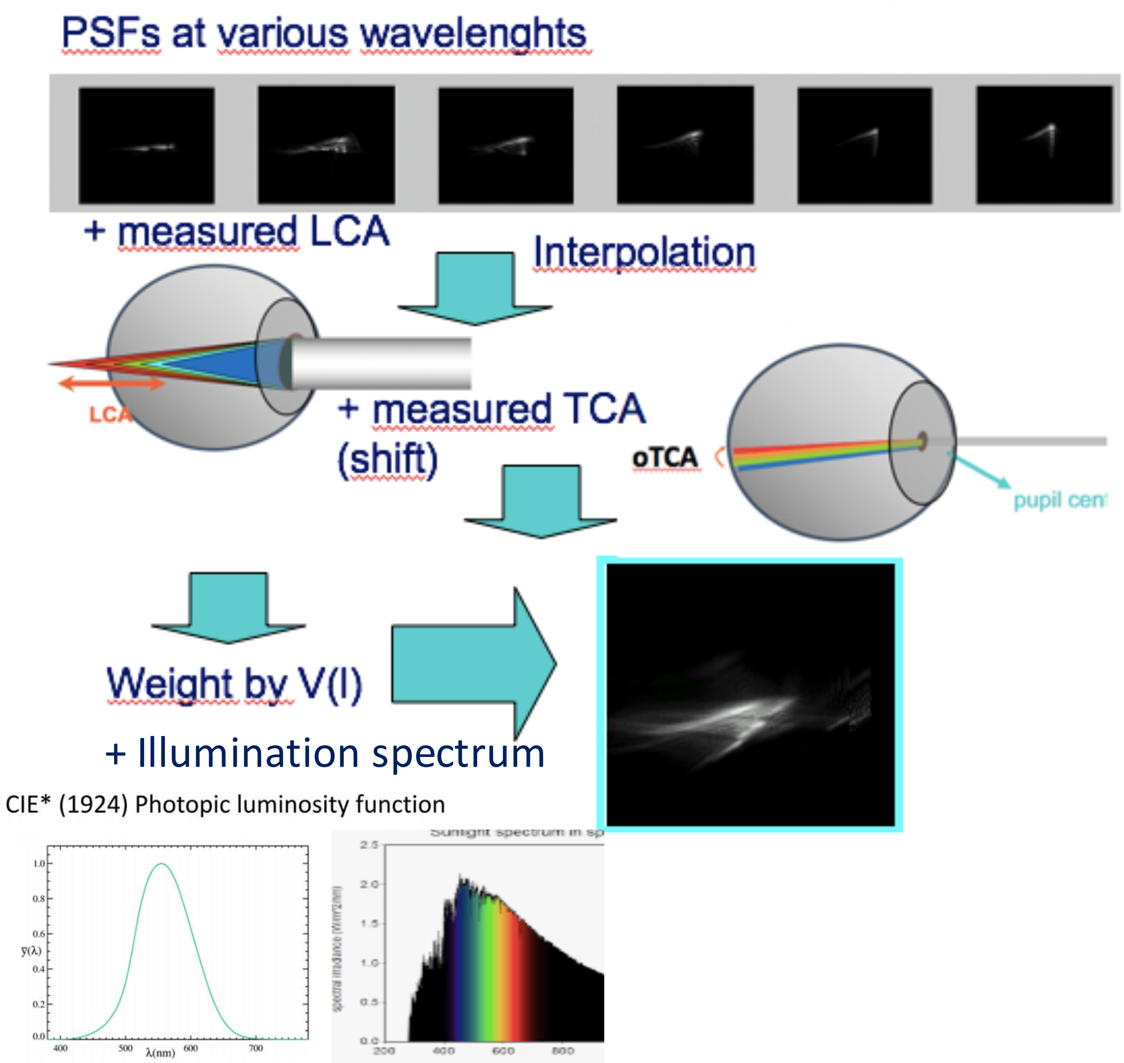


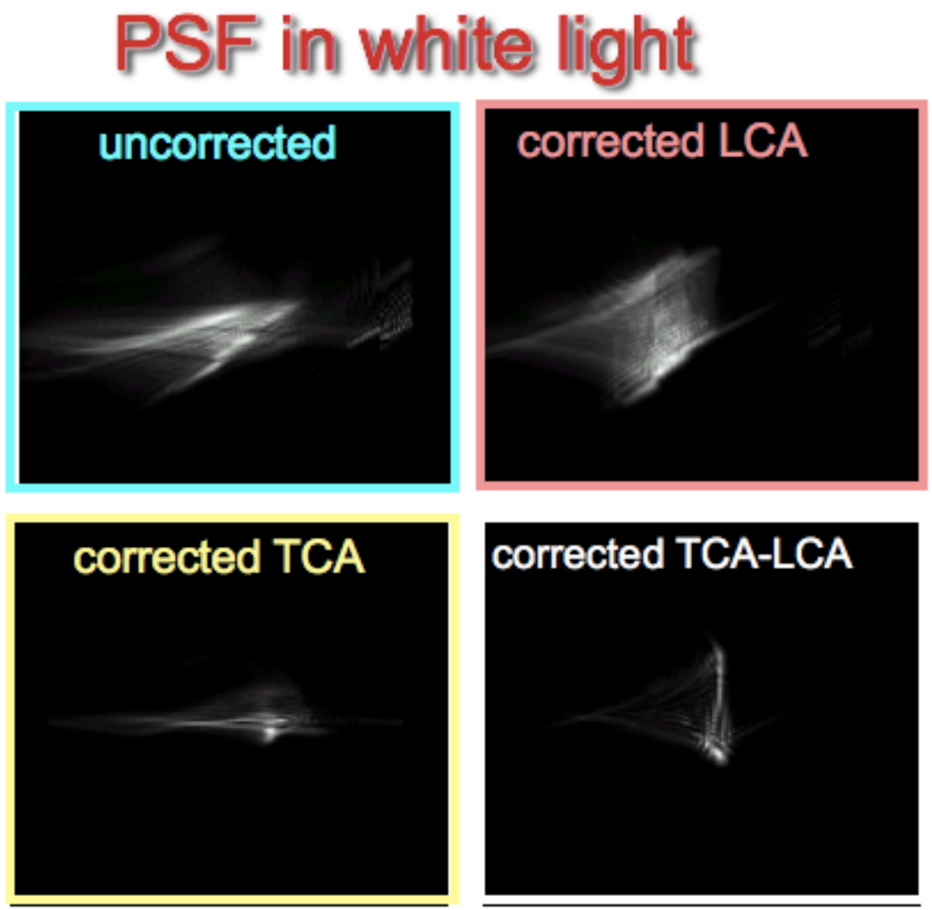


The magnitude and orientation of perceived TCA can be predicted from the oTCA, HOA and Stiles-Crawford Effect

Aissati et al. BOE 2020

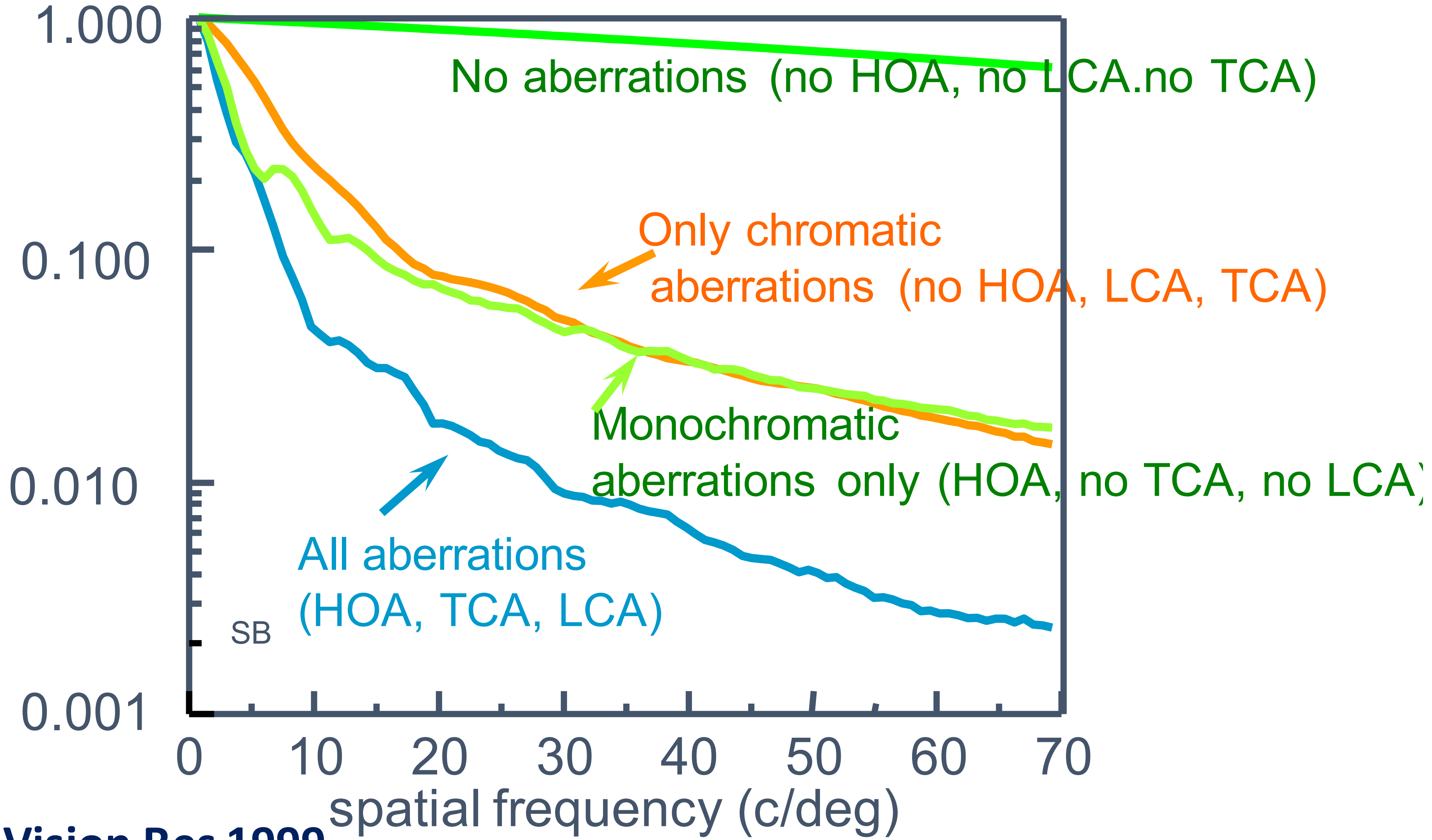
Polychromatic Optical Quality





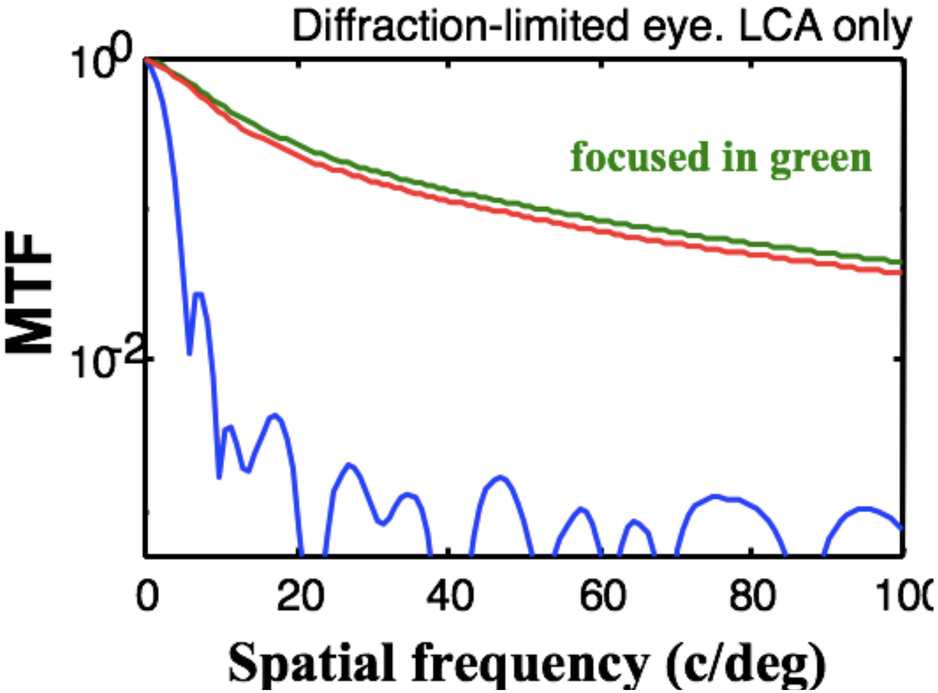
Marcos et al. Vision Res 1999

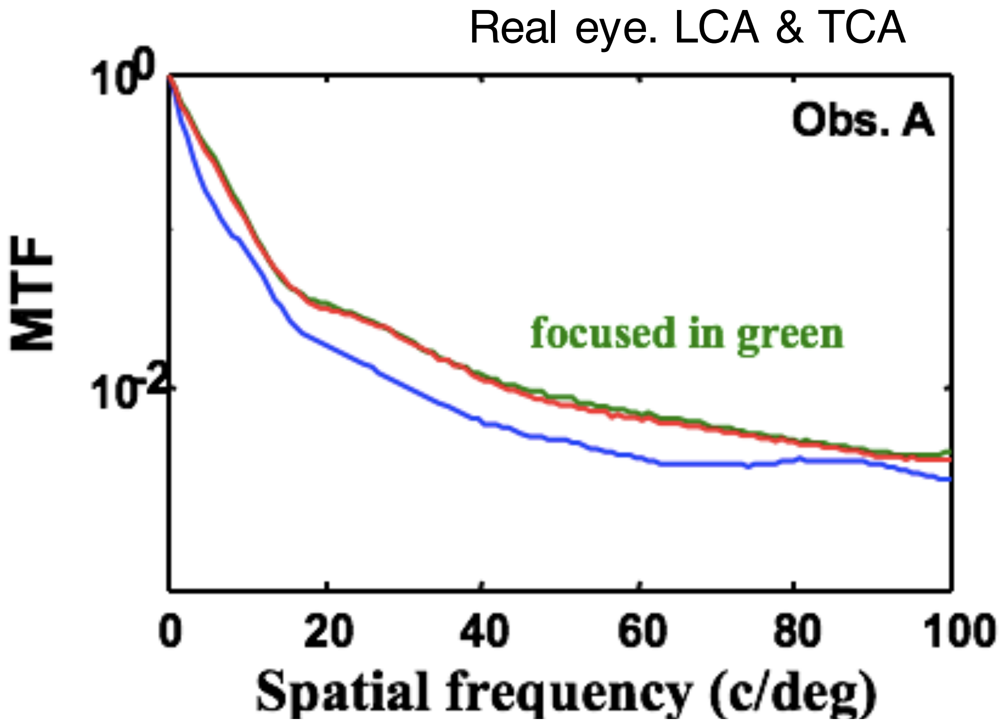
Effect of chromatic aberrations on a perfect eye



Marcos et al. Vision Res 1999

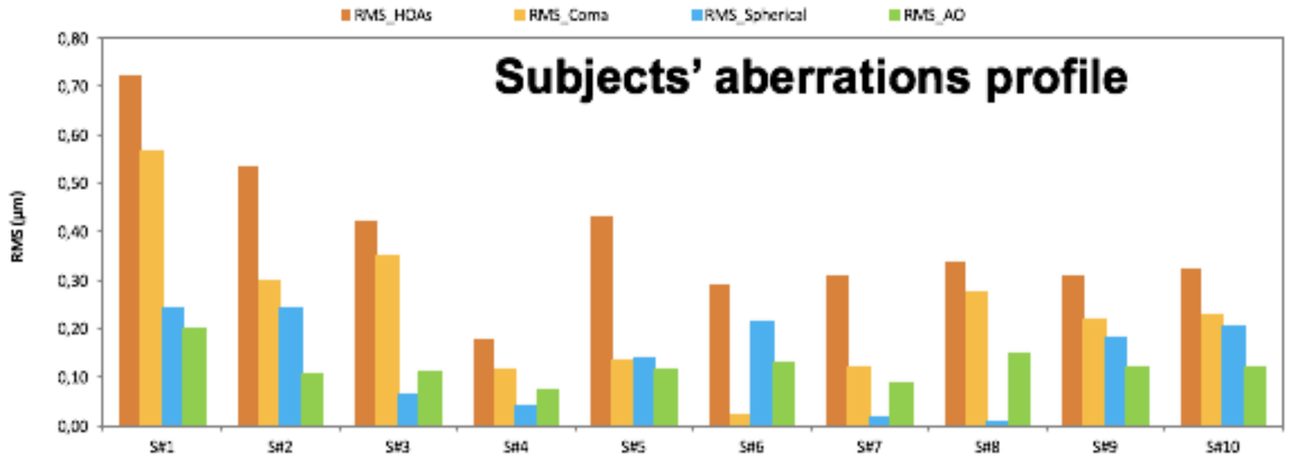
Monochromatic aberrations: eye's defense against chromatic optical blur



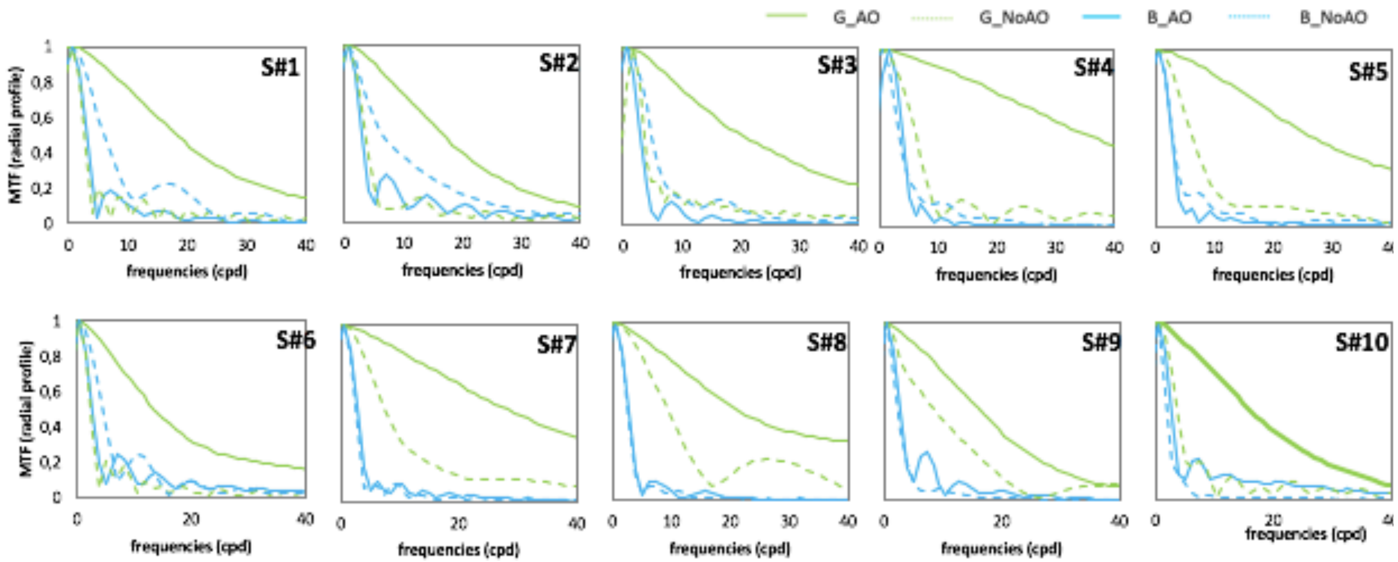


McLellan, Marcos, Prieto & Burns, Nature 2001

The higher the aberrations, the higher the effect



MTF radial profiles



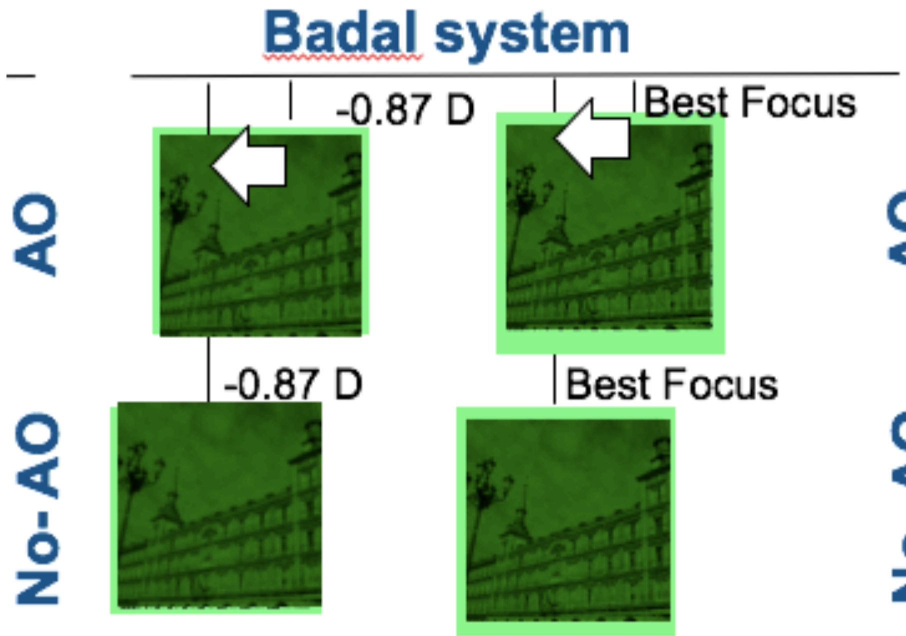
n=10 subjects

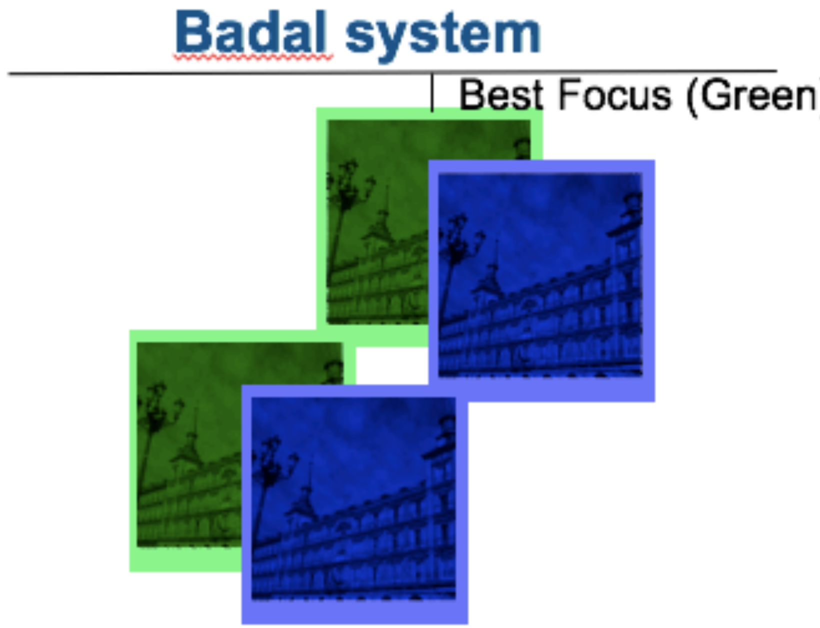
Benedi-Garcia et al.
Submitted

What is the perceptual effect of LCA on AO-corrected eyes?

