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Does blue-violet filtering affect contrast sensitivity?

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OPTICS AND OPTOMETRY RESEARCH CENTER
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1) blue-violet filtering contact lenses

Does blue-violet filtering in contact lenses improve contrast sensitivity?

S. Tavazzi [a,b], E. Ponzini [a,b,*], A. Caridi [a], S. Secreti [a], F. Miglio [a,b], A. Duse [a,b], F. Zeri [a,b]

Contact Lens and Anterior Eye

2021 • Article number 101558

2) blue-violet filtering ophthalmic lenses

Silvia Tavazzi [1,2]
Federica Cozza [1,2]
Gabriele Nigrotti [2]
Chiara Braga [2]
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Clinical Optometry

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ORIGINAL RESEARCH

Improvement or Worsening of Human Contrast Sensitivity Due to Blue Light Attenuation at 450 nm

OUTLINE

- T spectra
- Motivations and aim
- Materials and methods
- Results
  - Does a ceiling effect occur?
  - Does CS depend on age?
  - Is CS different between clear and BVF lenses?
  - Does the baseline CS (with the clear lens) play a role?

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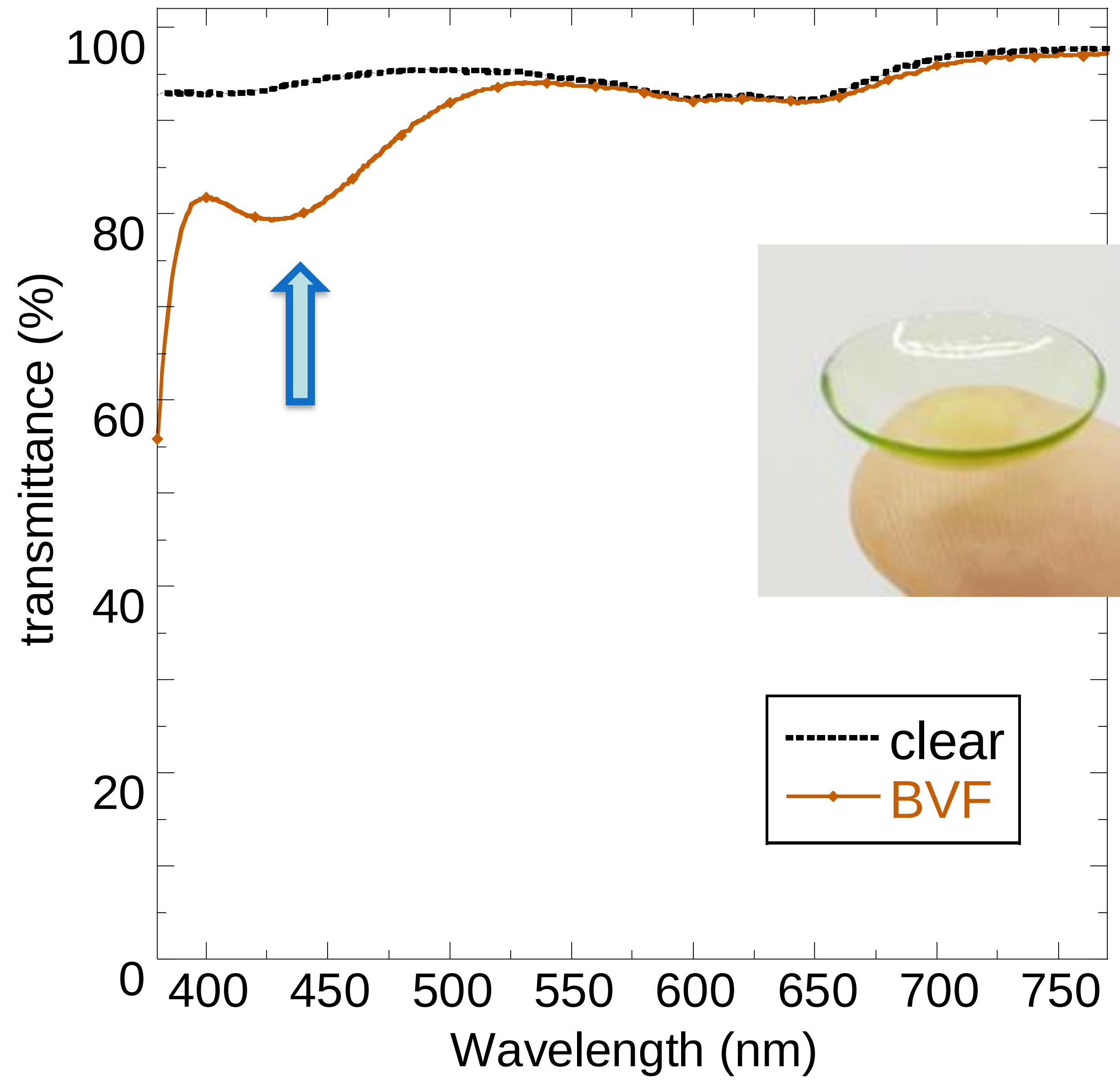
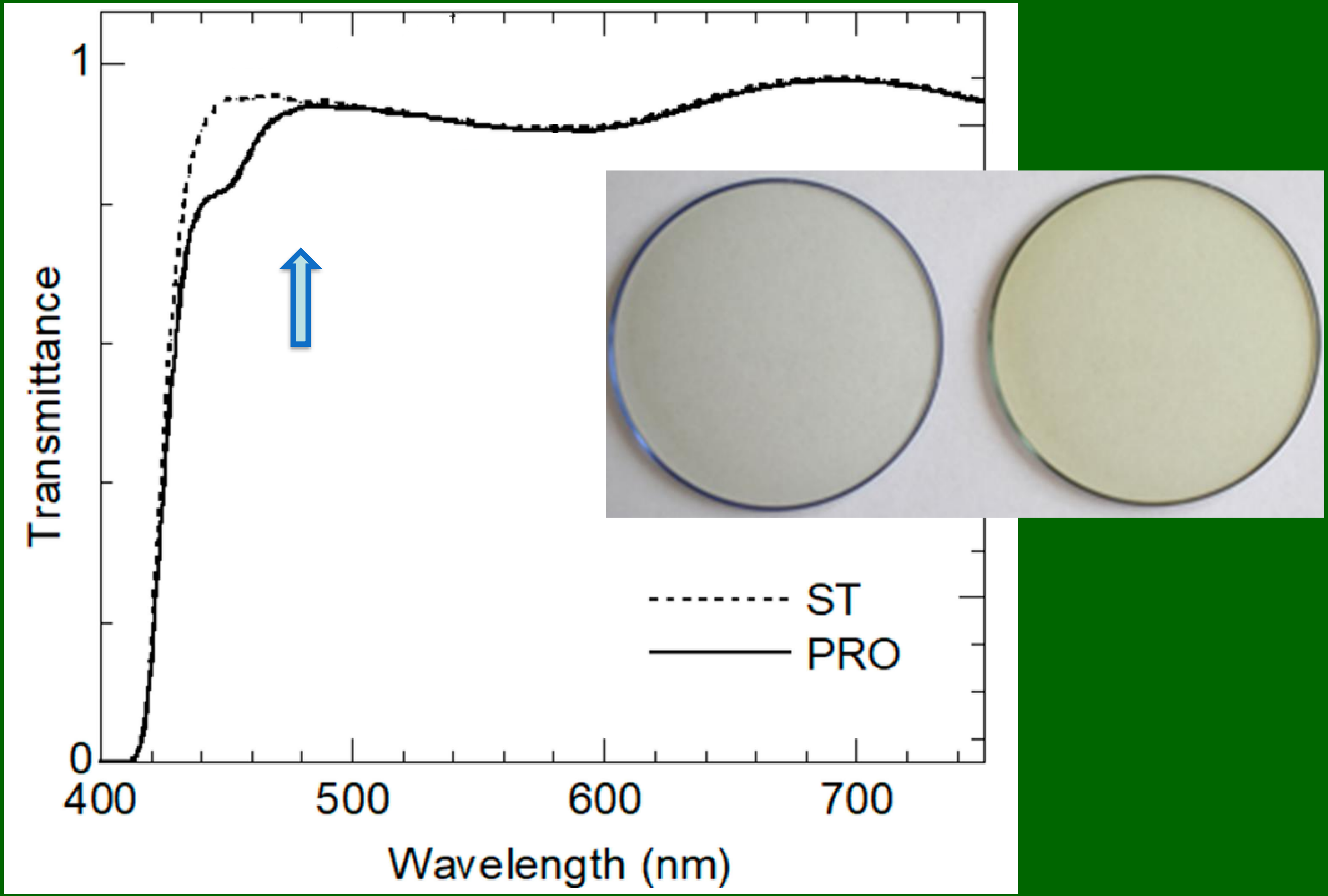
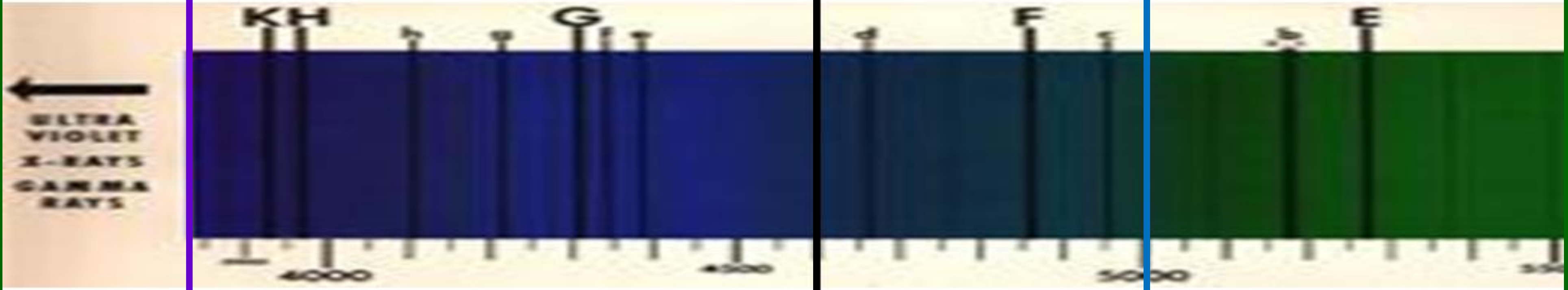