Green Focused images & defocused by LCA-equivalent

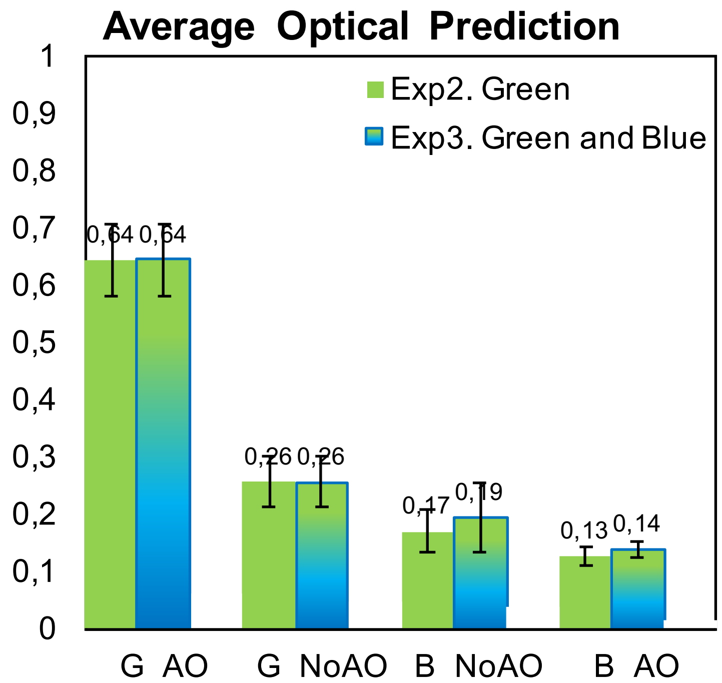
Green Focused images & Blue images naturally defocused by LCA

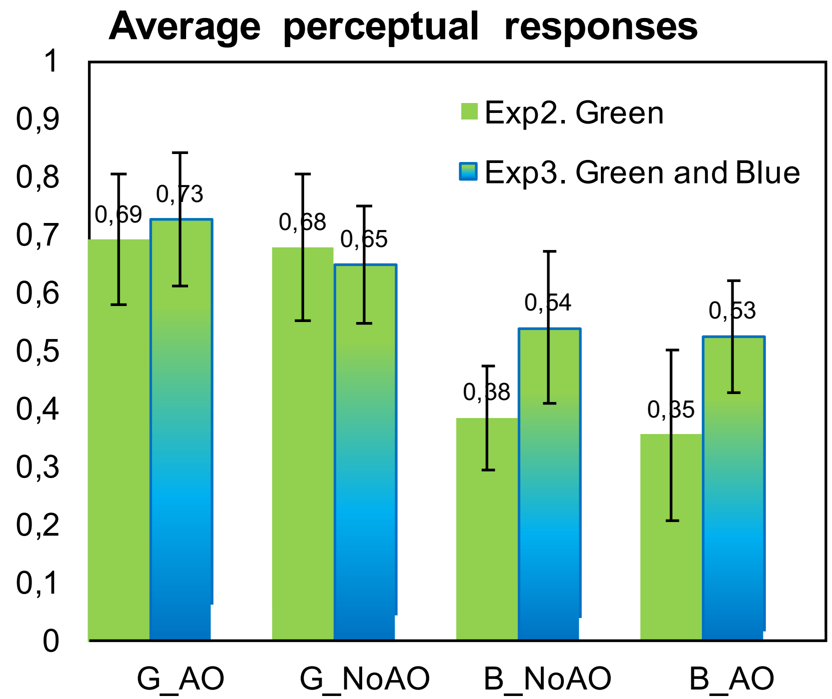




10 normal subjects; different amount of aberrations
Each subject judged 108 images (9 repetitions)

Optical vs perceptual effects





- ✓ The "protective chromatic effect" is preserved perceptually but highly attenuated
- ✓ The effect is higher in eyes with higher amounts of aberrations
- ✓ While the effect appears to be associated to blur, chromatic & adaptation factors may also play a role

Benedi-Garcia et al. *Submitted*

Take-home message

- ✓ Monochromatic aberrations, LCA, TCA (and SCE) all play a role in the polychromatic quality of the eye
- ✓ LCA does not vary much across individuals. Reflectometric techniques understimate the psychophysical LCA
- ✓ TCA (particularly perceived) varies across individuals, and is affected by high order aberrations and SCE
- ✓ LCA protects the eye against chromatic blur. This effect is also observed perceptually, but on top of it, there seems to be contingent adaptation to blur in blue color
- ✓ Adaptive Optics allows measurement and understanding of monochromatic and chromatic aberrations and their interactions

Visual Optics & Biophotonics Lab

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http://www.vision.csic.es

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Maria Vinas, Clara Benedí-García, Sara Aissati, Carlos Dorronsoro, Ana M Gomez (VioBio Lab)

Steve Burns (Indiana University) and Eli Peli (MEEI/Harvard)

Funding

erc European Research Council
Funding for top researchers from anywhere in the world

MARIE CURIE ACTIONS

European Commission

Chromatic aberrations in the pseudophakic eye

María Viñas, PhD

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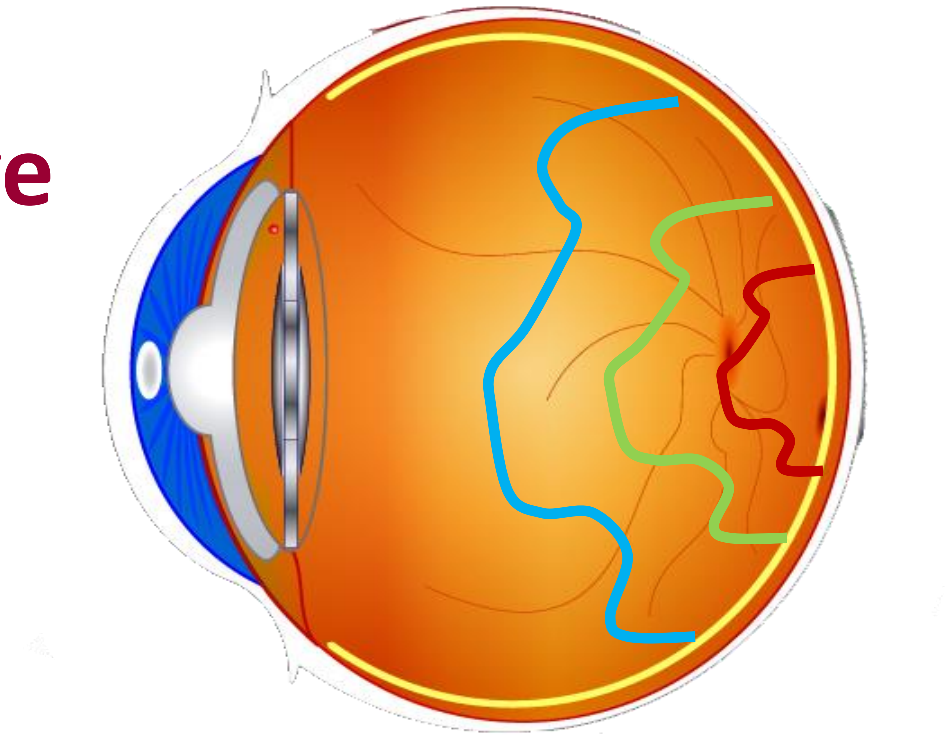
2EYESVISION

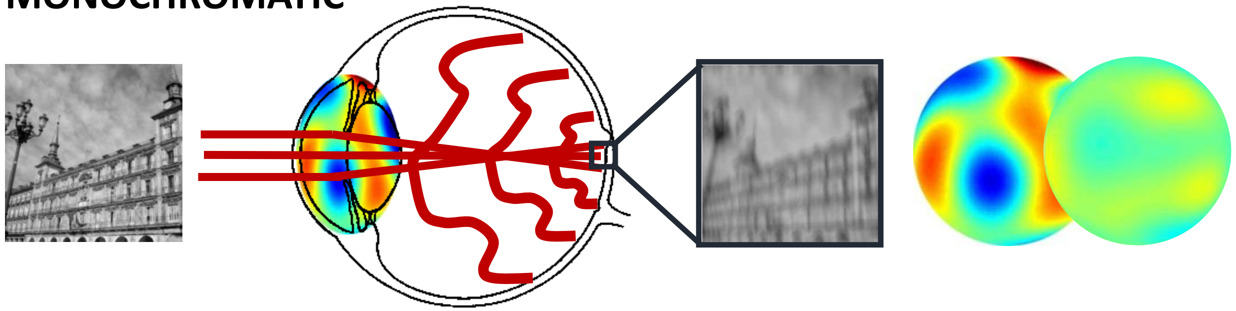


WE ARE ON
OSA 100
LET'S WORK

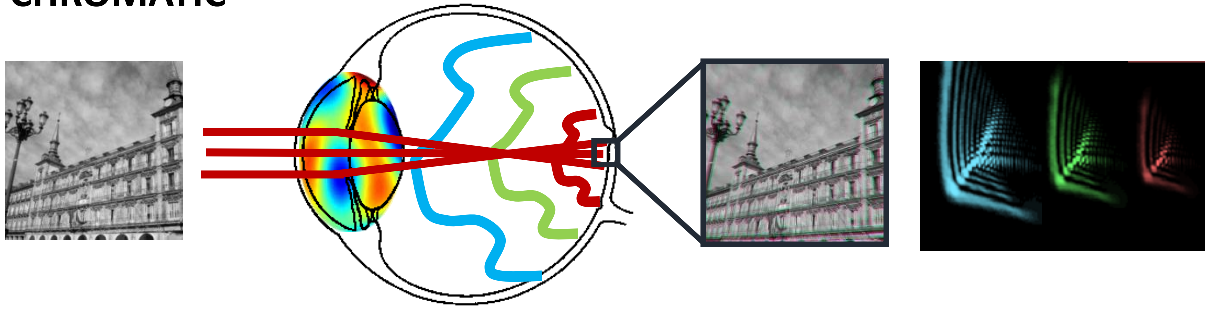
OSA Vision Technical Group
Workshop: Chromatic Aberrations in Vision Part II

Optical quality of the eye: optical aberrations

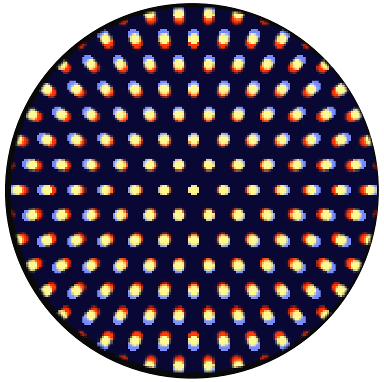
MONOCHROMATIC

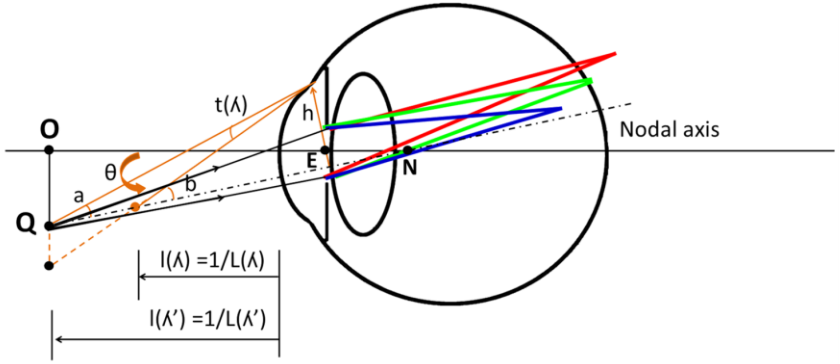


CHROMATIC



Transverse chromatic aberration





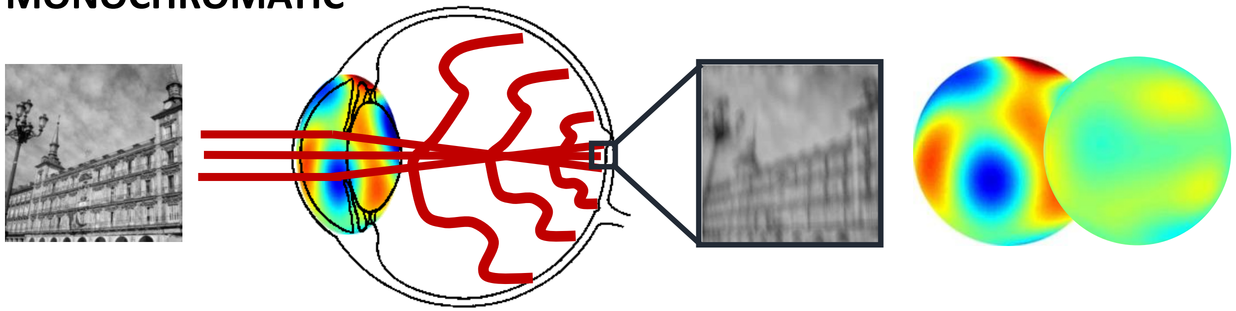
Chromatic difference of magnification

$$\boldsymbol{CDM} = \boldsymbol{t}(\Lambda)/\boldsymbol{\theta}$$

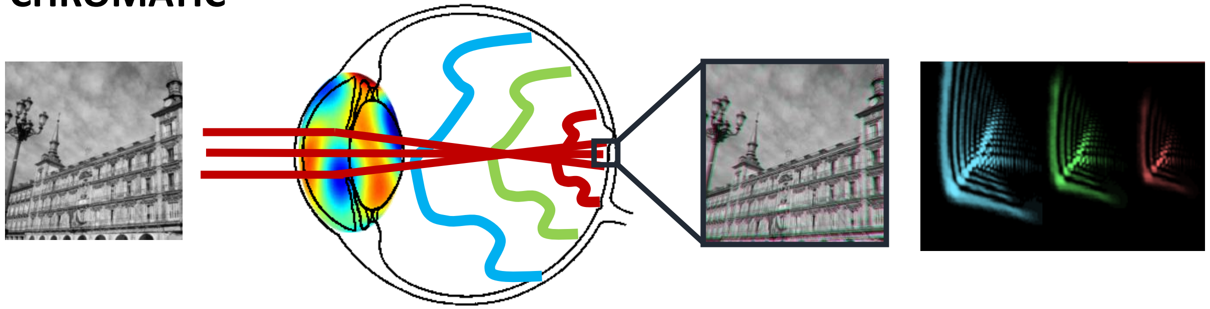
Atchison & Smith, Optics of the human eye, 2000

Optical quality of the eye: optical aberrations

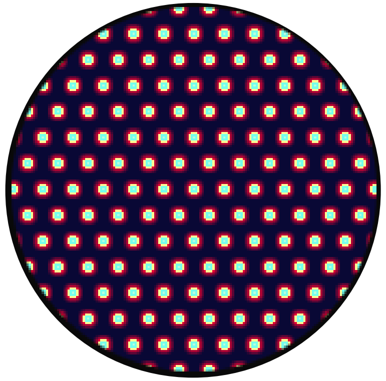
MONOCHROMATIC

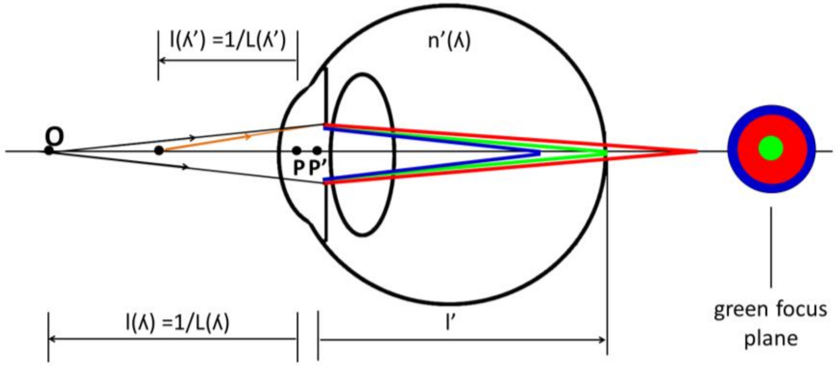


CHROMATIC



Longitudinal chromatic aberration





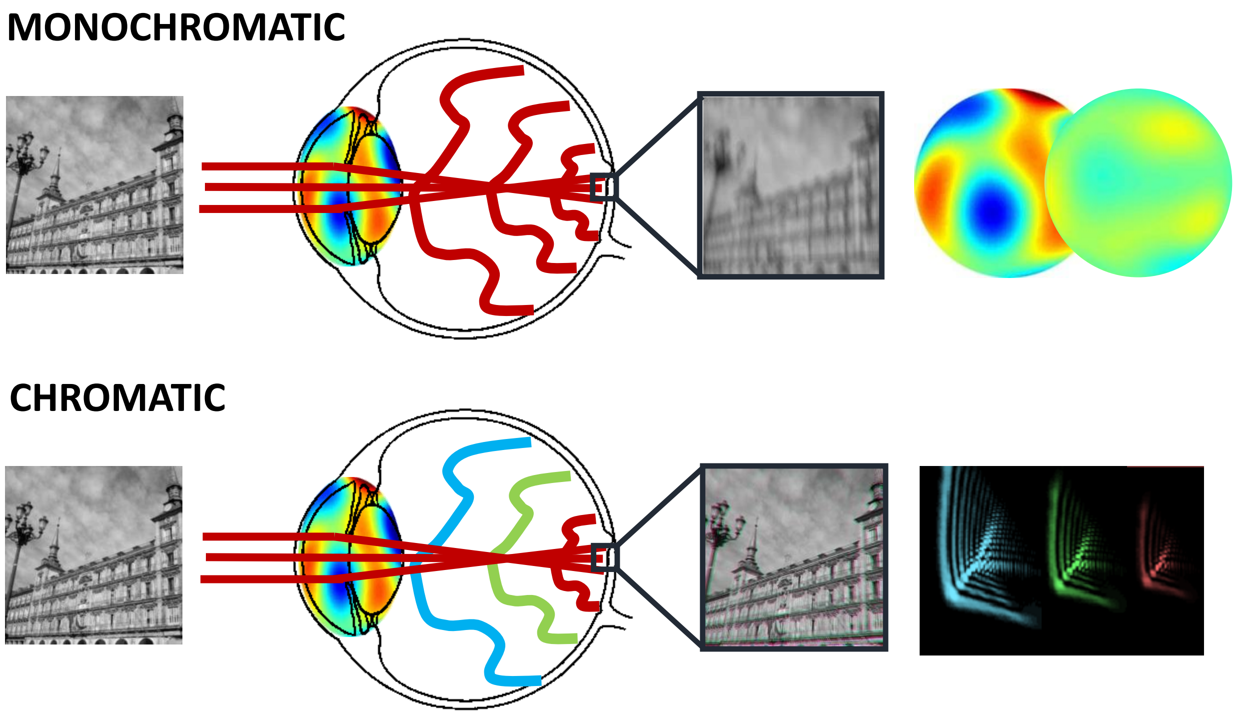
Chromatic difference of refraction

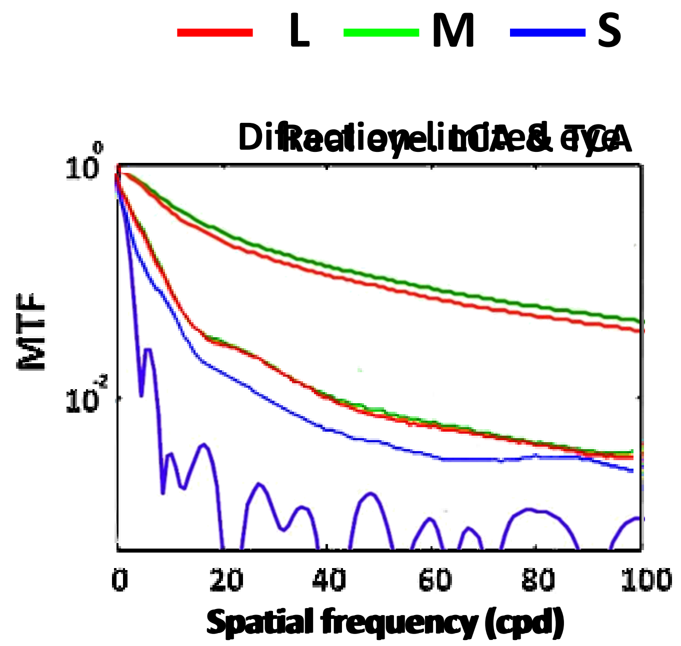
$$R_e(\lambda) = L(\lambda) - L(\lambda')$$

$$CDM = R_E(\lambda)EN$$

Atchison & Smith, Optics of the human eye, 2000

Optical quality of the eye: polychromatic optical quality





plays an important role in polychromatic optical quality

McLellan et al. (Nature, 2001)

Chromatic aberrations: impact on vision

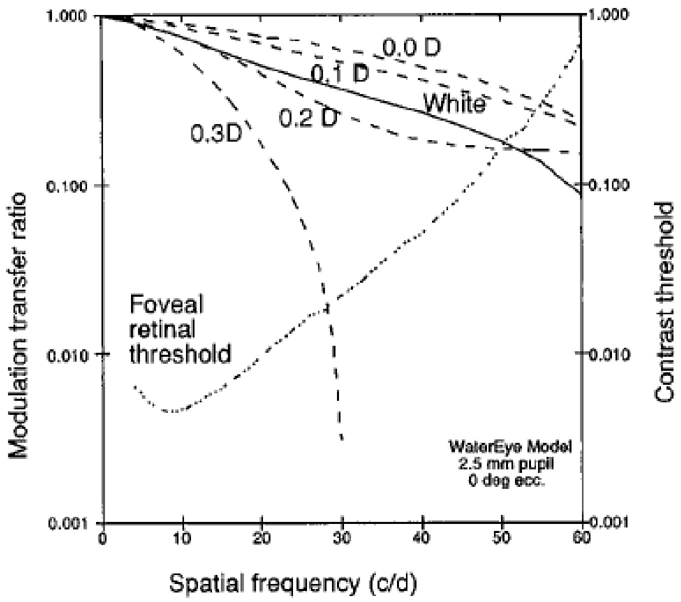
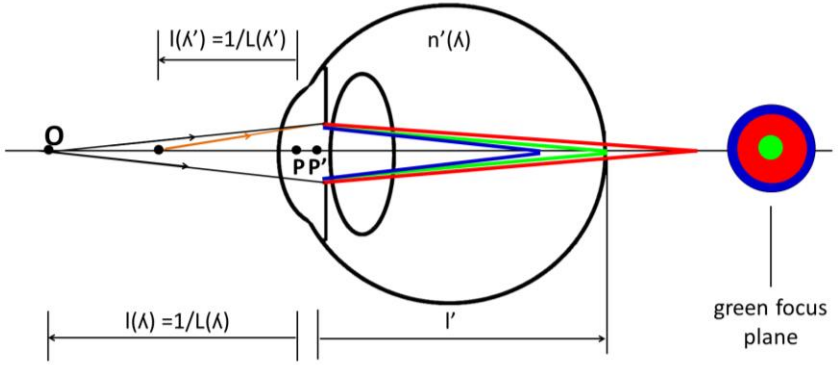
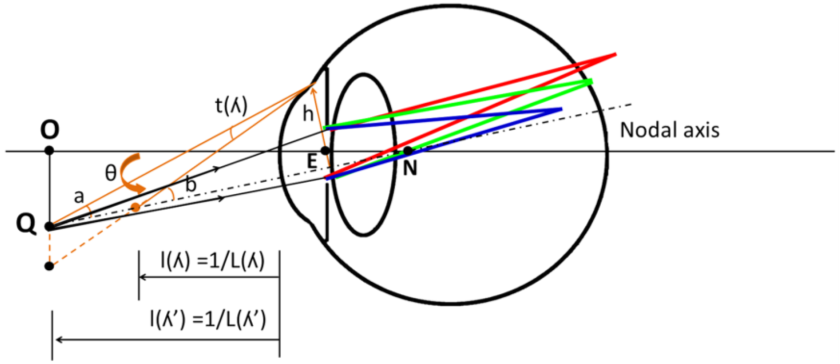


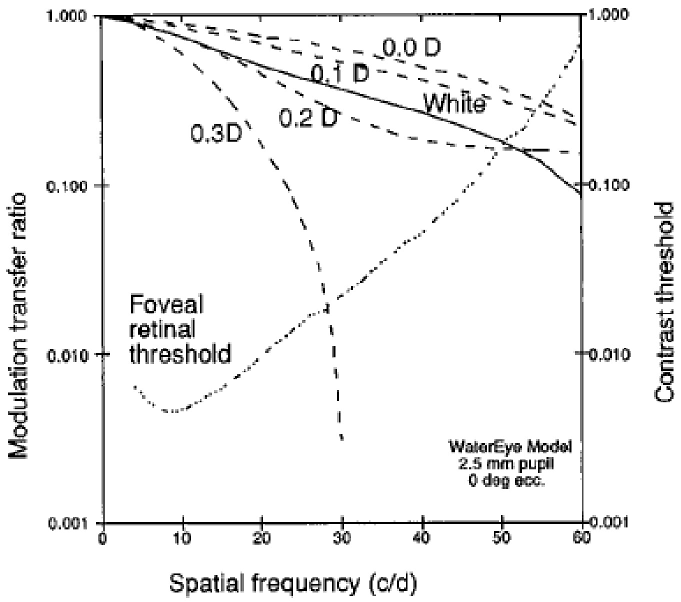
Figure 4. Comparison of the white-light MTF (solid curve) with three monochromatic MTF's (dashed curves) for the water-eye model. White-light calculation assumes zero transverse chromatic aberration and that 589 nm is the wavelength-in-focus. Numbers next to dashed curves indicate amount of defocus for monochromatic (589 nm) light. Circular pupil diameter = 2.5 mm; white-light = P4 cathode ray tube phosphor. Retinal contrast threshold[19] (i.e., inverse of contrast sensitivity for interference gratings) is shown for foveal vision by the dotted curve, which is referenced to the right-hand ordinate. Intersection of optical MTF's and retinal threshold curve predicts visual acuity under the various conditions.





Thibos et al. (OVS, 1991)

Chromatic aberrations: impact on vision



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Thibos et al. (OVS, 1991)

PHYSICAL MODEL EYE'S CHROMATIC ABERRATION

LCA

- reduces retinal image contrast (λ)
- reduces the eye's optical MTF for white-light by about the same amount as does <u>0.2 D of defocus for monochromatic light</u> (moderate loss of contrast sensitivity and a minor loss of VA)

TCA

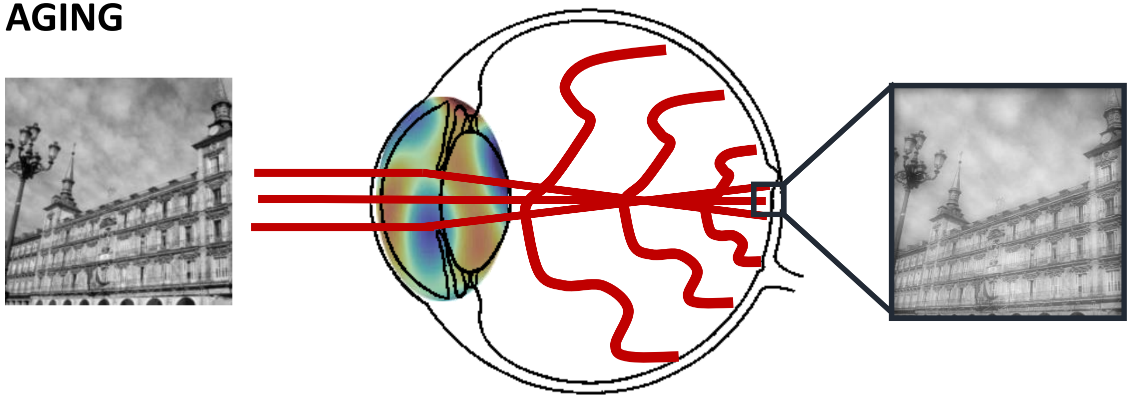
- small impact on monocular visual performance in a normal eye

Chromatic difference of position

- induces λ-dependent spatial phase shifts which affect image contrast through a mechanism of contrast cancellation. Major limiting factor for foveal vision through a displaced aperture.
- <u>Clinical assessment of visual function</u> if test targets are produced by an optical instrument that is misaligned with respect to the visual axis of the eye.

Aging processes in the eye: presbyopia & cataract

AGING

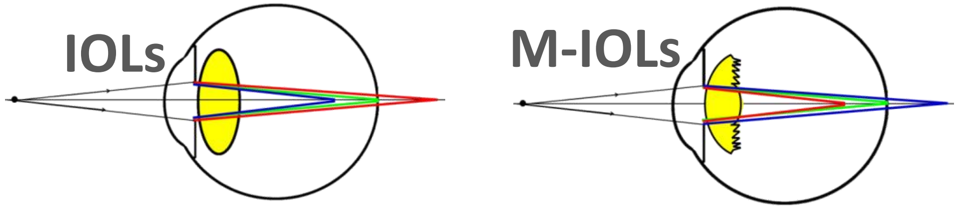


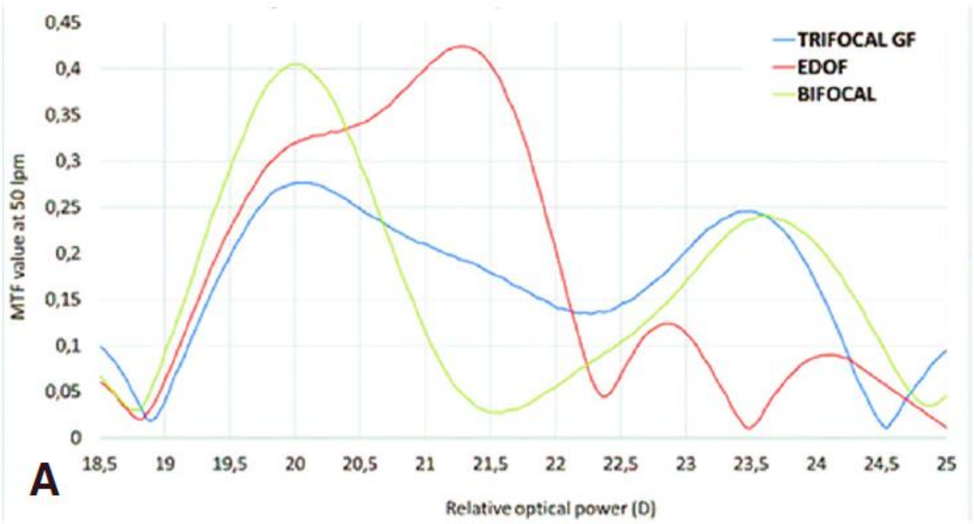
The magnitude/pattern of aberrations can be altered and will depend on:

- ❑ the lens optical design (refractive, diffractive)
- ❑ dispersion properties of the lens material and the ocular media

Moreover, an increasing number of IOLs aim at modulating LCA

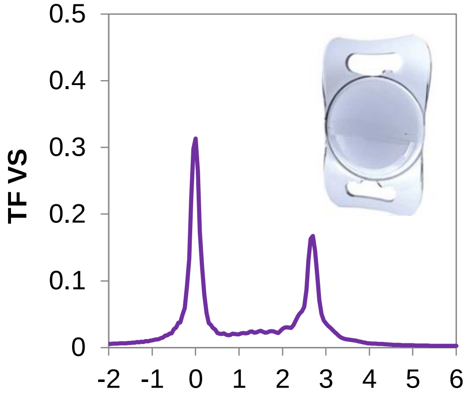
IOLs & designs



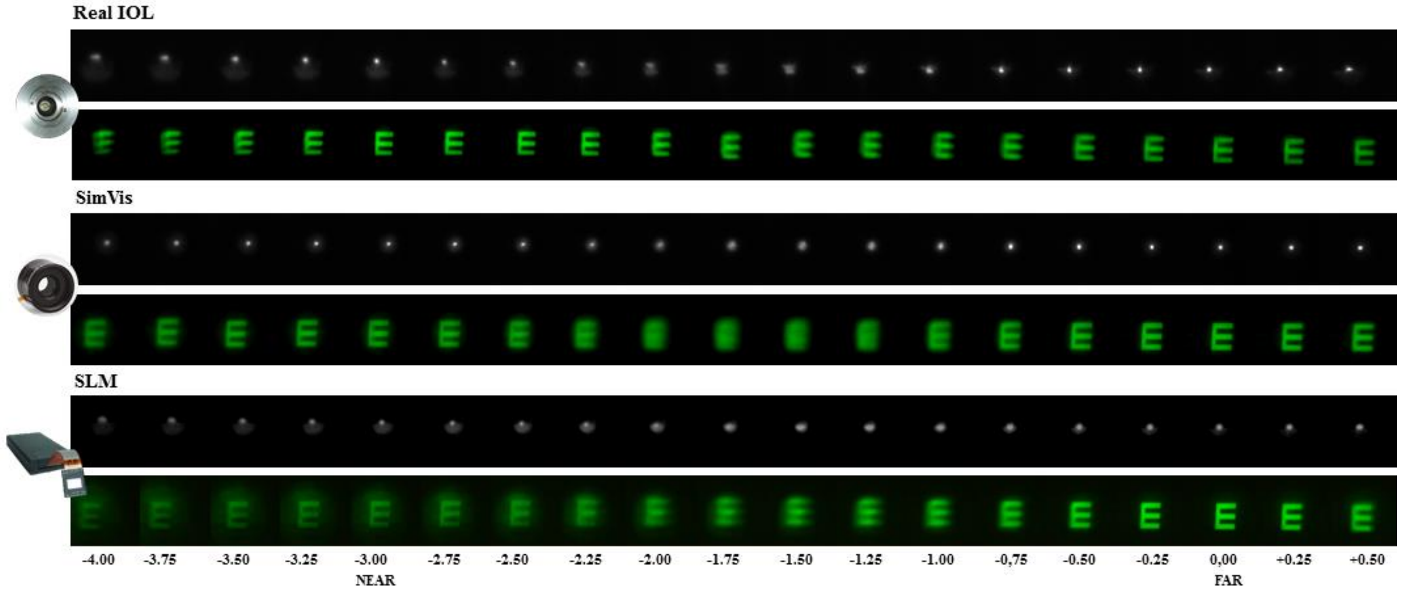


Gatinel & Loicq, JCRS, 2016

Bifocal Refractive

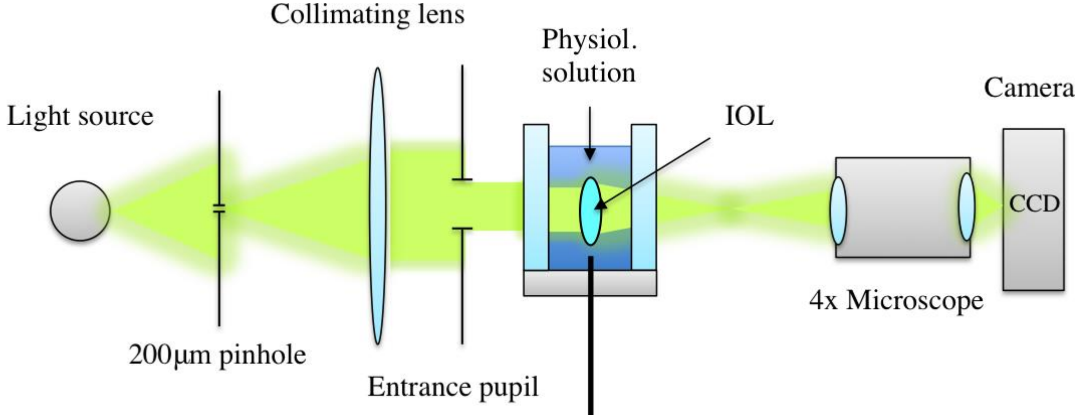


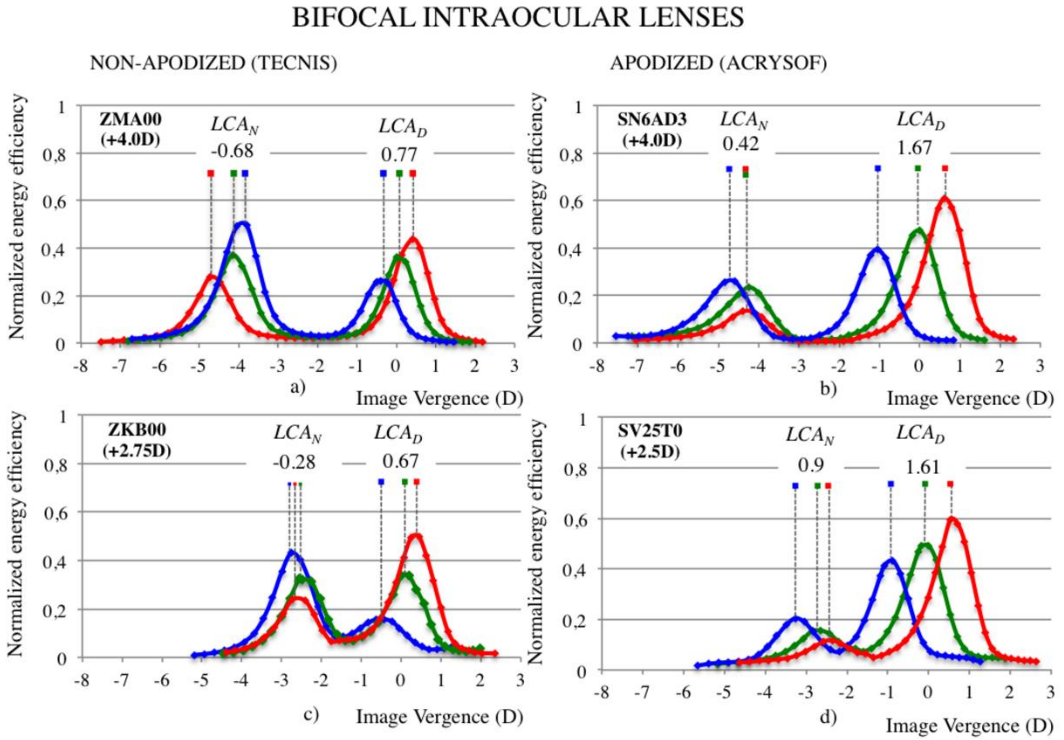
Vinas et al., Nature Sci Reps, 2019

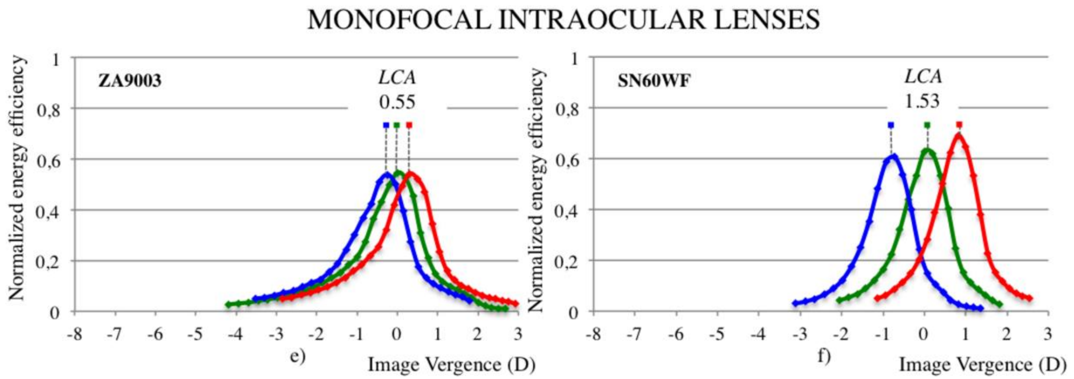


Monochromatic conditions (555 nm)