100
80
60
40
20
0
transmittance (%)
400
450
500
550
600
650
700
750
Wavelength (nm)
clear
BVF


1
0
Transmittance
400
500
600
700
Wavelength (nm)
ST
PRO

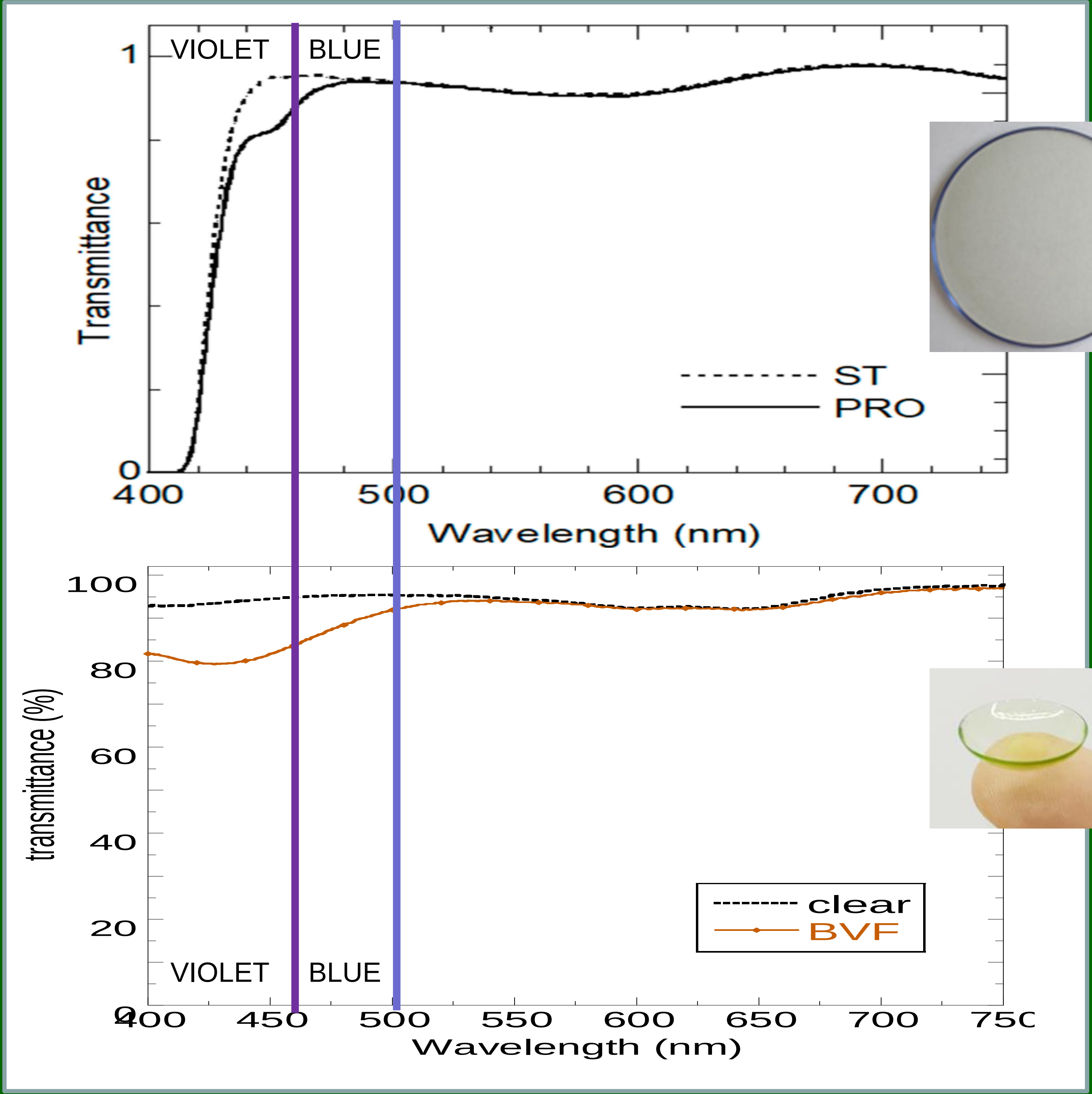
VIOLET
380-460 nm

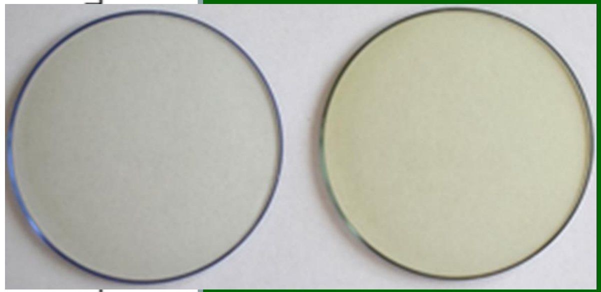
BLUE
460-500 nm

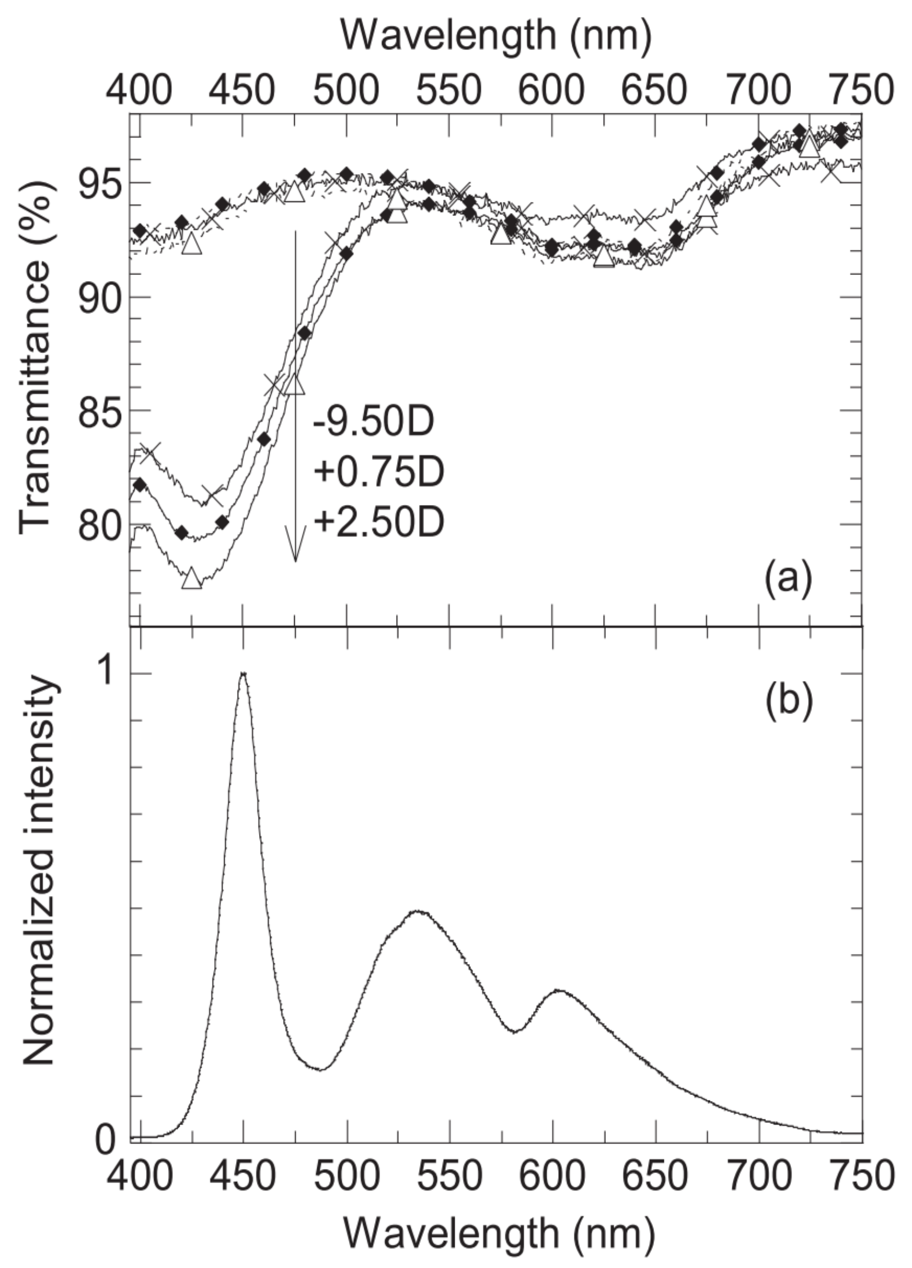


[1] Violet and Blue Light: Impact of High-Energy Light on Vision and Health, Daniel Chang, Tawnya Pastuck, Robert Rosen, Sarah Hollmann, Tanja Babic, Andris Stapars, Journal of Ophthalmic Studies ISSN 2639-152X, vol 3, issue 2.

[2] (a) International Organization for Standardization (2007) Optics and photonics-spectral bands. (b) International Organization for Standardization (2018) Technical Report: Ophthalmic optics-Spectral lenses-Short wavelength visible solar radiation and the eye.


VIOLET
BLUE
Transmittance
1
0
400
500
600
700
Wavelength (nm)
ST
PRO
100
80
60
40
20
0
transmittance (%)
clear
BVF
VIOLET
BLUE
400
450
500
550
600
650
700
750
Wavelength (nm)





Wavelength (nm)
400 450 500 550 600 650 700 750
Transmittance (%)
95
90
85
80
-9.50D
+0.75D
+2.50D
(a)
Normalized intensity
1
0
(b)
400 450 500 550 600 650 700 750
Wavelength (nm)