IOLs & chromatic aberrations: on-bench testing

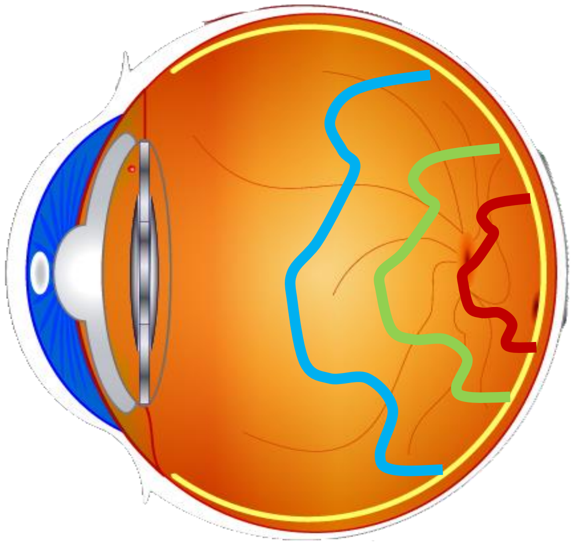






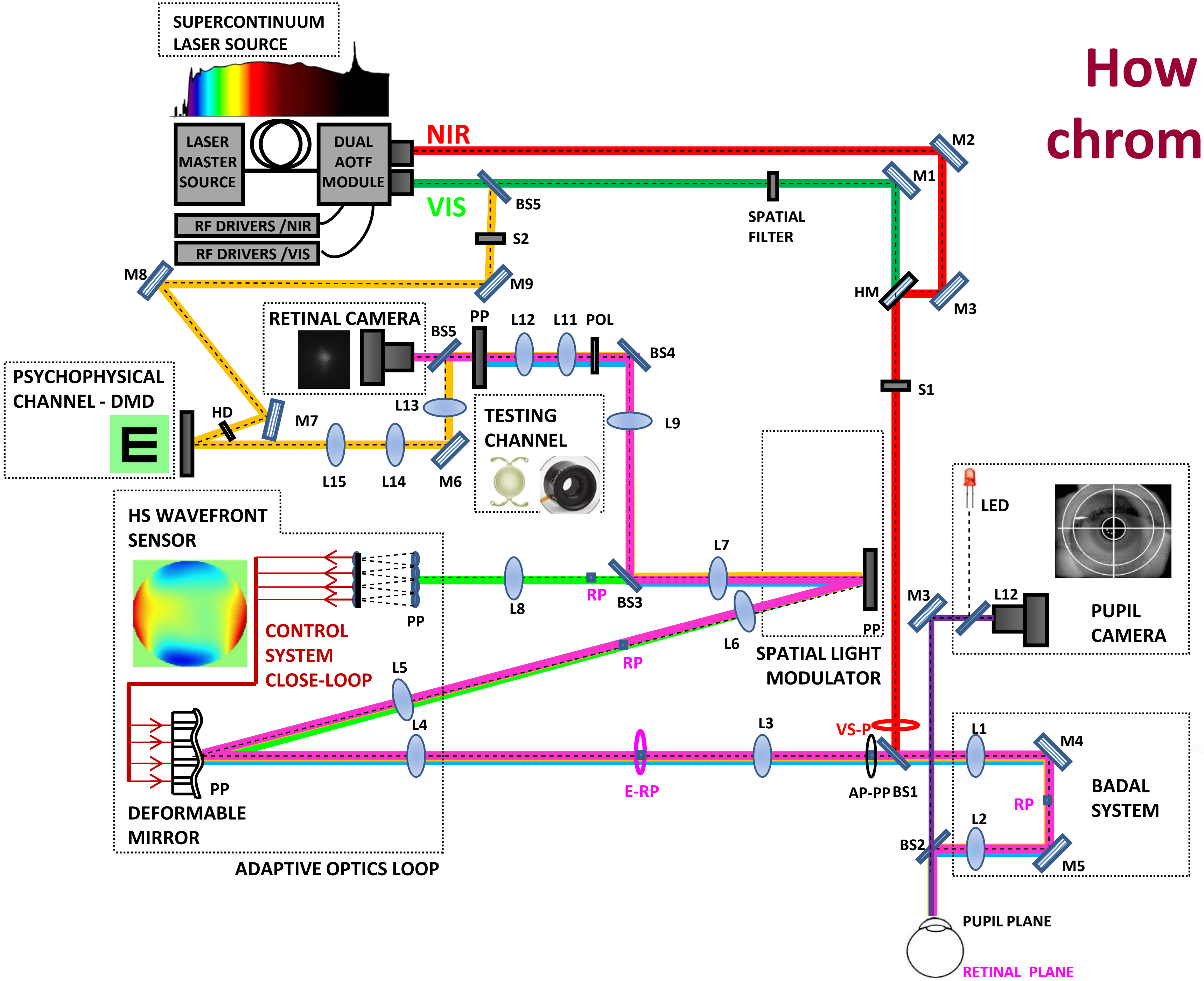
Millan et al., IOVS, 2016

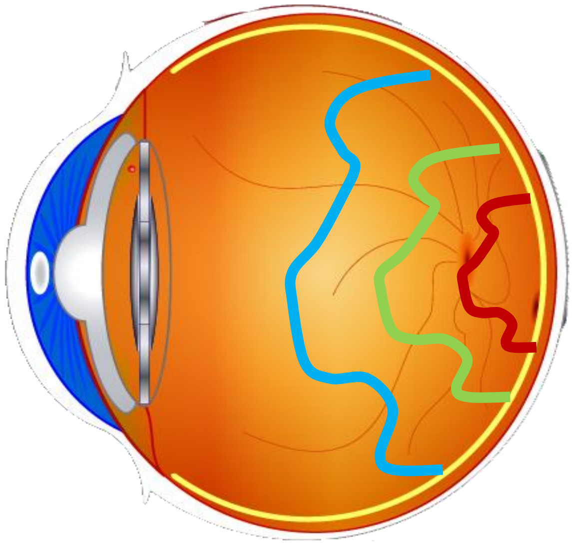
How do we measure chromatic aberrations on eye?



How do we measure chromatic aberrations on eye?

the set-up



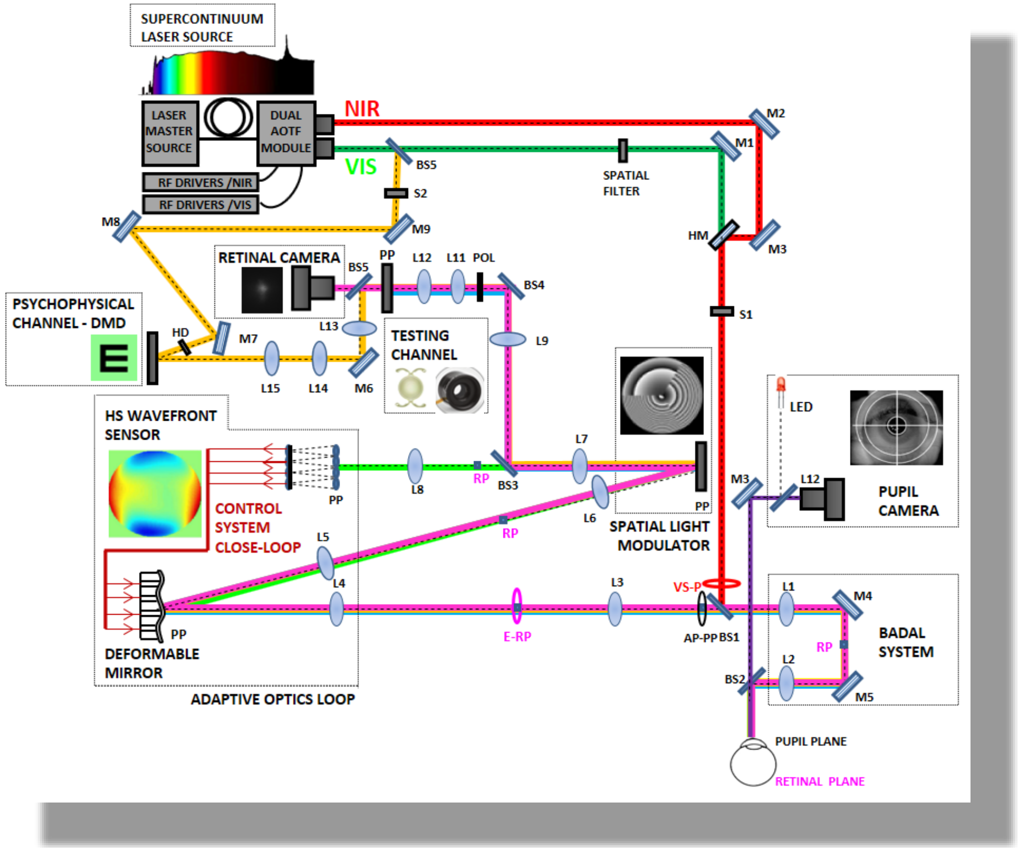


Vinas et al. OSA BOEx, 2015

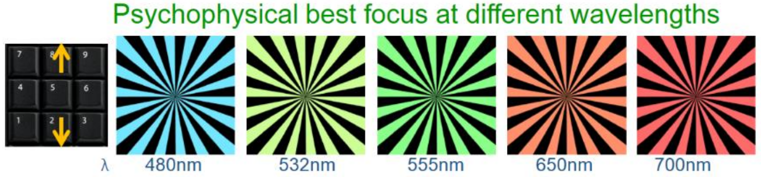
Vinas et al. Nature Sci Reps, 2019

How do we measure chromatic aberrations on eye?

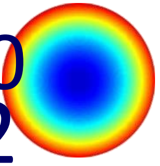
the experiments

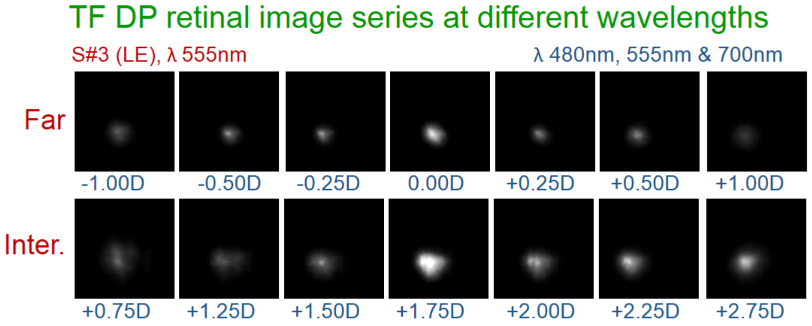


❑ LCA

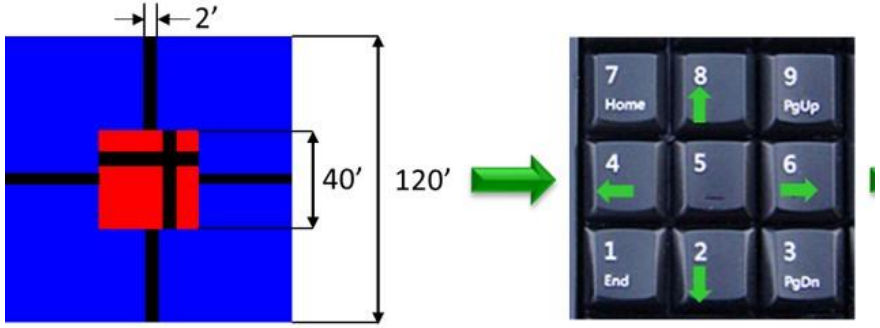


Z_2^0



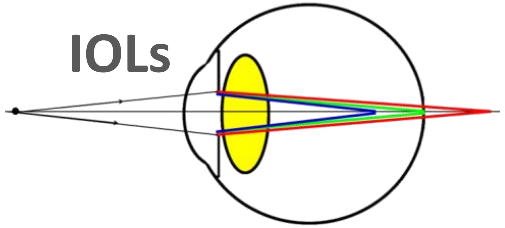


❑ TCA

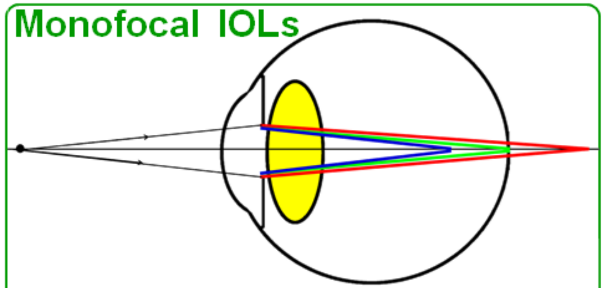


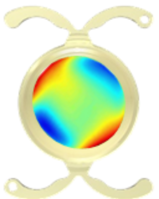
❑ Visual function

LCA in DIFFERENT MATERIALS IOLs implanted eyes



Monofocal IOLs

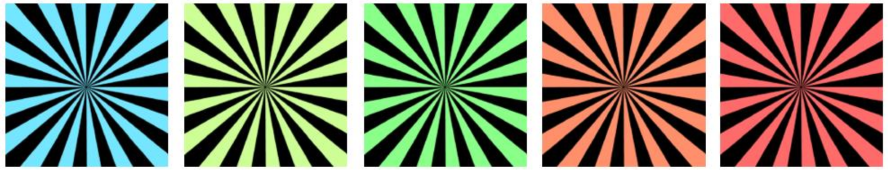




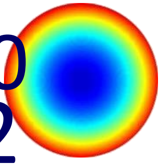
- ❑ Monofocal aspheric
- ❑ Hydrophilic (Poday)
- ❑ Abbe 58

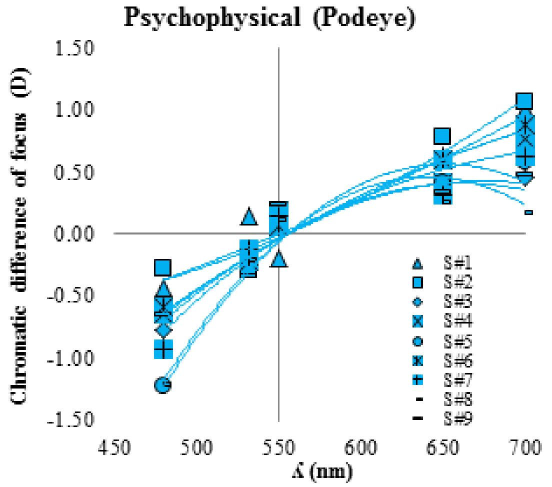
- ❑ Monofocal aspheric
- ❑ Hydrophobic (Podeye) in contralateral eye;
- ❑ Abbe 41.91

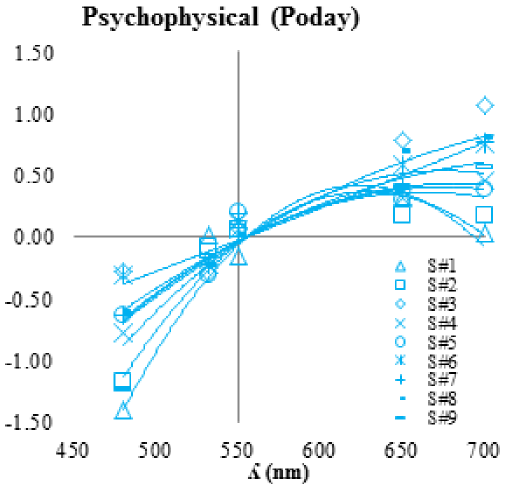
- ❑ 9 patients (74±4 yrs)
- ❑ Physiol
- ❑ Poday & Podeye
- ❑ Monocular measurements in both eyes

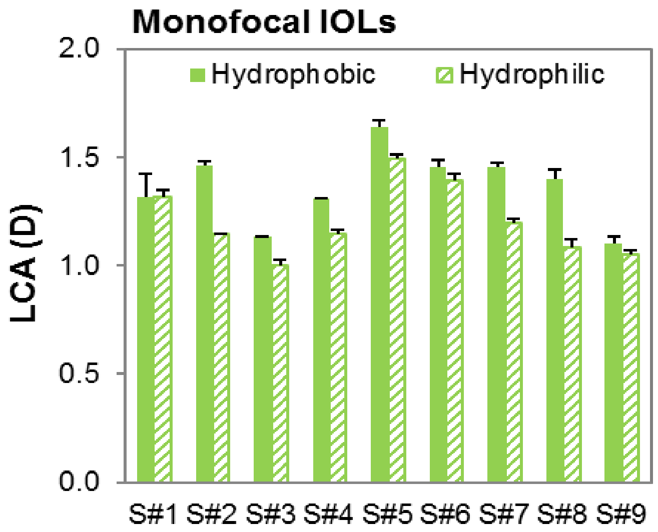


Z_2^0



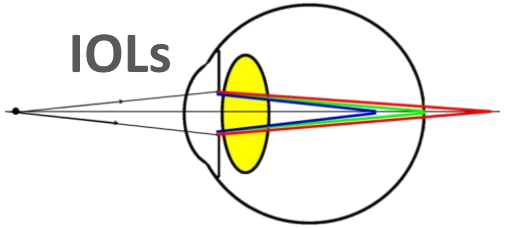




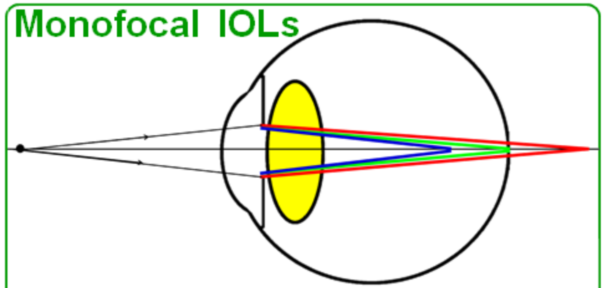


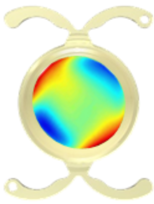
Vinas et al. JRS, 2015

LCA in DIFFERENT MATERIALS IOLs implanted eyes



Monofocal IOLs



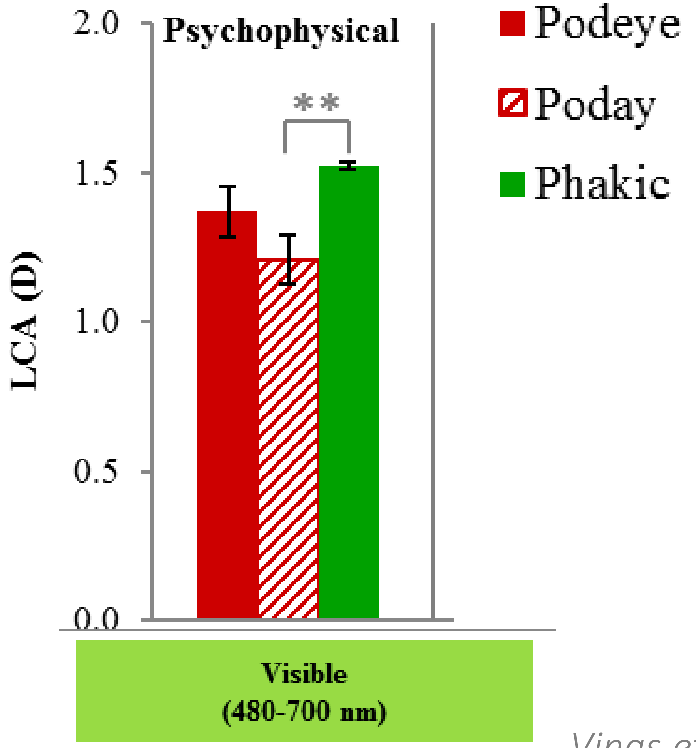


- ❑ Monofocal aspheric
- ❑ Hydrophilic (Poday)
- ❑ Abbe 58

- ❑ Monofocal aspheric
- ❑ Hydrophobic (Podeye) in contralateral eye;
- ❑ Abbe 41.91

- ❑ 9 patients (74±4 yrs)
- ❑ Physiol
- ❑ Poday & Podeye
- ❑ Monocular measurements in both eyes

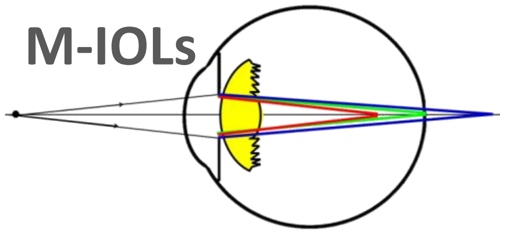
PhysIOL

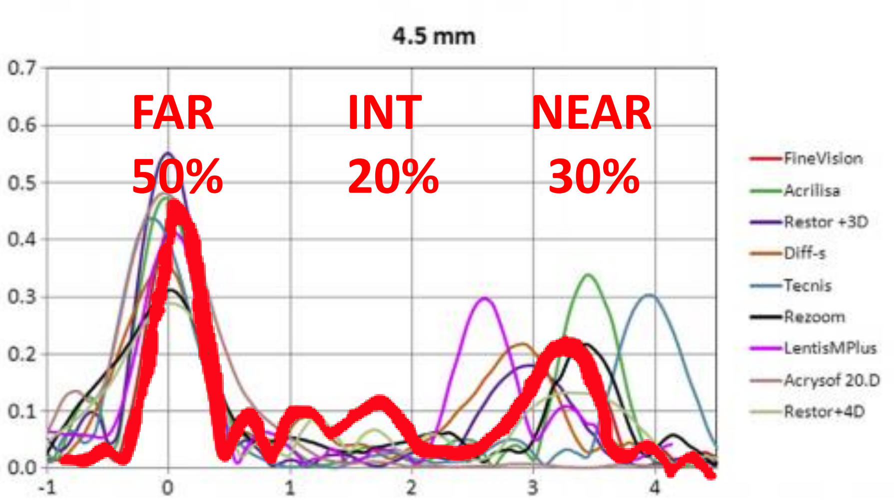


- ❑ Similar values than phakic eyes
- ❑ LCA-hydrophobic > LCA hydrophilic (1.4D±0.08) > (1.2±0.08D)
- ❑ IOL-material has a significant impact on the LCA of the pseudophakic eye.