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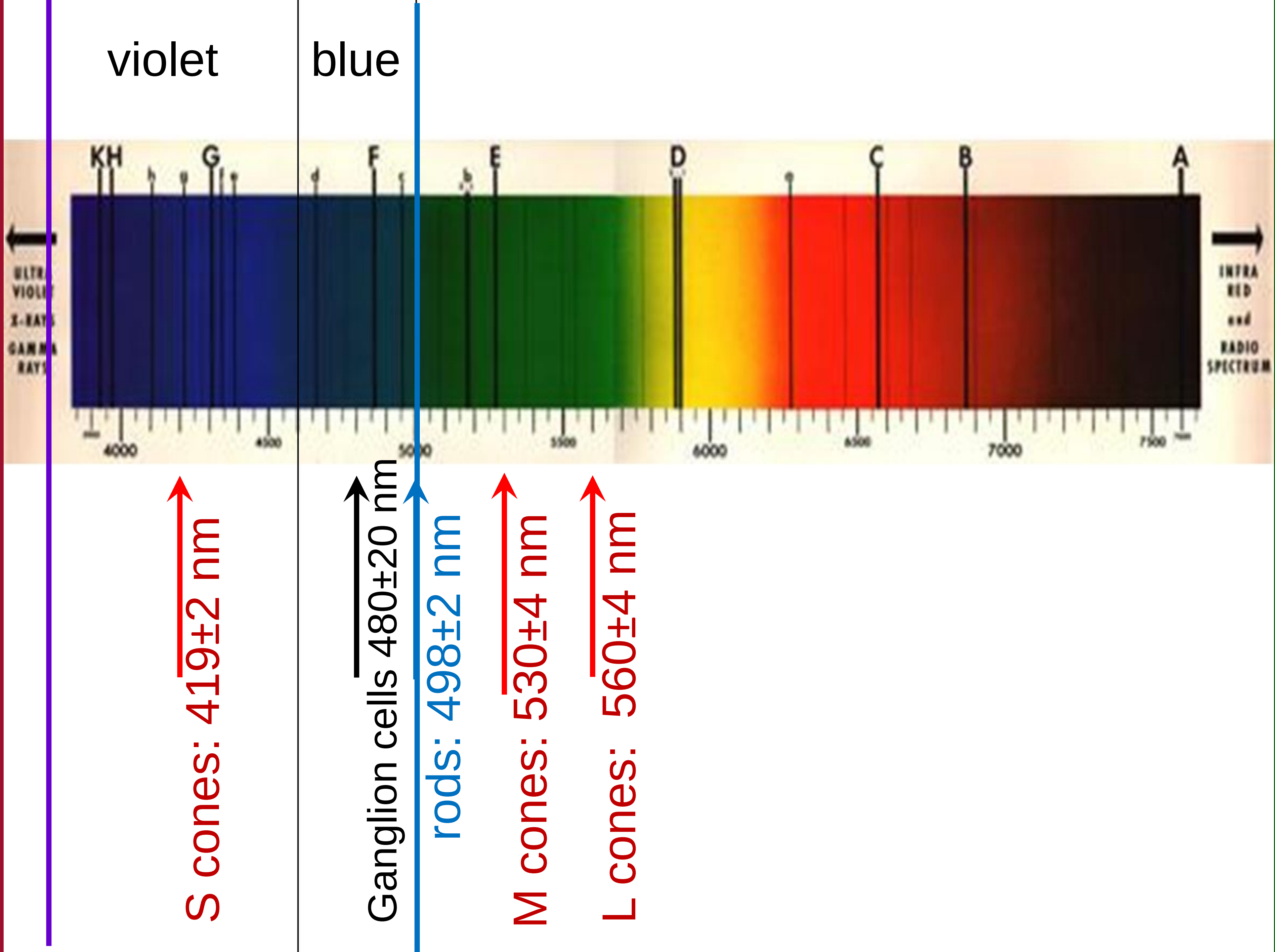
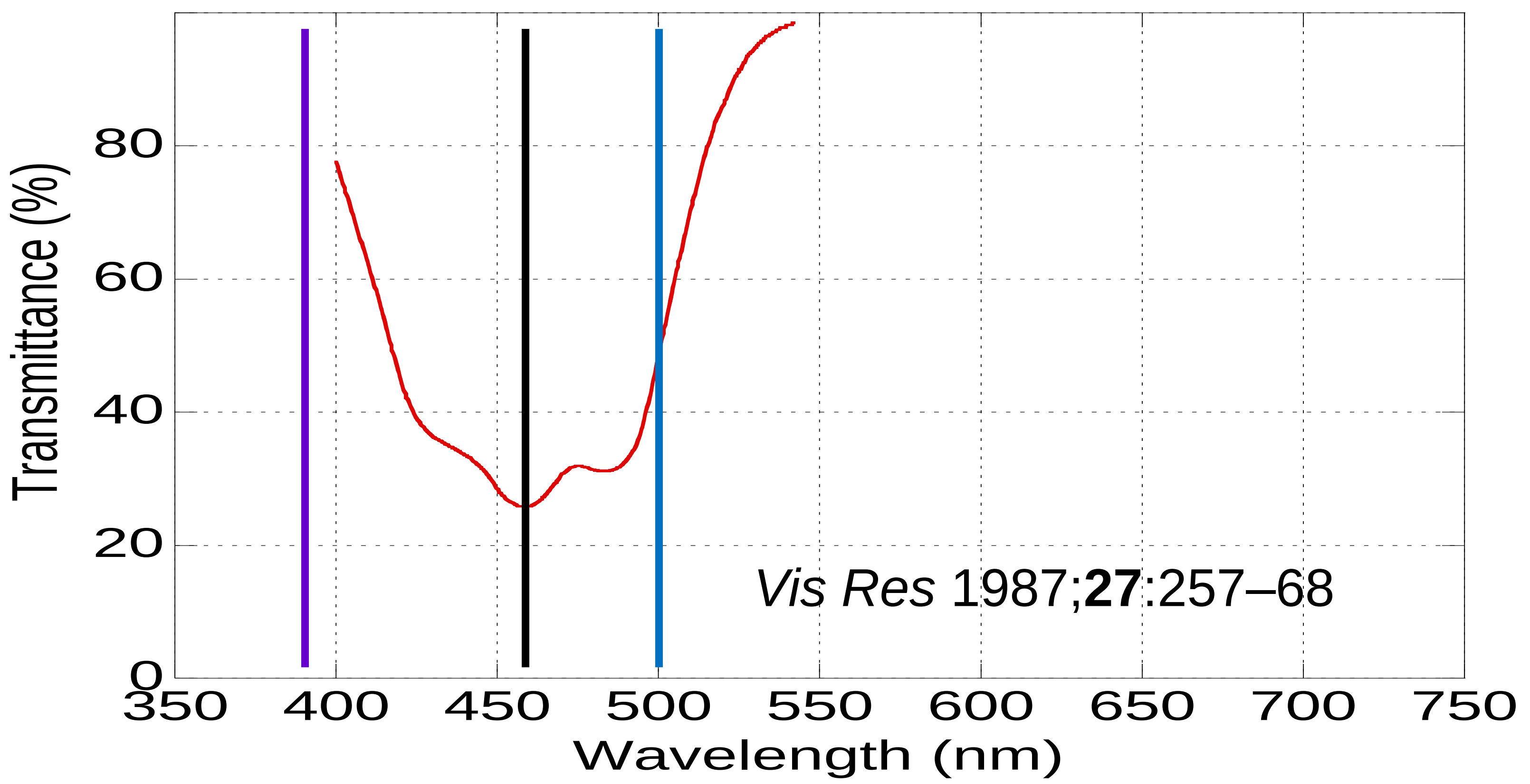