Vinas et al. JRS, 2015

LCA in multifocal (diffractive) IOLs implanted eyes

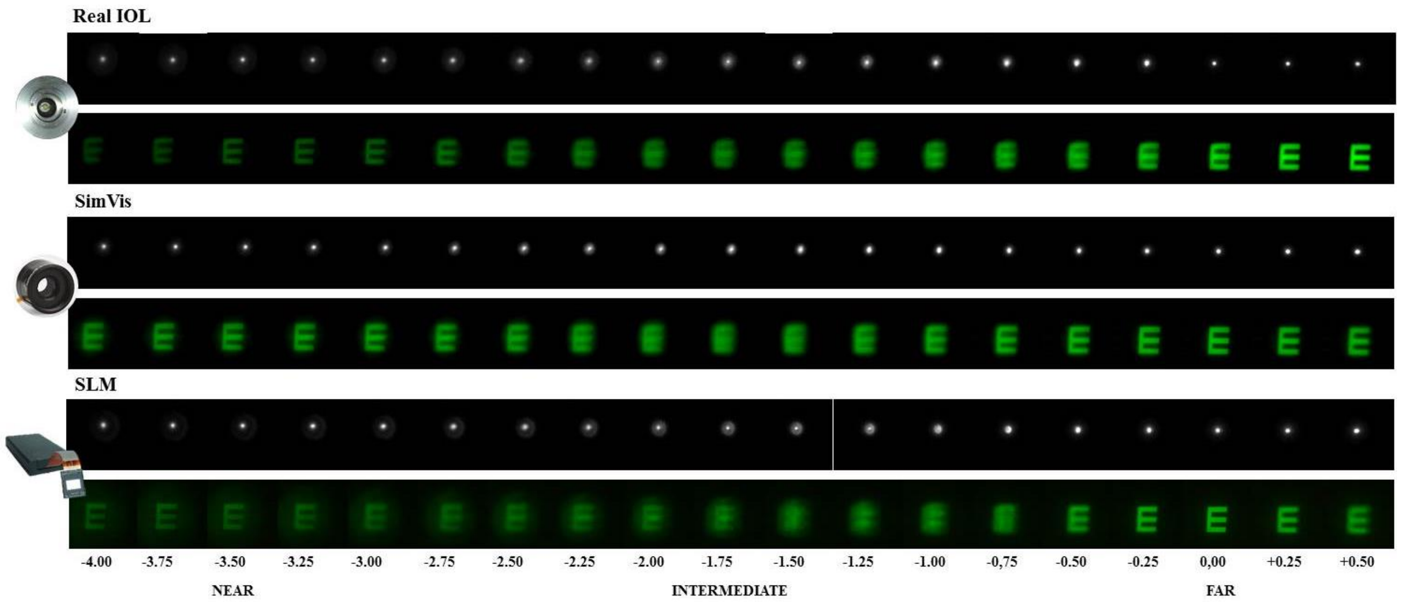




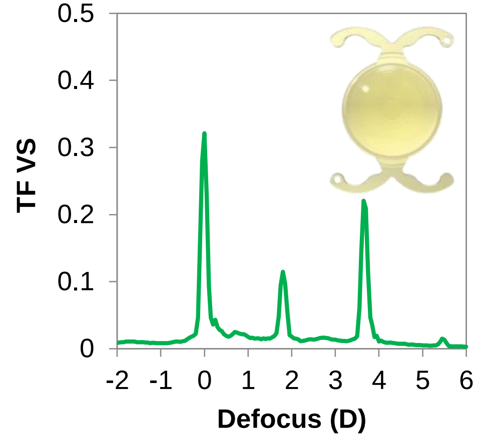
Gatinel et al. JCRS, 2013

LCA-modulation
↑multifocality

Topography and LCA characterizations of refractive–diffractive multifocal intraocular lenses. Loicq et al., JCRS, 2019

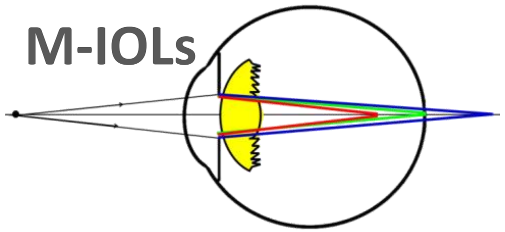


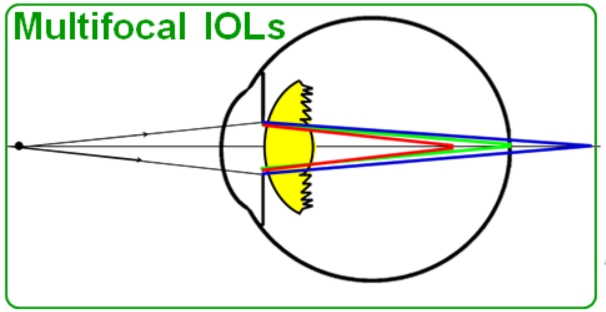
Trifocal Diffractive

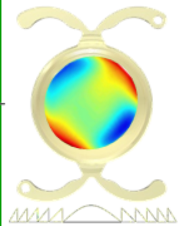


Vinas et al., Nature Sci Reps, 2019

LCA in multifocal (diffractive) IOLs implanted eyes







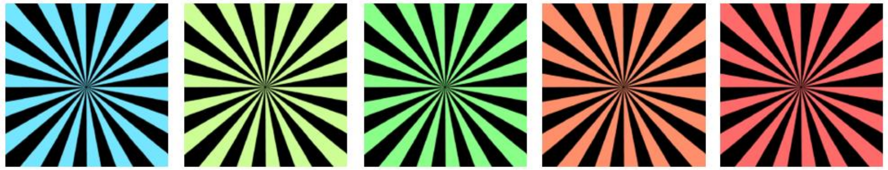
- ❑ M-IOL diffractive trifocal
- ❑ 26% hydrophilic acrylic

- ❑ 10 patients (67±4 yrs)
- ❑ FINeVision Pod F
- ❑ Monocular

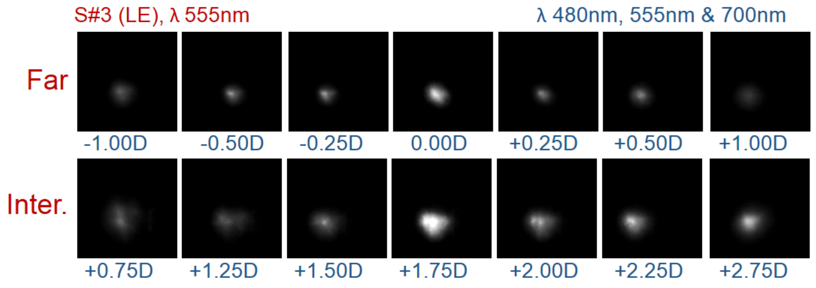
PhysIOL

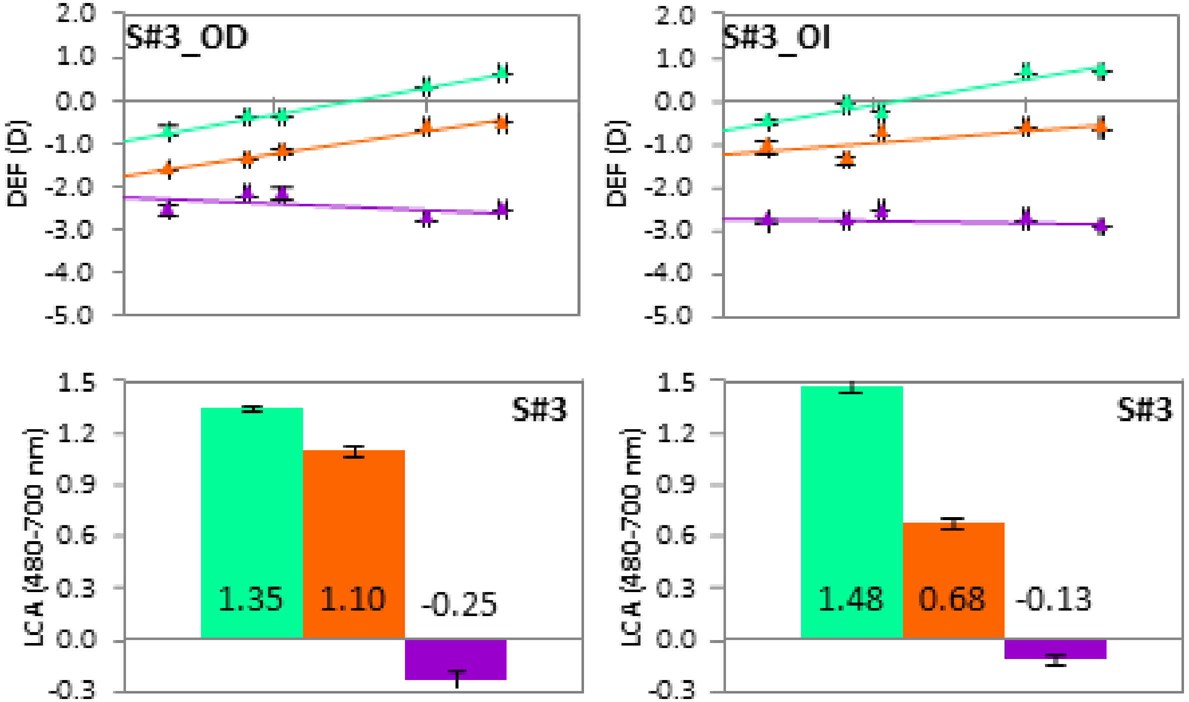
3 useful distances:
F 0.00D I +1.75D N +3.50D

Hydrophilic

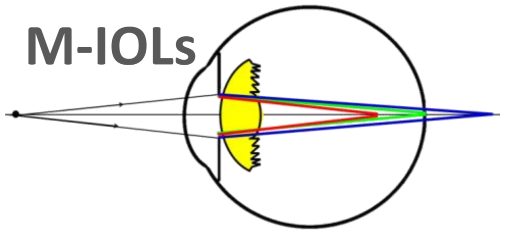


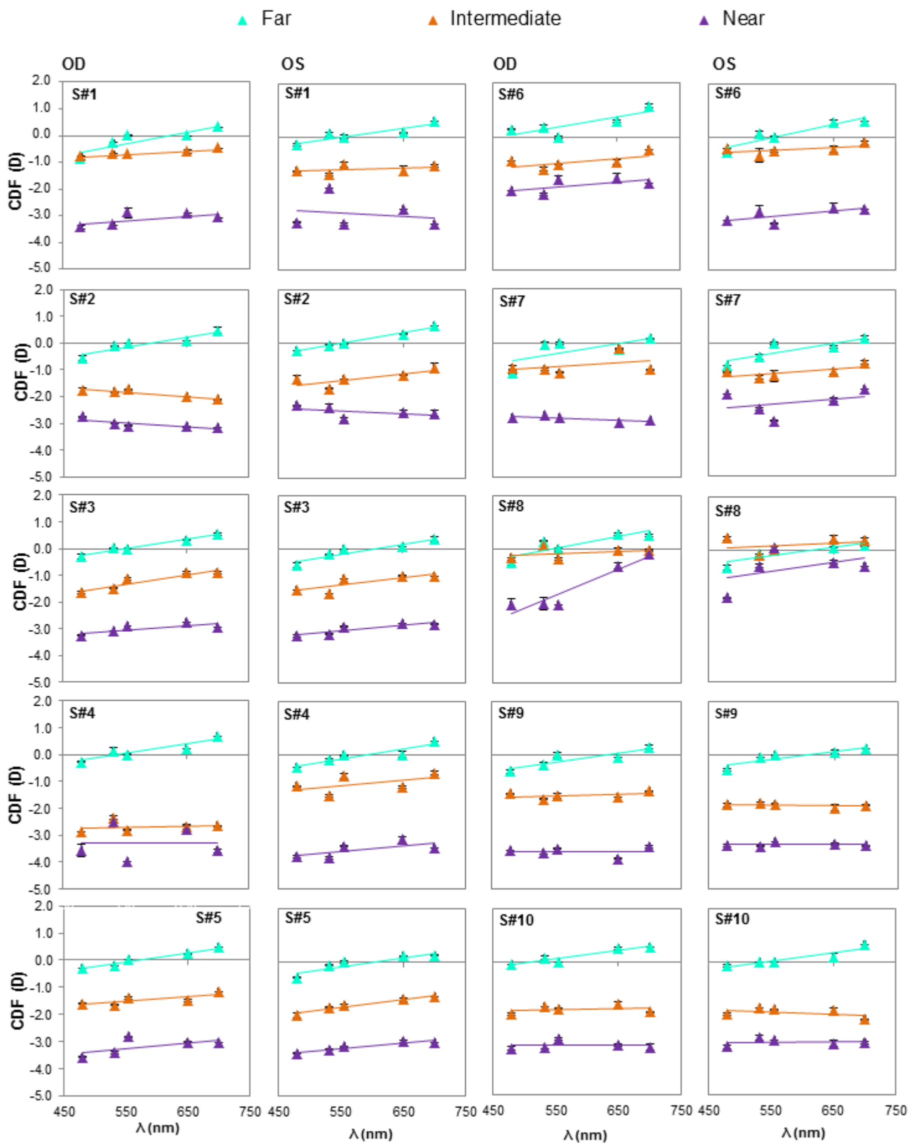
TF DP retinal image series at different wavelengths

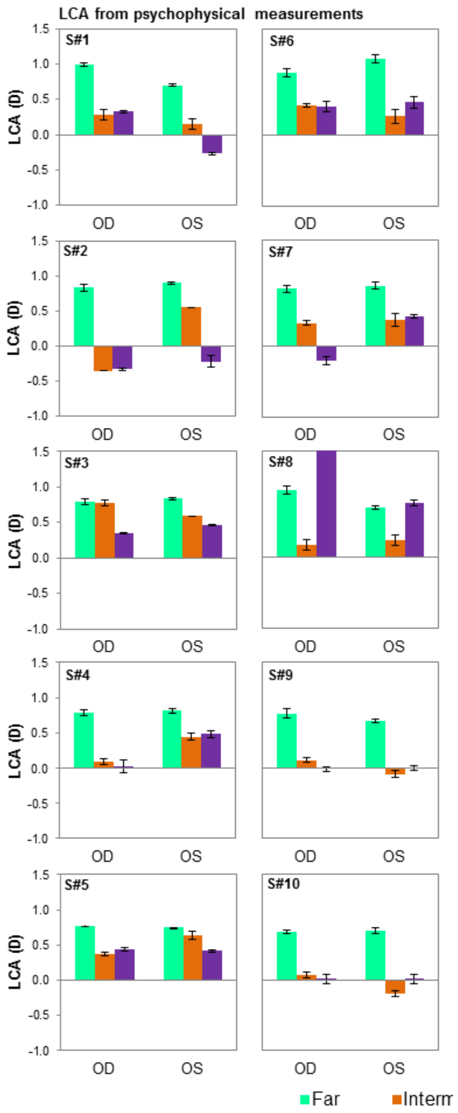




LCA in multifocal (diffractive) IOLs implanted eyes

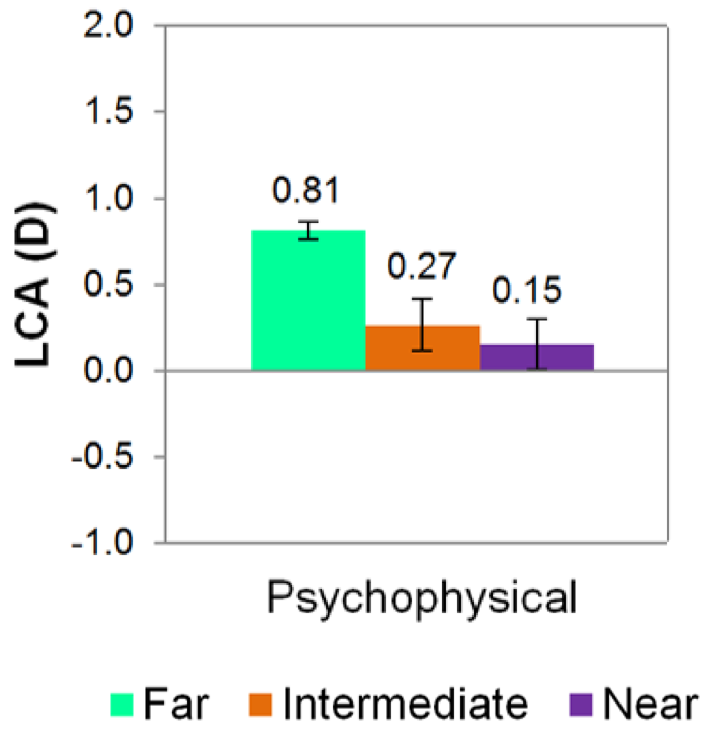




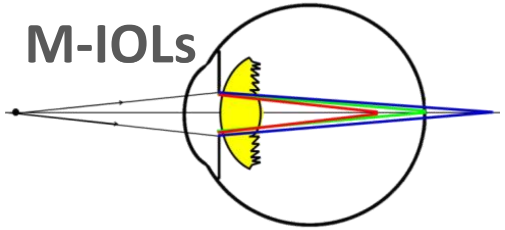


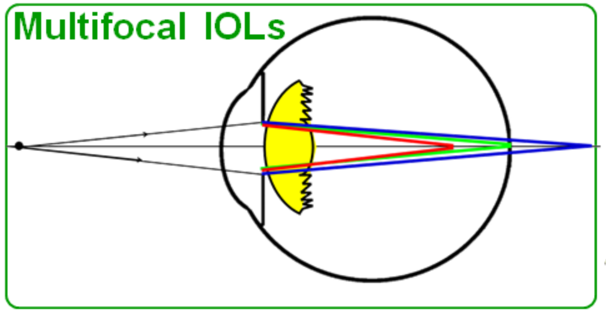
Hydrophilic

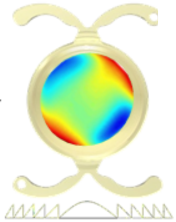
Vinas et al. JRS, 2017



LCA in multifocal (diffractive) IOLs implanted eyes







PhysIOL

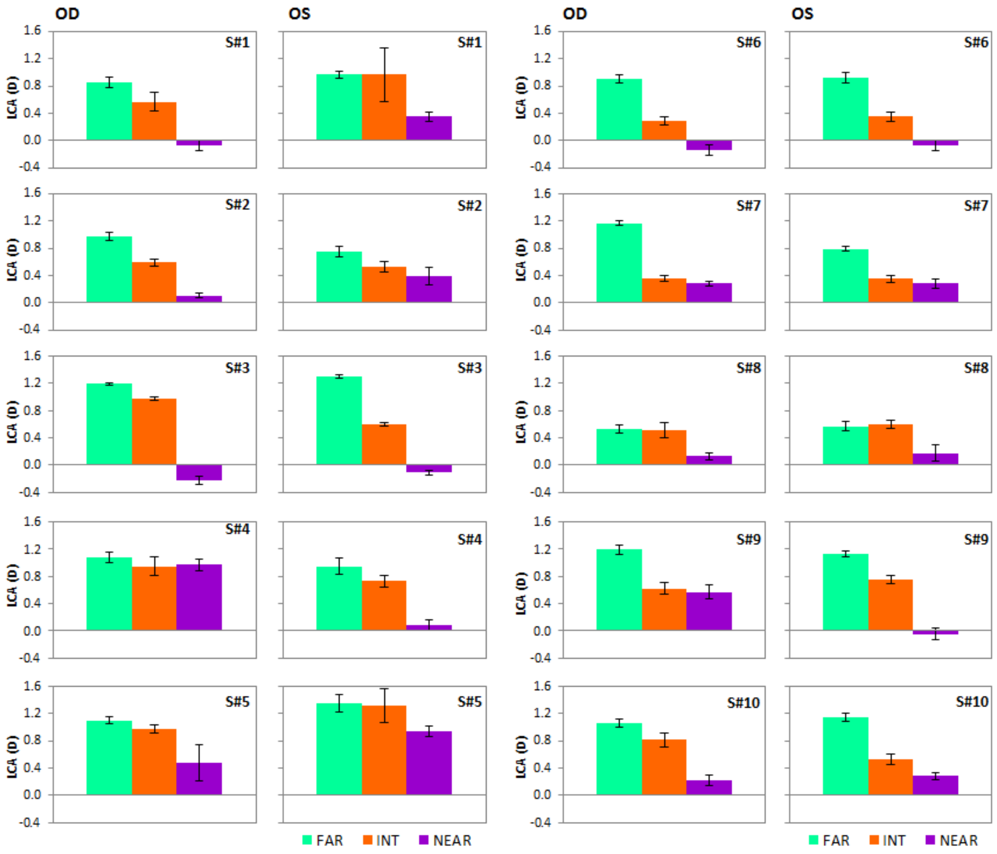
- ❑ M-IOL diffractive trifocal
- ❑ Hydrophobic

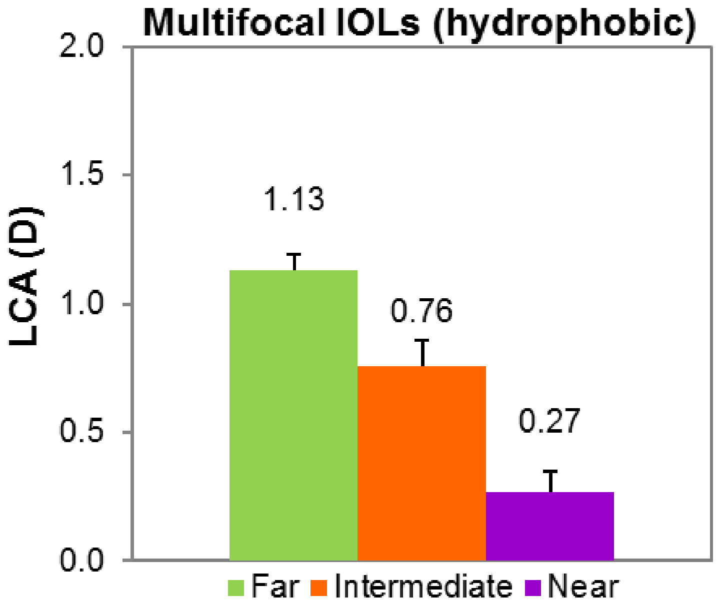
3 useful distances:
F 0.00D I +1.75D N +3.50D

- ❑ 7 patients (62±5 yrs)
- ❑ FINeVision Pod F GF
- ❑ Monocular

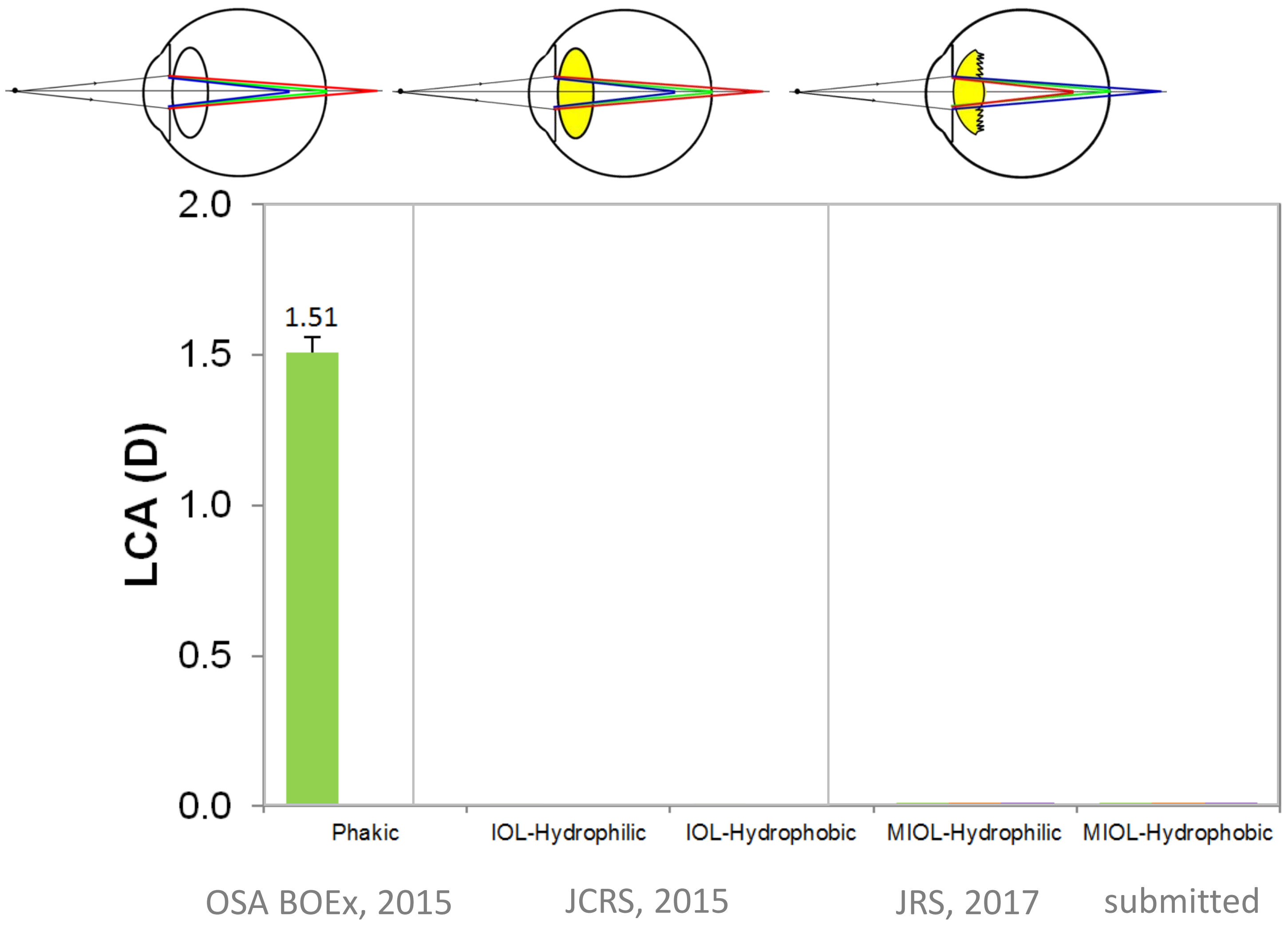
Hydrophobic

Vinas et al. submitted





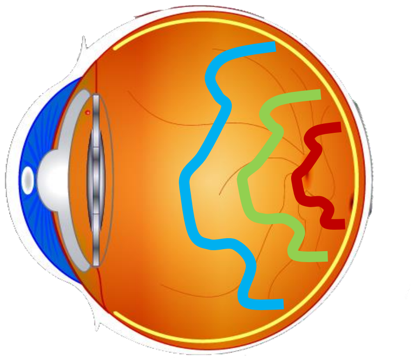
LCA of the phakic & pseudophakic eye

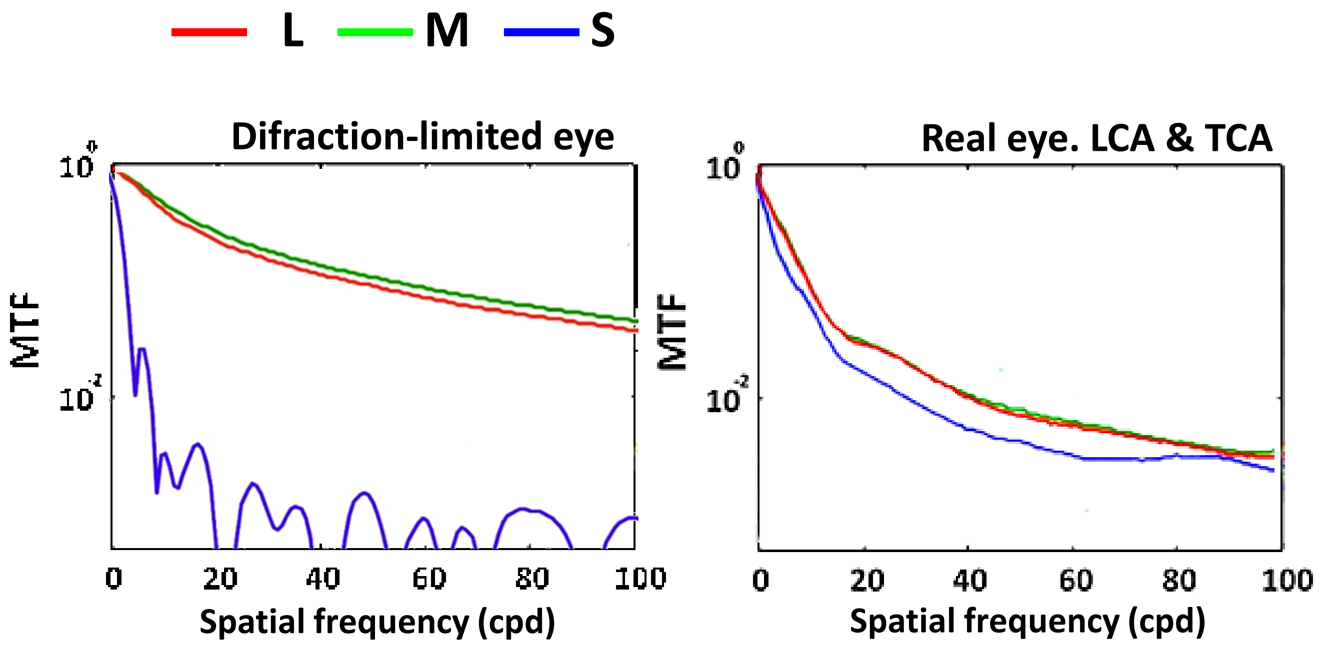


- ❑ **LCA in phakic eyes show similar trends with monofocal IOLs, but lower values for M-IOLs. In all cases LCA correspond to the IOLs Abbe number.**
- ❑ **Hydrophobic-LCA is slightly higher than hydrophilic-LCA (monofocal and M-IOLs for far vision), with similar values to phakic-LCA.**
- ❑ **LCA decreases for intermediate and near vision in M-IOLs.**
- ❑ **The diffractive component in multifocal IOLs allows modulating the chromatic aberration of the eye at different distances.**

LCA of the pseudophakic eye: impact on vision ??

Interaction of mono- & chromatic aberrations in pseudophakic patients





McLellan et al. (Nature, 2001)

From HOAs at various wavelengths
monofocal aspheric IOL (Clareon, Alcon)

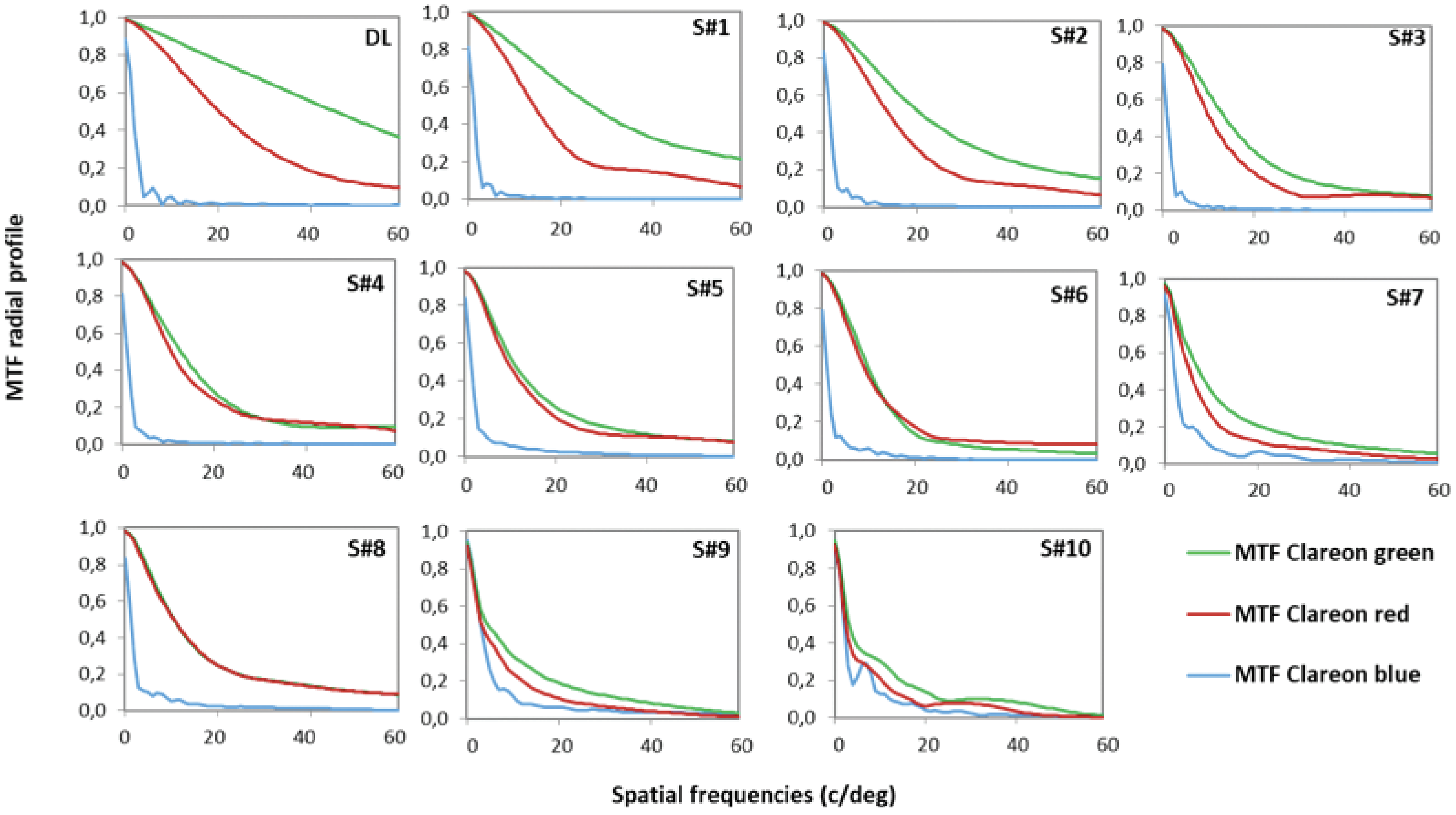
- ❑ **LCA**
- ❑ **MTF**
- ❑ **impact of interactions** between chromatic and monochromatic aberrations on retinal image quality.

plays an important role in polychromatic optical quality

LCA of the pseudophakic eye: impact on vision ??

Interaction of mono- & chromatic aberrations in pseudophakic patients

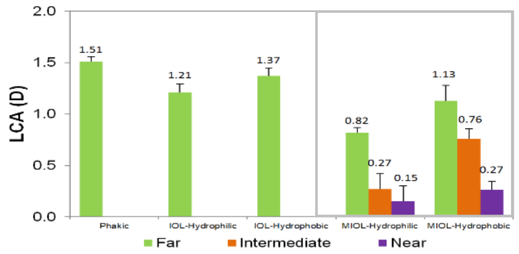
- ❑ **The impact of LCA in blue is largely dependent on the magnitude of monochromatic aberrations.**
- ❑ **The visual Strehl555/visual Strehl480 ratio ranged from 1.38 to 3.82.**
- ❑ **This is consistent with observations in normal phakic eyes, which led to the conclusion that monochromatic aberrations are the eye's protection against chromatic blur.24**



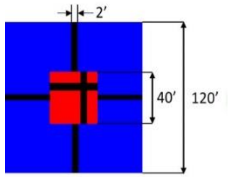
Estimated MTFs in green (best focus), blue & red defocused by the measured chromatic defocus. Data ranked by increasing RMS.

Marcos et al. JRS, 2020

Other factors to be explored…

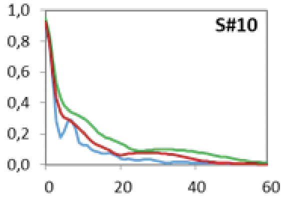


- ❑ LCA. The diffractive component in multifocal IOLs allows modulating the chromatic aberration of the eye at different distances. We still need to understand all interactions.

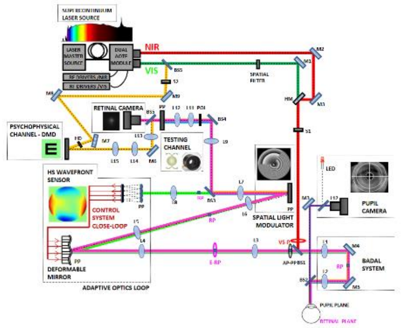


- ❑ TCA. Misalignments IOL-Eye. Posible impact on visual function?

- ❑ Impact of LCA&TCA on Visual Performance & Perception



- ❑ Polychromatic visual quality of the pseudophakic eye



- ❑ Visual simulation & novel M-IOL designs using an improved chromatic modulation method

Acknowledgements

European Research Council
ERC-2011-AdG-294099

Spanish Government FIS2014 & FIS 2017
Spanish Ministry of Science Aids for recruiting Technical Support Personnel PTA2017-13787-I (MR)
Madrid Regional Government for recruiting Technical Support Personnel PTA2017-13787-I (AG-R)

Collaborative agreement with PhysIOL

Agreement with Innova Ocular (Madrid, Spain)

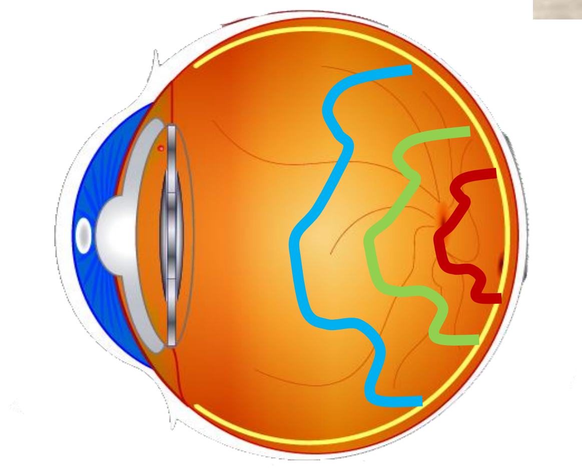
Collaborative agreement with Alcon Research Labs

OSA Ambassador program 2019 to MV

C Dorronsoro
AM Gonzalez-Ramos
D Pascual
S Aissati
S Marcos

N Garzón
F Poyales

Innova Ocular
IOA Madrid



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María Viñas, PhD

Thank You!

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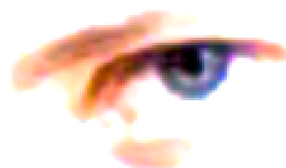
http://viobiolabs.wordpress.com

Chromatic Aberrations of the Peripheral Human Eye



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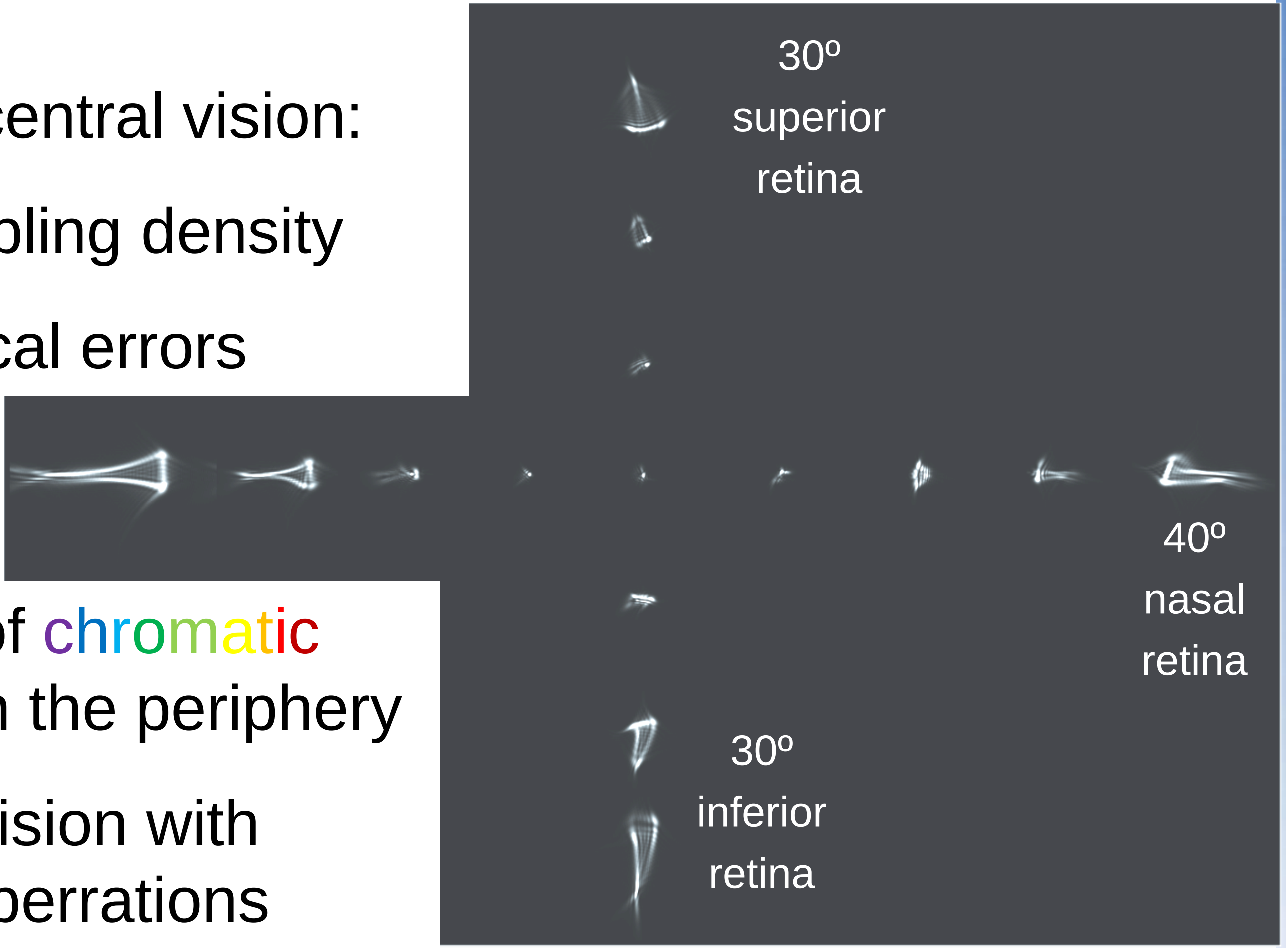
OSA Vision Technical Group Workshop:
Chromatic Aberrations in Vision
June 26, 2020

The peripheral eye

Compared to central vision:

- Lower sampling density
- Larger optical errors



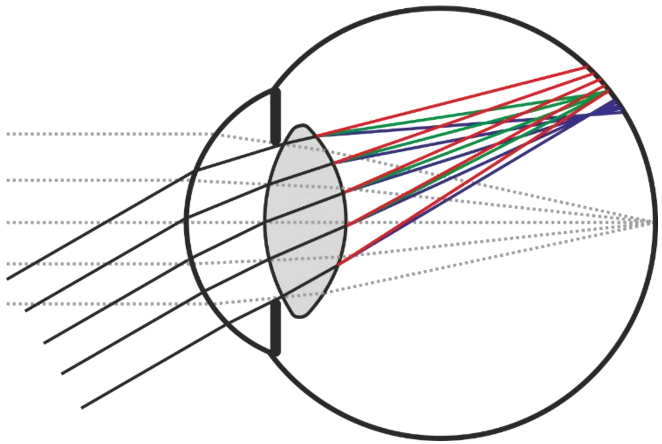
- Magnitude of chromatic aberration in the periphery
- Peripheral vision with chromatic aberrations
- Chromatic aberrations and myopia development?