SPECTRAL DISTRIBUTION

vs

spectral response of photo-receptors



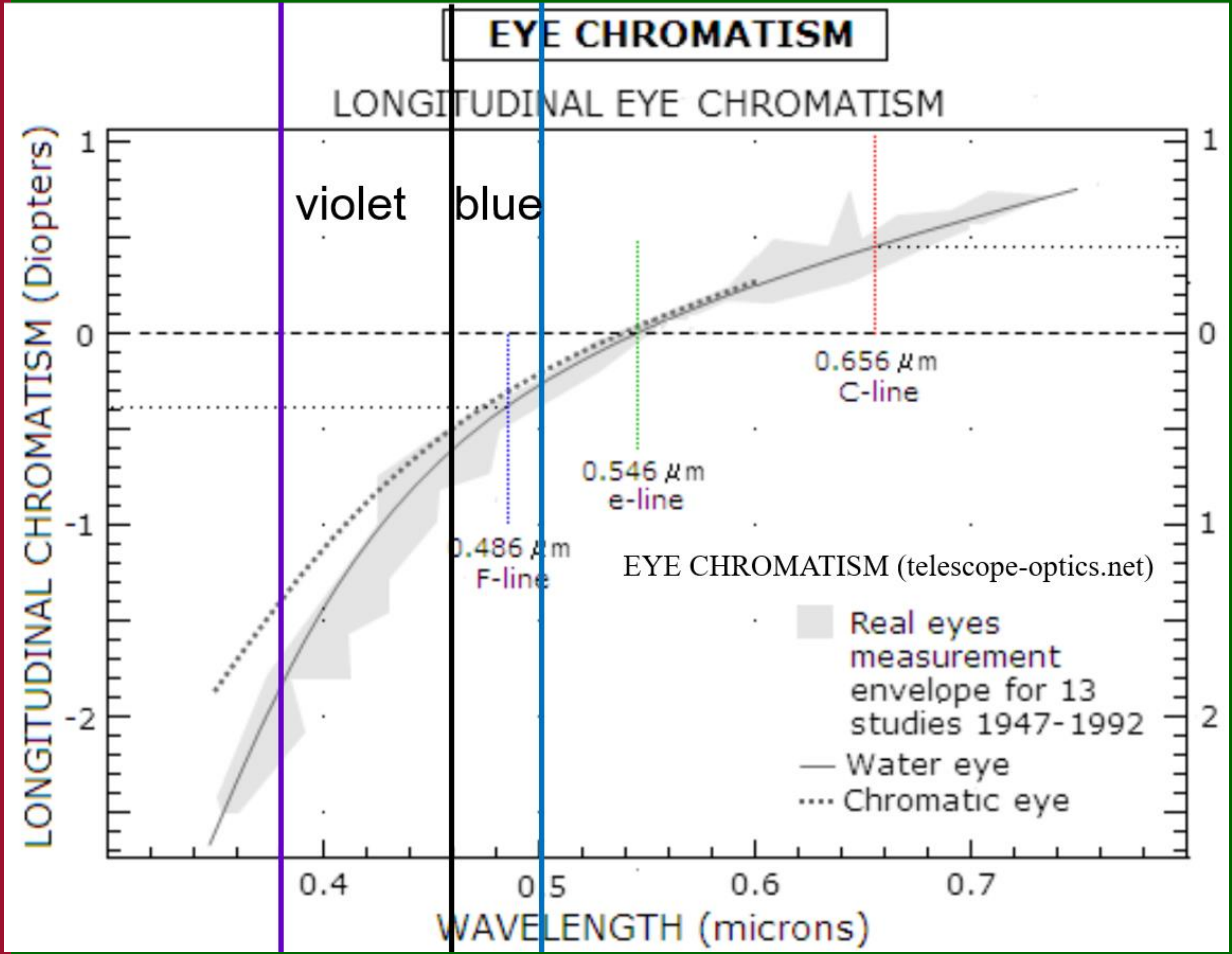
SPECTRAL DISTRIBUTION

VS

macular pigment

Lutein, zeaxanthin (carotenoids)

- Its concentration peaks in the foveola.
- Max of the absorption spectrum at ~ 460 nm (it acts as an optical filter).



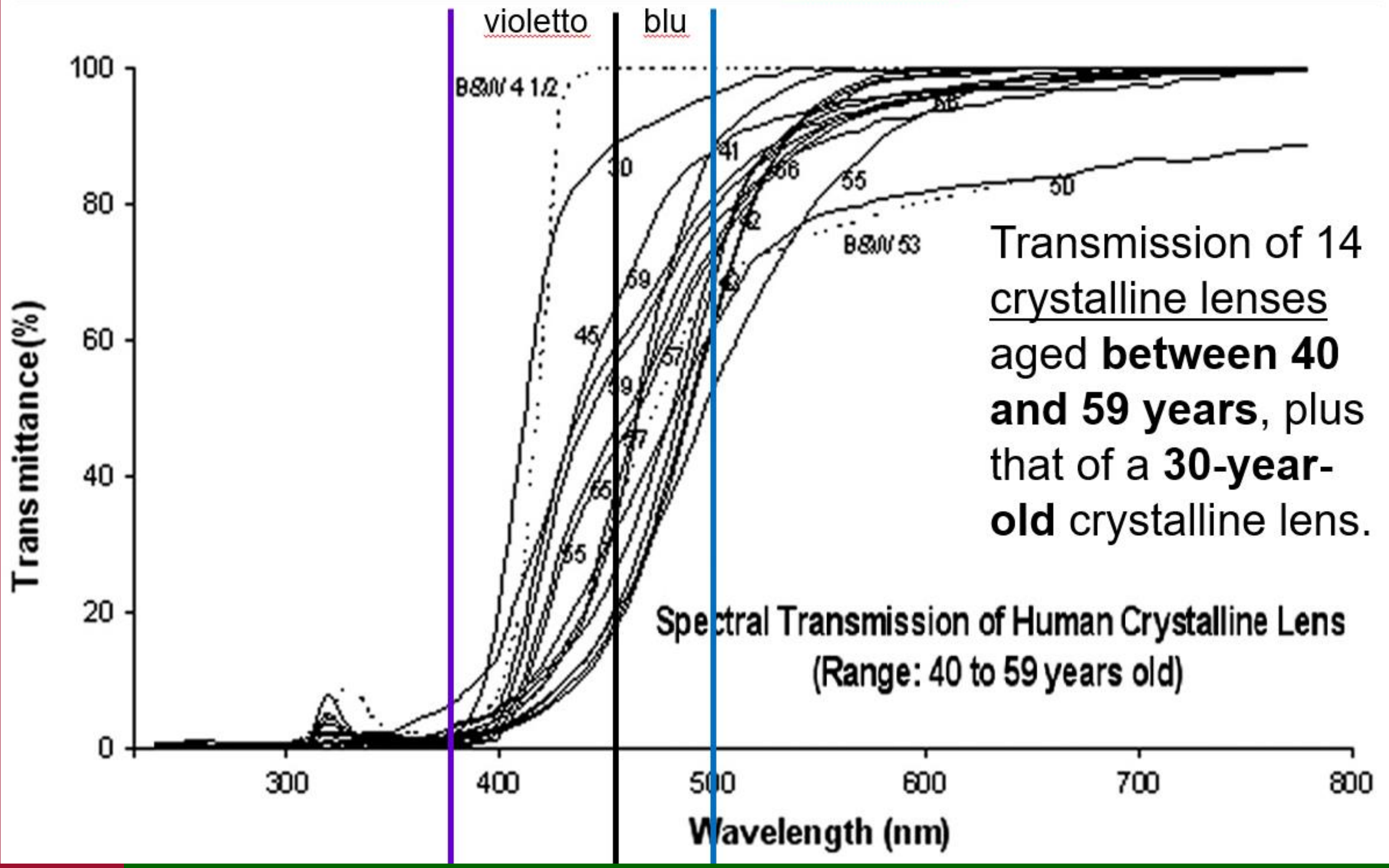
SPECTRAL DISTRIBUTION

vs

chromatic aberration

In the visual system, the difference in refraction for violet light is about twice that of blue light.

Spectral Transmission of the Human Crystalline Lens in Adult and Elderly Persons: Color and Total Transmission of Visible Light, Invest. Ophthalmol. Vis. Sci.. 2012;53(7):4076