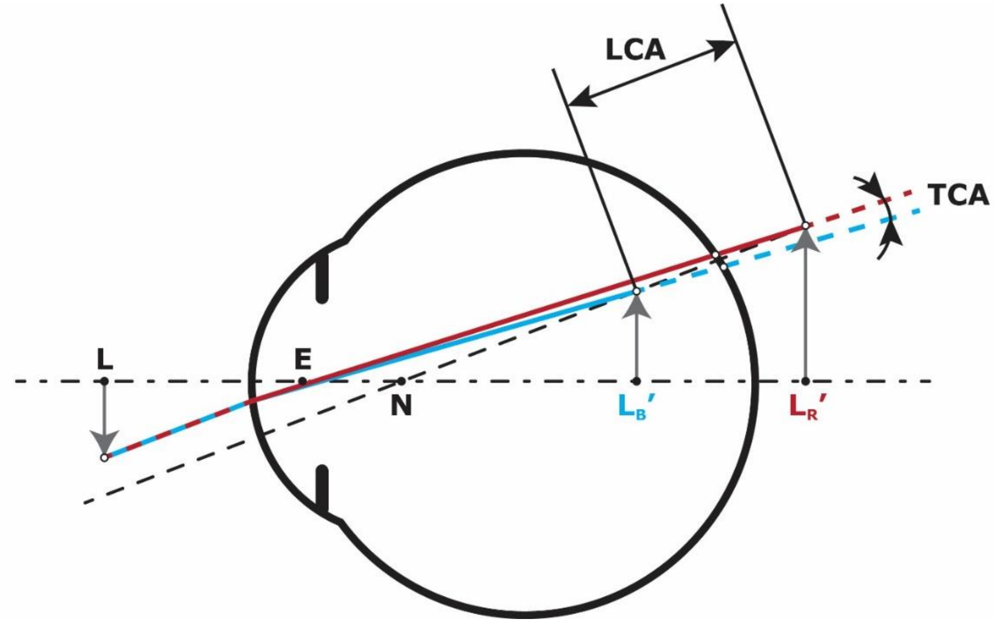
Chromatic aberration over the visual field

From theory:

Longitudinal Chromatic Aberration (LCA) causes chromatic difference in refraction ~ stable with angle

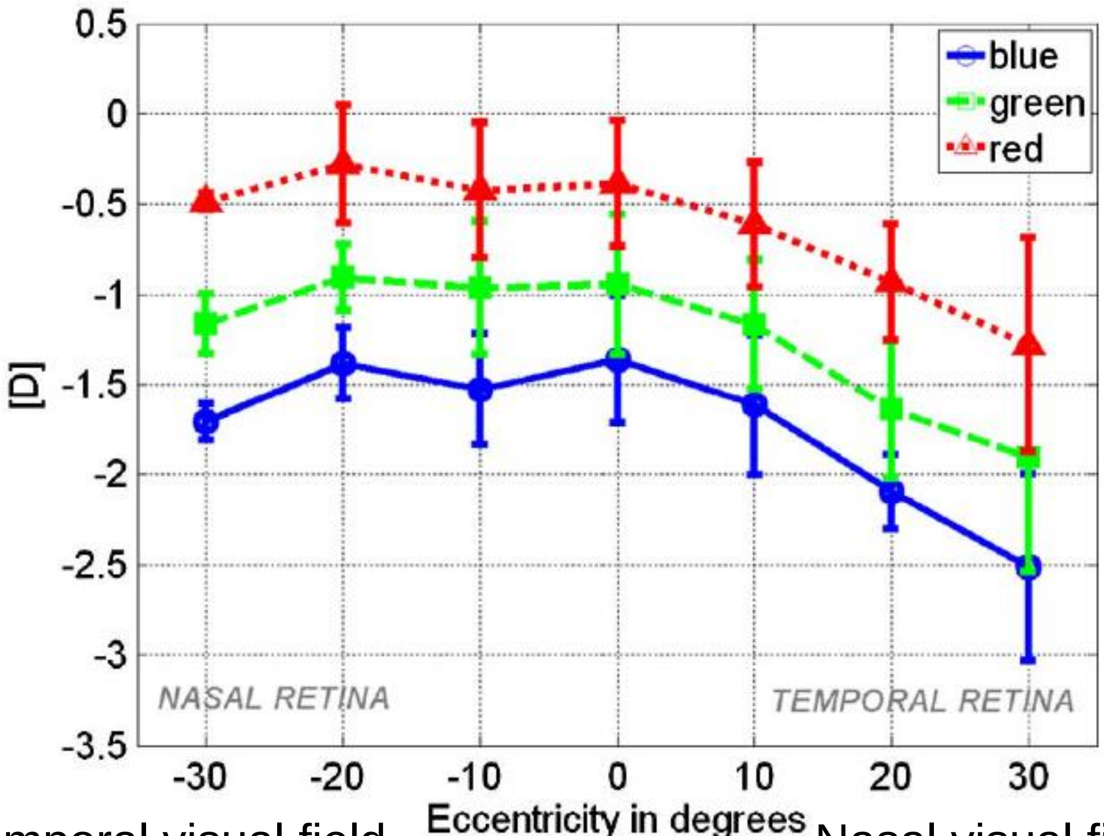
Transverse Chromatic Aberration (TCA) causes chromatic difference in magnification ~ linear with angle





Chromatic aberration over the visual field

LCA measured with a wavelength tunable wavefront sensor (473, 532, 671 nm).



Temporal visual field

Nasal visual field

Slight increase in the periphery ~0.3 D at 30°

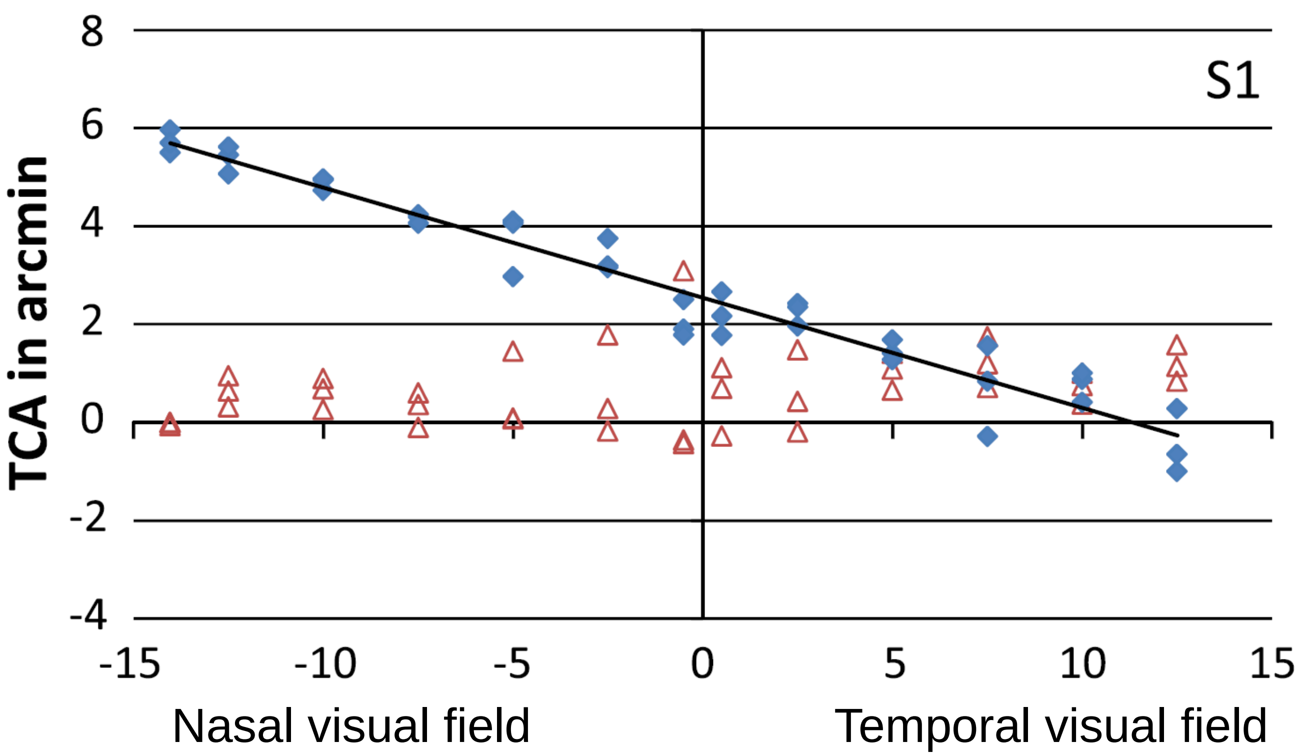
Similar to *Rynders, Navarro, Losada, Vision Res. 38, 513–522 (1998)*

Jaeken, Lundström, Artal. J Opt Soc Am A 28 (2011)

lo·um http://lo.um.es

Chromatic aberration over the visual field

TCA estimated from interleaved retinal images in an adaptive optics scanning laser ophthalmoscope.



Linear increase by 0.41 arcmin / degree for 430 nm to 770 nm

A bit larger than *Ogboso, Bedell, J Opt Soc Am A 4 (1987)* *& Thibos, J Opt Soc Am A 4 (1987)*

Winter, Sabesan, Tiruveedhula, Privitera, Unsbo, Lundström, Roorda, J. Vision 16(14), 9 (2016)

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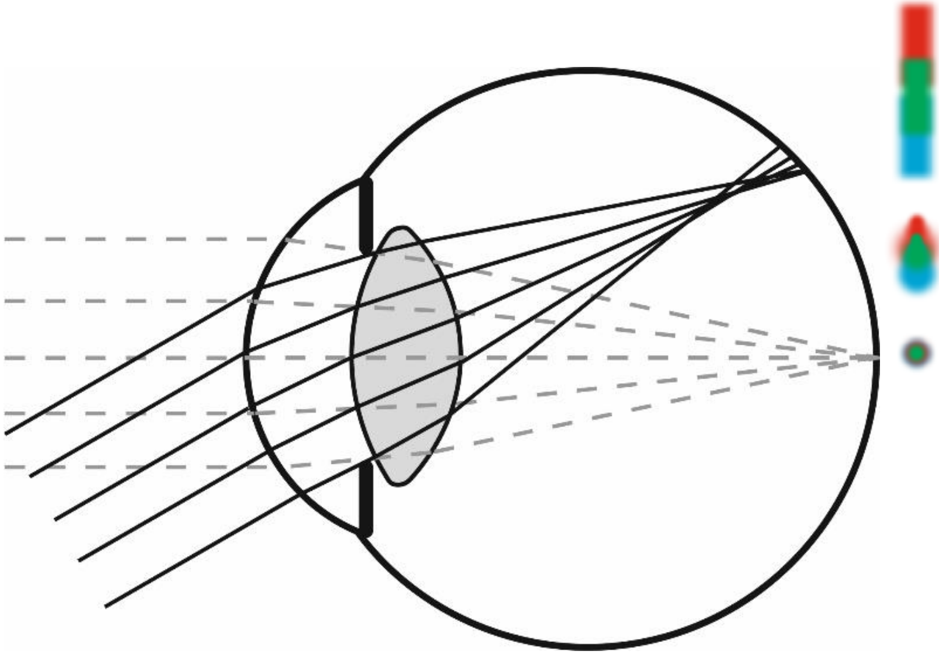
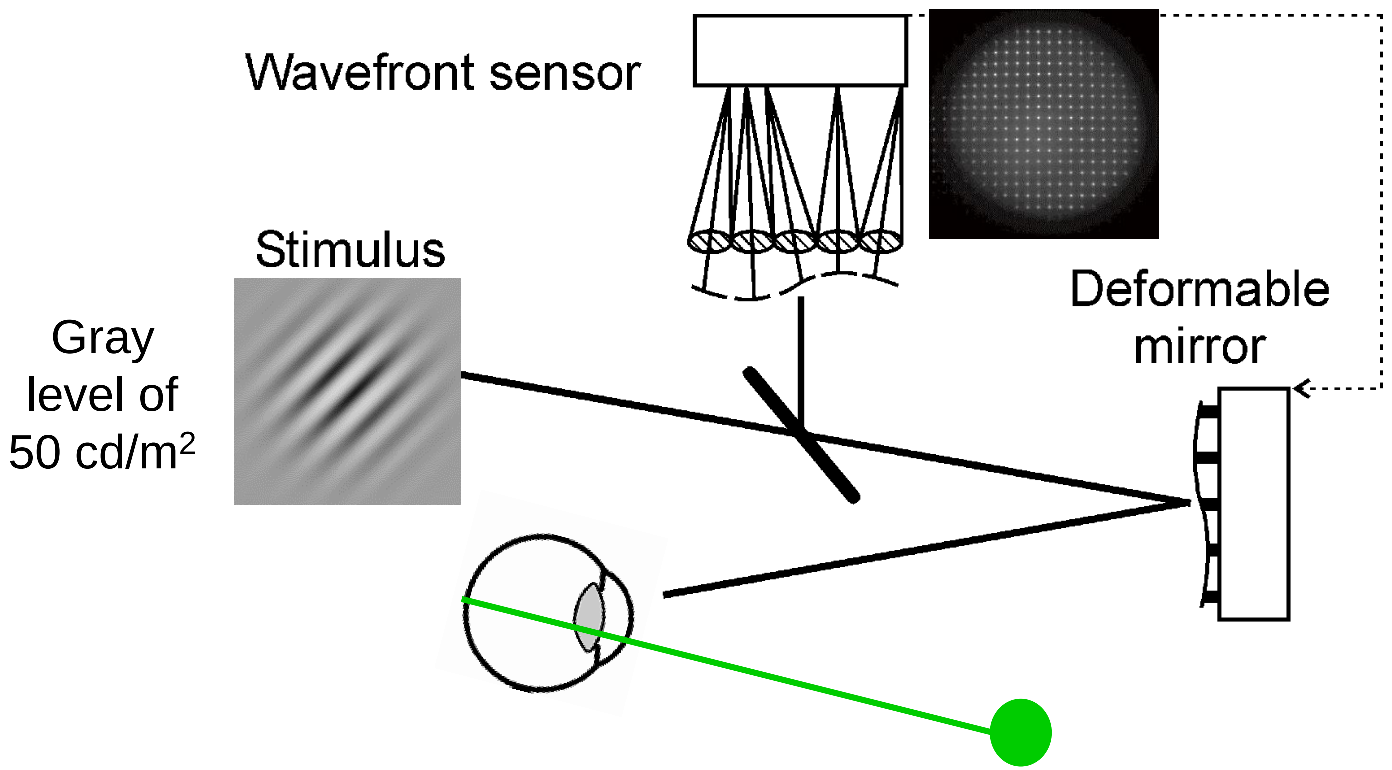
Peripheral vision with chromatic aberrations?



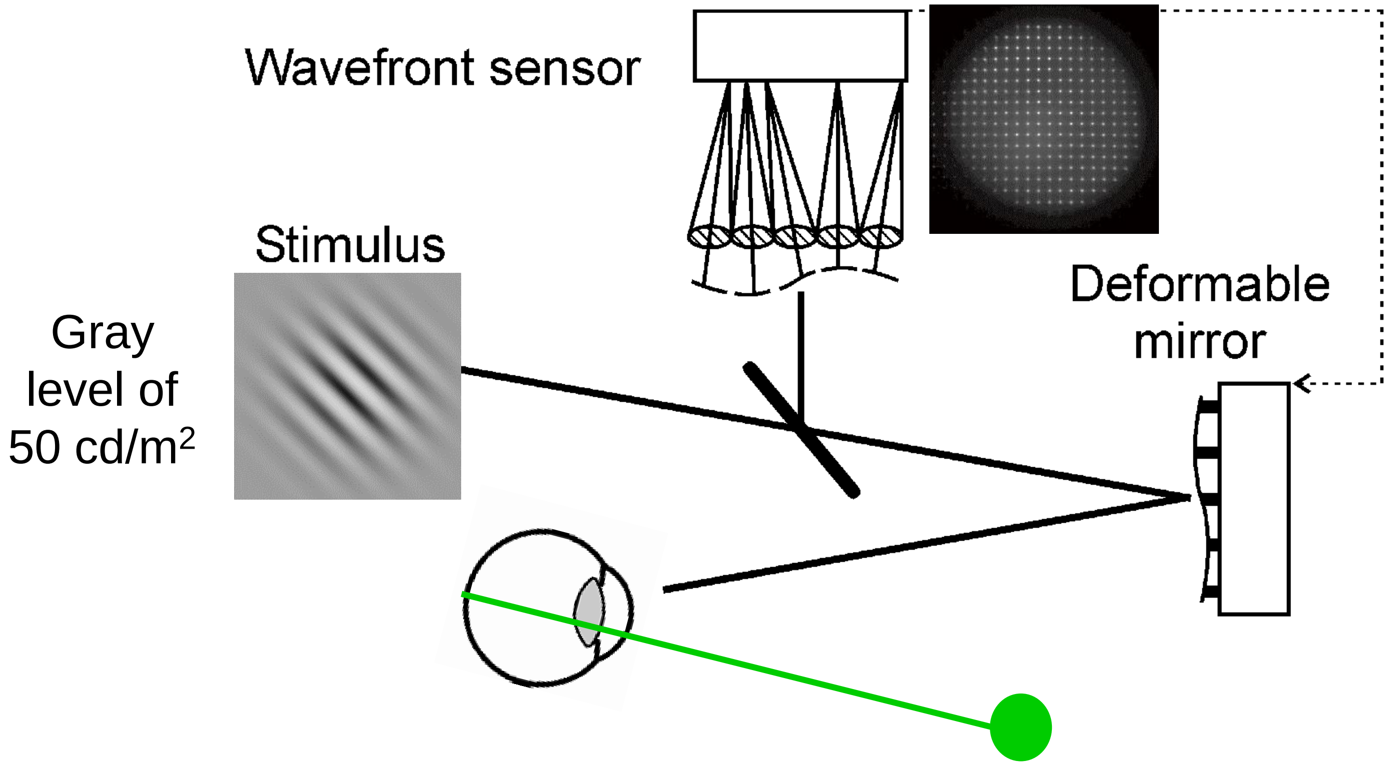
Manipulating and measuring peripheral vision

- Trial lenses (defocus and astigmatism)
- Prisms (transverse chromatic aberration)
- Filters (scattering, spectrum)
- Adaptive optics (monochromatic aberrations)

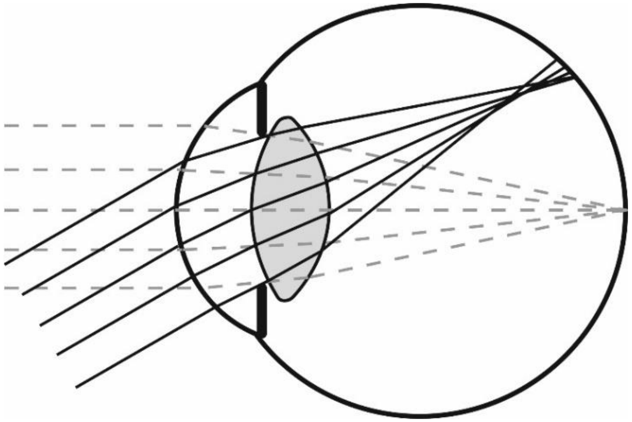


Manipulating and measuring peripheral vision

- Peripheral resolution and detection acuity threshold
- Gabor gratings of different orientations
- Calibrated monitor with 10 bit and stable luminance
- Bayesian psychophysics with forced choice



Effect of refractive errors on peripheral vision



In the 20° nasal visual field:

10% contrast resolution is reduced if:

|Defocus| ≥ 1 D (~0.1 logMAR / D)

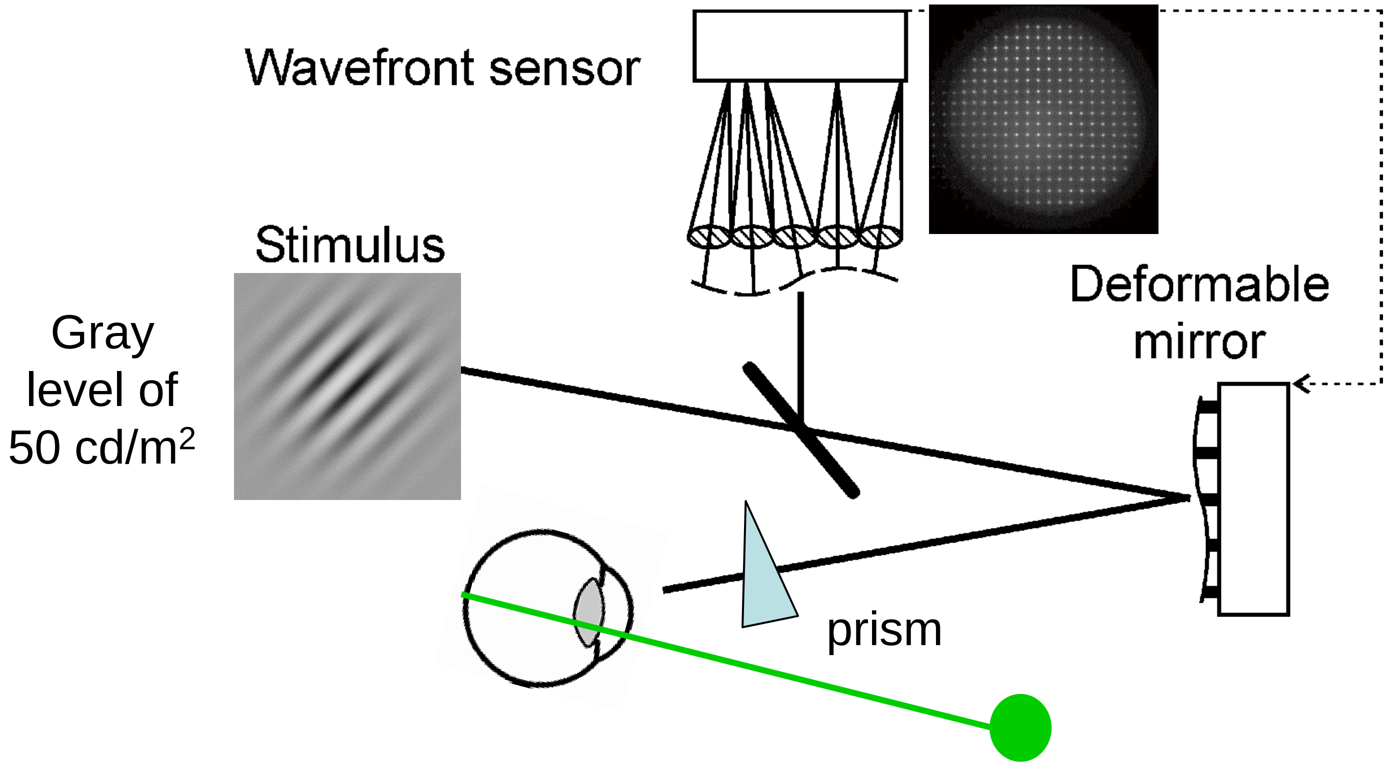
and/or

|Astigmatism| ≥1.50 D

Lundström, Manzanera, Prieto, Ayala, Gorceix, Gustafsson, Unsbo, Artal, Opt. Express 15 (2007)
Rosén, Lundström, Unsbo, Invest. Ophthalmol. Vis. Sci. 52 (2011)
Lewis, Baskaran, Rosén, Lundström, Unsbo, Gustafsson, Optom. Vis. Sci. 91 (2014)