SPECTRAL DISTRIBUTION
VS
transmission of ocular media

Transmission of the ocular media

Edward A. Boettner and J. Reimer Wolter

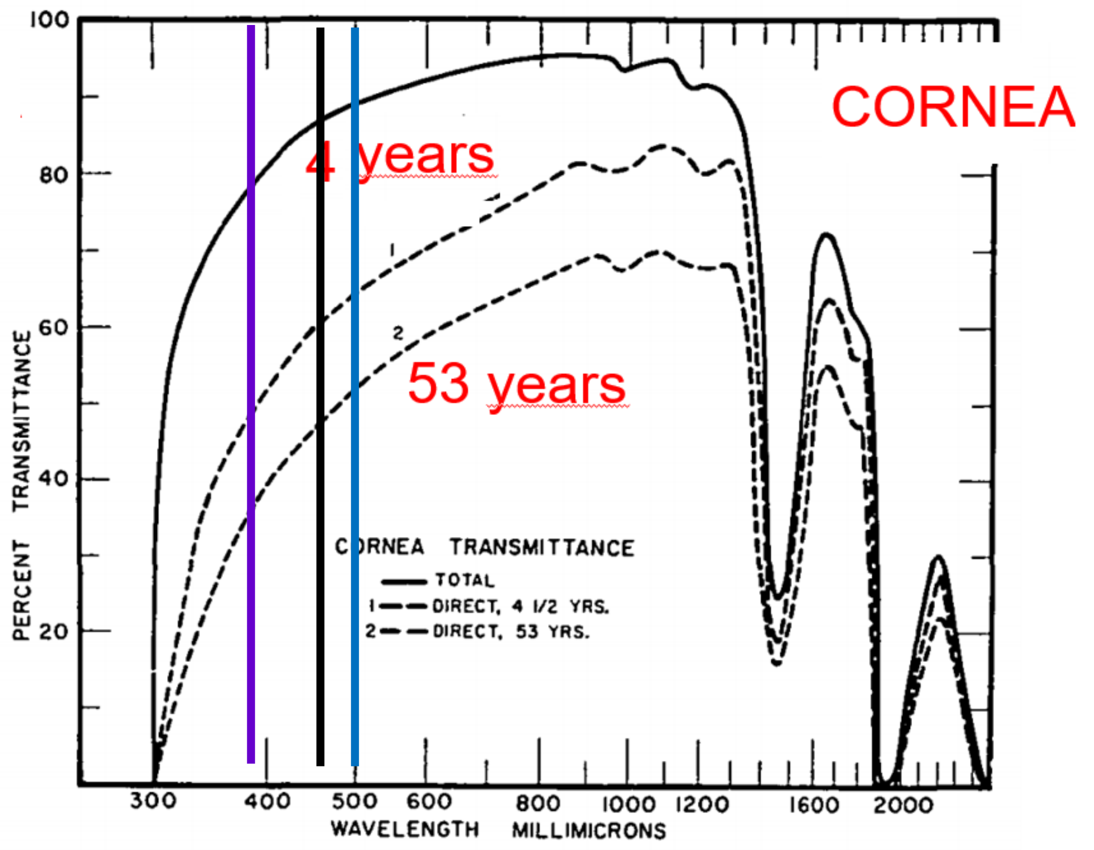
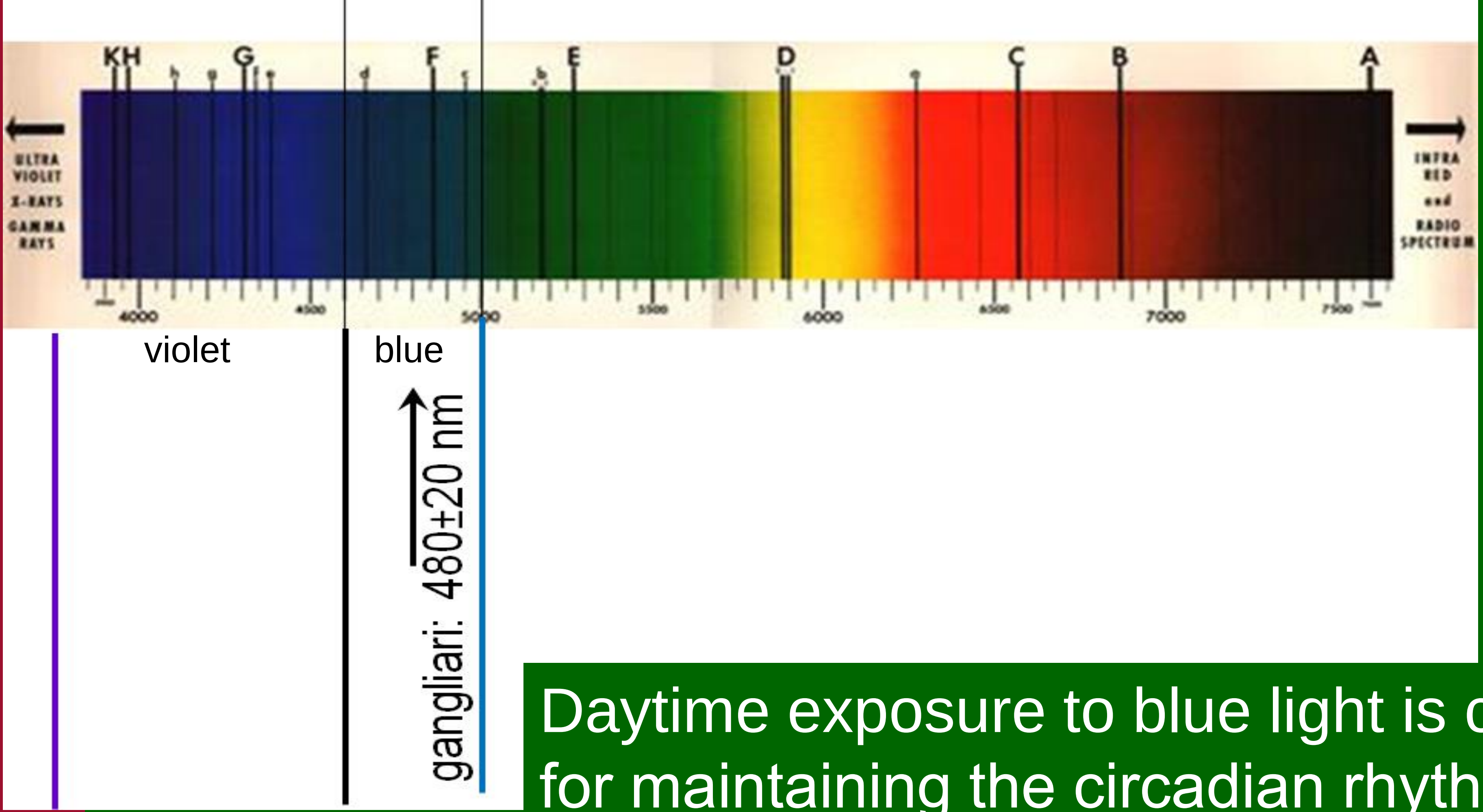


Fig. 3. Transmittance of the cornea.



SPECTRAL DISTRIBUTION

VS

circadian rhythm and physiological functions

Daytime exposure to blue light is considered essential for maintaining the circadian rhythm, BUT….

… excessive exposure in the evening / night hours is believed to have adverse effects since the ganglion cells, when stimulated by blue light, release melanopsin, which suppresses the release of melatonin (hormone that regulates the circadian rhythm).

SPECTRAL DISTRIBUTION VS phototoxicity

While various pathological ocular conditions have been related to **chronic exposure to ultraviolet radiation**, suggesting the inclusion of UV-blocking systems also in contact lenses, less certainty exists on the effect on ocular structures of chronic exposure to visible radiation.

Exposure to violet light can contribute to oxidative stress by producing reactive oxygen species (ROS) with possible eye damage. Instead, it has been proposed that blue light does not pose a substantial risk.

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Table 1

Main characteristics of the clear and BVF CLs under investigation.

	Clear CL	BVF CL
Manufacturer	Mark'ennovy (Spain)	Mark'ennovy (Spain)
Brand name	Xtensa	Jade
Manufacturer-recommended replacement frequency	Monthly	Monthly
Lens material	Filcon IV	Filcon IV
Water content (%)	55	52
Central thickness @ −3.00D (mm)	0.10	0.09
Oxygen transmissibility @ −3.00D (10^{-9} cm mLO_2/s mL mmHg)	19	20
UV blocking filter	No	Yes
Geometry	Aspherical	Spherical
Back optic zone radius (mm)	8.70	8.70
Total diameter (mm)	14.40	14.40

Table 2
Demographic data of the recruited subjects.