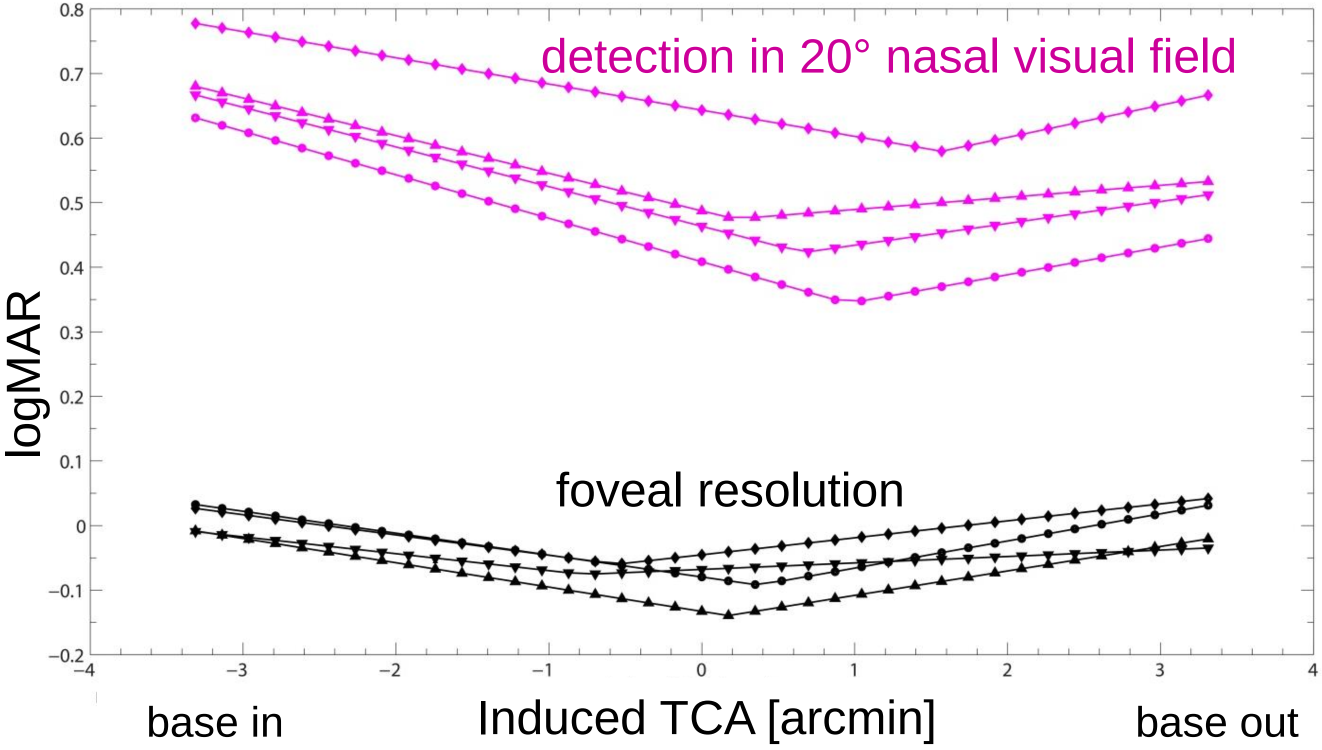
Inducing peripheral TCA

- Peripheral resolution and detection acuity threshold
- Gabor gratings of different orientations
- Calibrated monitor with 10 bit and stable luminance
- Bayesian psychophysics with forced choice



Effect of induced TCA on peripheral vision

TCA induced by prisms in an adaptive optics system correcting the monochromatic aberrations.

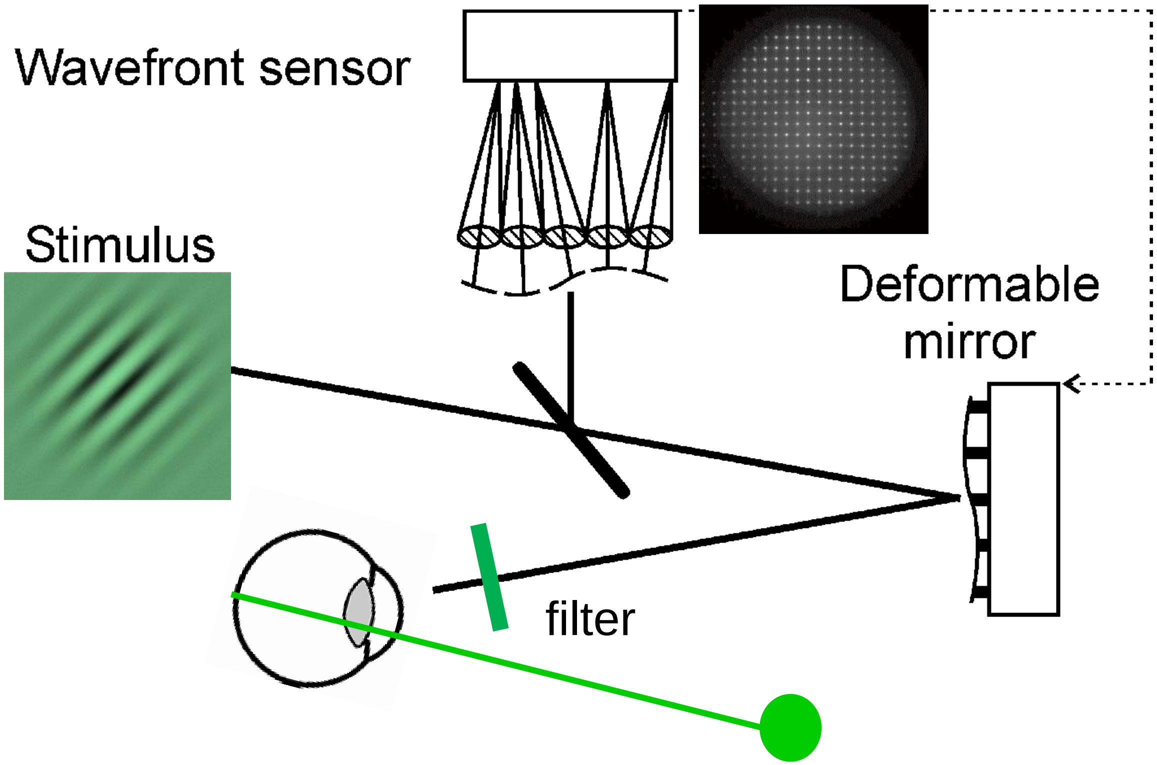


Reduction of 0.057 logMAR / arcmin of TCA peripherally and 0.032 logMAR / arcmin of TCA foveally

Winter, Taghi Fathi, Venkataraman, Rosén, Seidemann, Esser, Lundström, Unsbo, J. Opt. Soc. Am. A 32(10), 1764-1771 (2015)

Correcting the natural chromatic aberrations

- Peripheral resolution and detection acuity threshold
- Gabor gratings of different orientations
- Calibrated monitor with 10 bit and stable luminance
- Bayesian psychophysics with forced choice



Effect of aberrations on peripheral vision

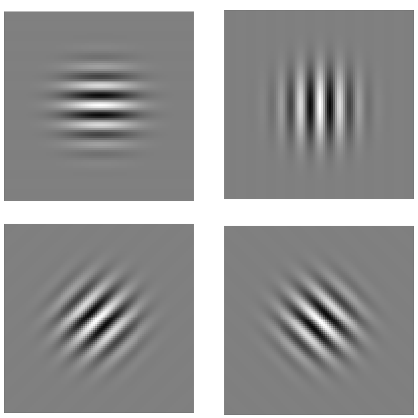
With/without polychromatic blur

With/without mono-chromatic blur

	White stimuli	Green stimuli
Spectacle correction	**Ref-W**	**Ref-G**
Adaptive optics correction	**AO-W**	**AO-G**

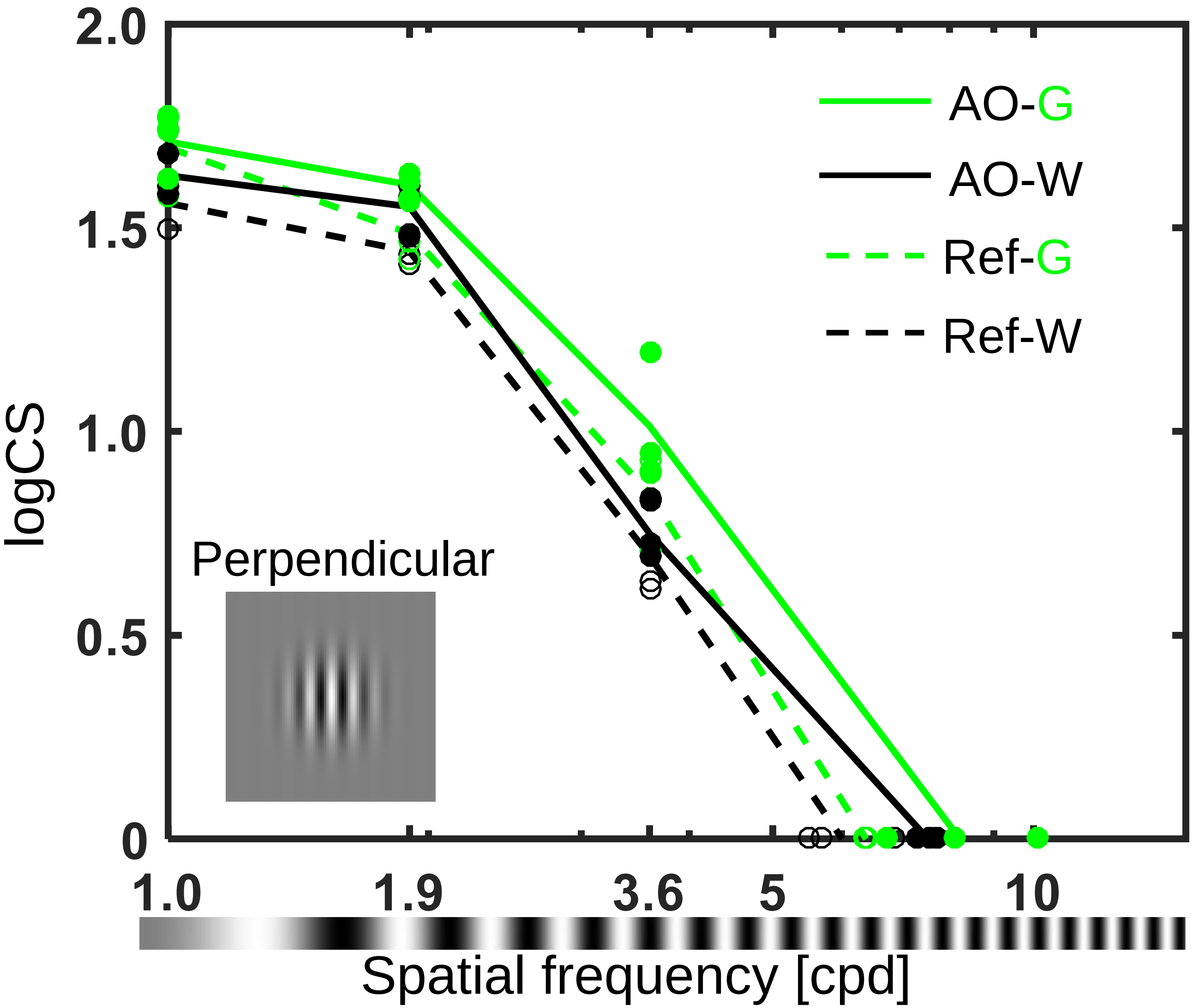
Full CRT spectrum

Green filter (550nm, FWHM 25 mm)



- 20° nasal visual field
- 7 subjects with 3 repetitions

Effect of aberrations on peripheral vision

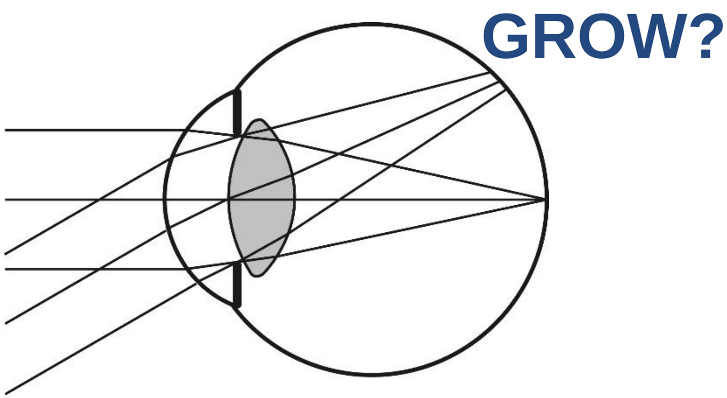


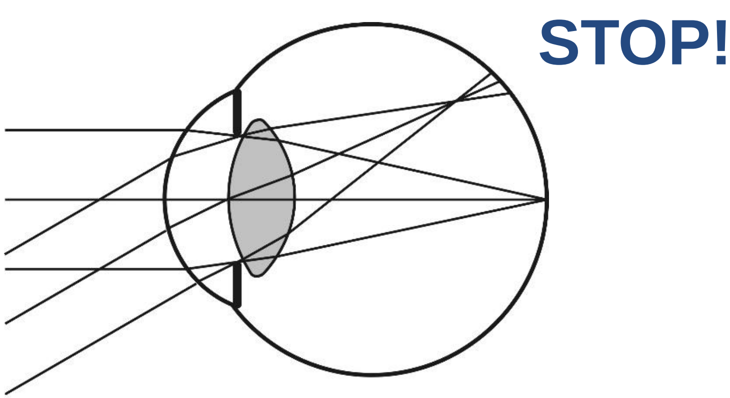
Largest effect on gratings perpendicular to the horizontal field angle due to coma and TCA.

Similar reduction by monochromatic and chromatic aberrations

Venkataraman, Winter, Rosén, Lundström, Optom. Vis. Sci. 93(6), 567-574, 2016.

Peripheral refraction and eye growth





Not seen in humans

- Peripheral refraction and ocular shape change during eye growth

How tell the difference between positive and negative defocus?

Myopia control for humans

- Peripheral myopic defocus may reduce eye growth

Vision and the sign of defocus

Optical causes to asymmetric depth of field:

- Astigmatism
- Chromatic aberrations
- Monochromatic high-order aberrations

This asymmetry shows up in through-focus vision evaluation experiments both in the fovea and in the periphery (not clear if more common for myopes).*

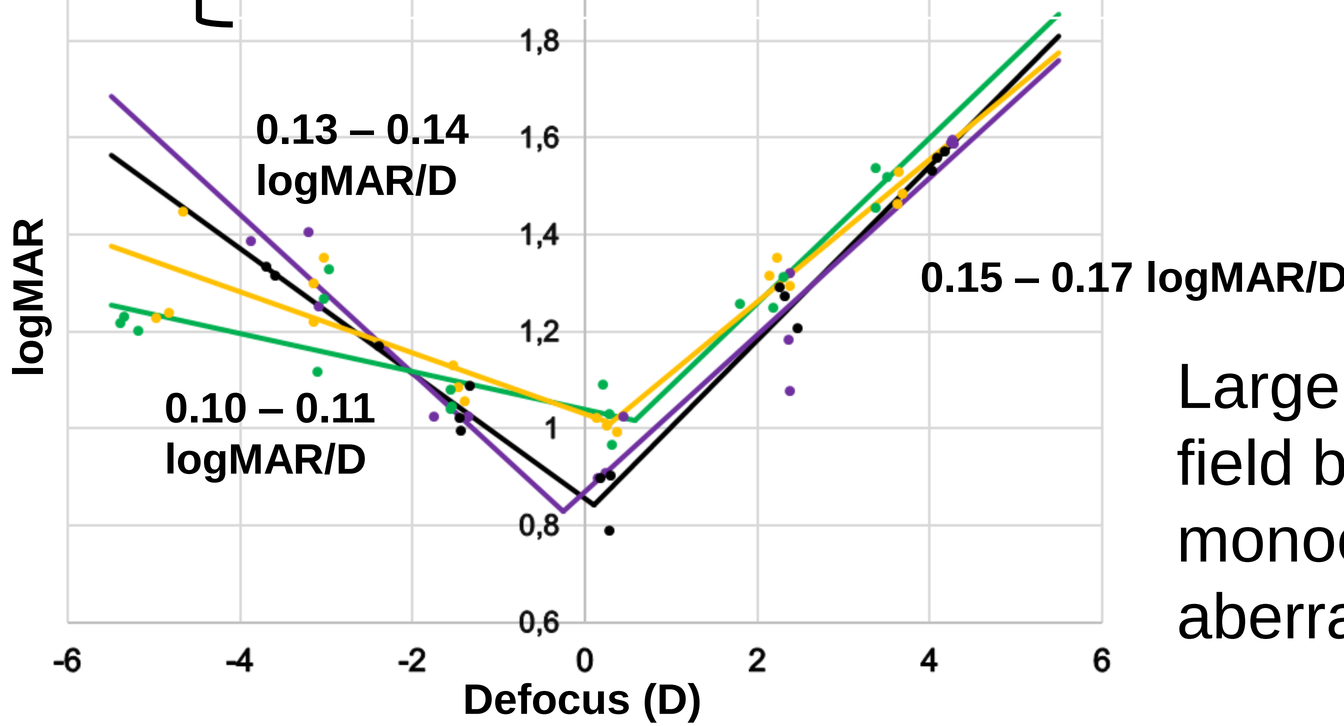
*Radhakrishnan, Pardhan, Calver, O'Leary Optom Vis Sci 81:14–17 (2004)
*Guo, Atchison, Birt Vision Res 48: 1804–1811 (2008)
*Rosén, Lundström, Unsbo, Invest Ophthalmol Vis Sci 52, 318-323 (2011)
*Rosén, Lundström, Unsbo, Invest Ophthalmol Vis Sci 53, 7176 – 82 (2012)

Peripheral vision and the sign of defocus

With/without polychromatic blur

With/without mono-chromatic blur

	White stimuli	Green stimuli
Spectacle correction	Ref-W	Ref-G
Adaptive optics correction	AO-W	AO-G



Large depth of field because of monochromatic aberrations

Papadogiannis, Romashchenko, Unsbo, Lundström. Ophthalmic Physiol Opt 2020.

Conclusions

- Magnitude of chromatic aberration in the periphery:
  - ➢ LCA slight increase
  - ➢ TCA linear increase
- Effect of chromatic aberrations on peripheral vision:
  - ➢ Peripheral TCA more disturbing
  - ➢ Perpendicular stimulus orientations more affected
  - ➢ Similar reduction as by monochromatic aberrations
- Chromatic aberrations and myopia development?
  - ➢ Lower sensitivity to peripheral hyperopic defocus mainly due to monochromatic aberrations

Acknowledgements

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http://lo.um.es

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Main references

1. B. Jaeken, L. Lundström, P. Artal, “Peripheral aberrations in the human eye for different wavelengths: off-axis chromatic aberration”, J. Opt. Soc. Am. A 28:1871-1879 (2011).
2. S. Winter, M. Taghi Fathi, A.P. Venkataraman, R. Rosén, A. Seidemann, G. Esser, L. Lundström, P. Unsbo, “Effect of induced transverse chromatic aberration on peripheral vision”, J. Opt. Soc. Am. A 32(10), 1764-1771 (2015).
3. S. Winter, R. Sabesan, P.N. Tiruveedhula, C. Privitera, P. Unsbo, L. Lundström, A. Roorda, “Transverse chromatic aberration across the visual field of the human eye”, J. Vision 16(14), 9 (2016).
4. A.P. Venkataraman, P. Papadogiannis, D. Romashchenko, S. Winter, P. Unsbo, L. Lundström “Peripheral resolution and contrast sensitivity: Effects of monochromatic and chromatic aberrations” J. Opt. Soc. Am. A 36(4), B52-57 (2019).
5. P. Papadogiannis, D. Romashchenko, P. Unsbo, L. Lundström “Lower sensitivity to peripheral hypermetropic defocus due to higher order ocular aberrations” Ophthalmic Physiol. Opt. https://doi.org/10.1111/opo.12673 (2020).