		Younger adults	Older adults
Number of subjects		19	22
Number of females (percentage of the total)		13 (68%)	14 (64%)
Number of subjects whose right eye is dominant (percentage of the total)		11 (58%)	12 (55%)
Age (years)	Mean	24.4	55.5
	Std dev	4.3	4.9
	Min	20	45
	Max	36	66
CL optical power (D)	Mean	−2.17	−1.40
	Std dev	2.52	2.40
	Min	−9.00	−6.00
	Max	1.50	1.75
LogMAR of the dominant eye	Mean	−0.14	−0.13
	Std dev	0.07	0.06
	Min	−0.30	−0.26
	Max	0.00	0.02

- clear and BVF CLs with the appropriate mean spherical equivalent fitted **in both eyes**
- in **random order**: half of the participants received the clear CLs before the BVF CLs whereas the other half received the reverse order
- “wash out” period of **10 min**
- Ten minutes after CL insertion, the logarithm of the **photopic CS** (logCS) was measured **monocularly on the dominant eye** through a digital optotype system (Vision Chart) at a distance of **4.30 m**
- **Sloan letter** stimuli at five different spatial frequencies
- adaptive psychometric procedure for this kind of stimulus (**QUEST**)

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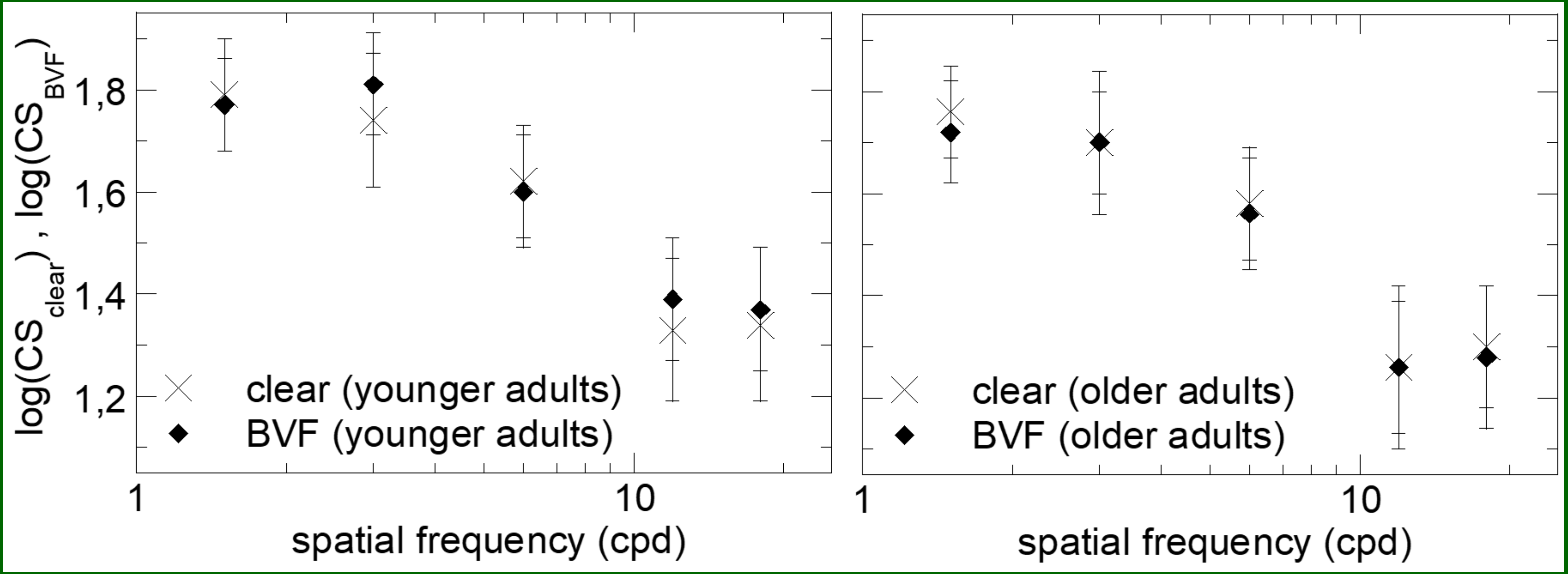
RESULTS



log(CS_clear) , log(CS_BVF)
1,8
1,6
1,4
1,2
clear (younger adults)
BVF (younger adults)
1
10
spatial frequency (cpd)
clear (older adults)
BVF (older adults)
1
10
spatial frequency (cpd)

1- Does a ceiling effect occur?

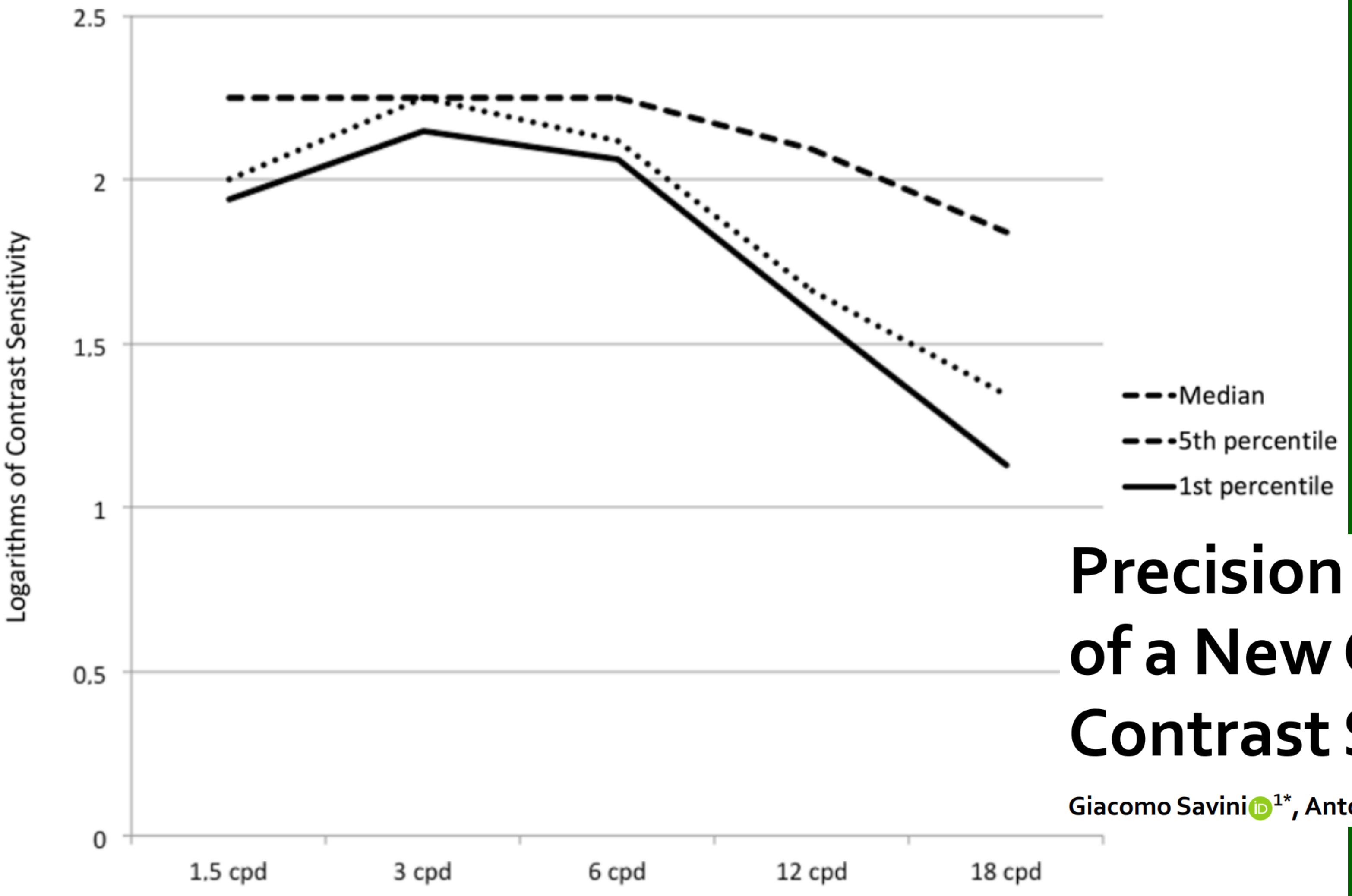


Figure 1. Distribution of CS measurements in the healthy sample.

Precision and Normative Values of a New Computerized Chart for Contrast Sensitivity Testing

Giacomo Savini[1*], Antonio Calossi[2], Domenico Schiano-Lomoriello[1] & Piero Barboni[3,4]

SCIENTIFIC REPORTS | (2019) 9:16537 | https://doi.org/10.1038/s41598-019-52987-9

1- Does a ceiling effect occur?

Savini et al

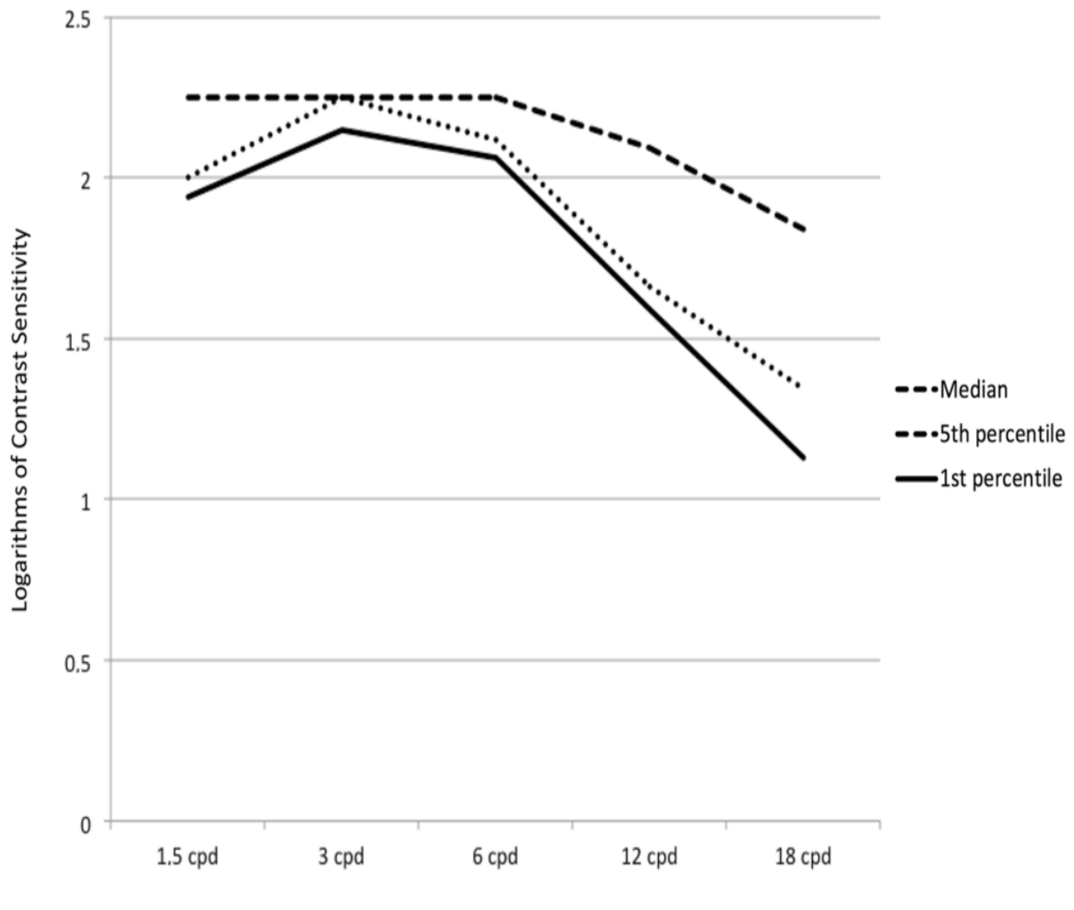
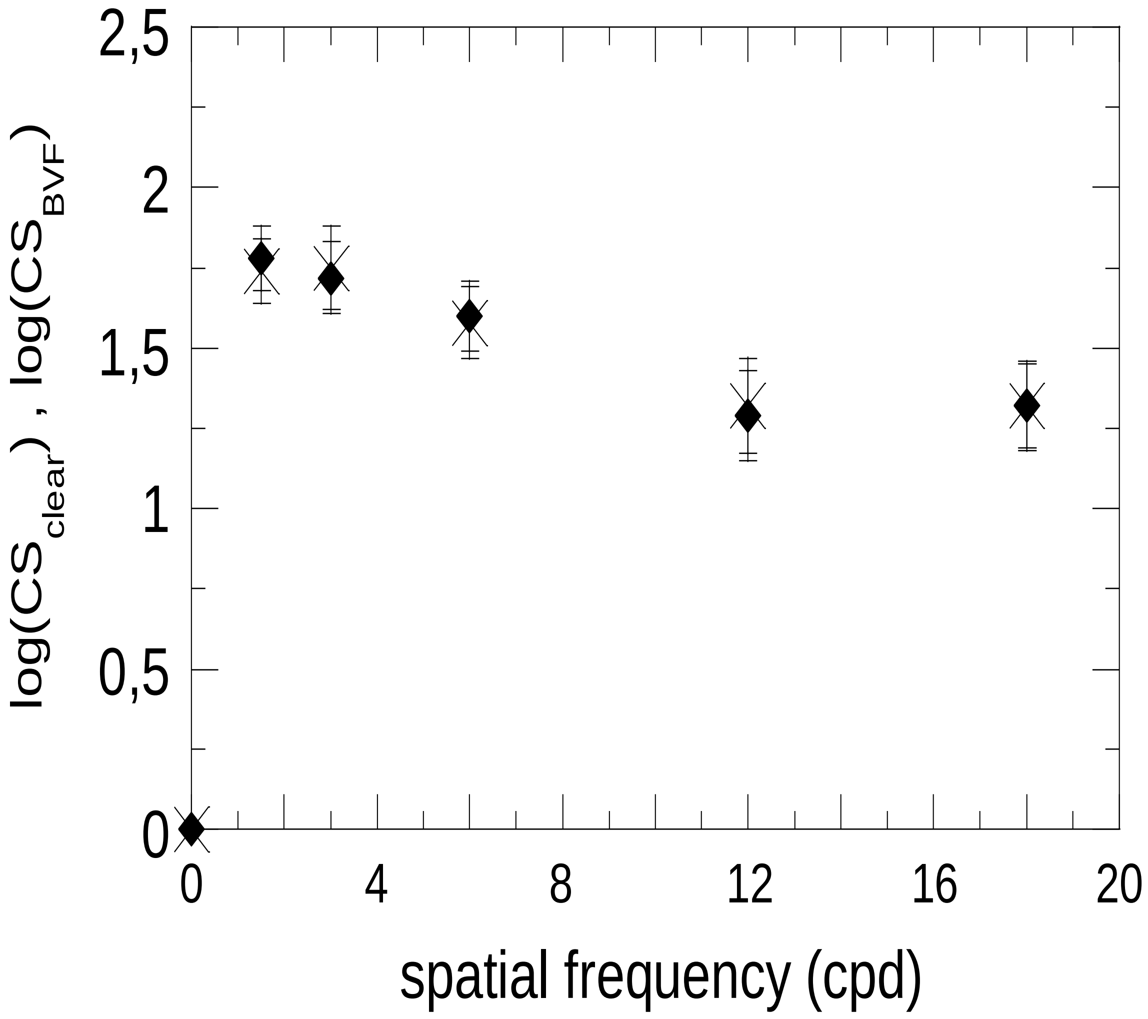


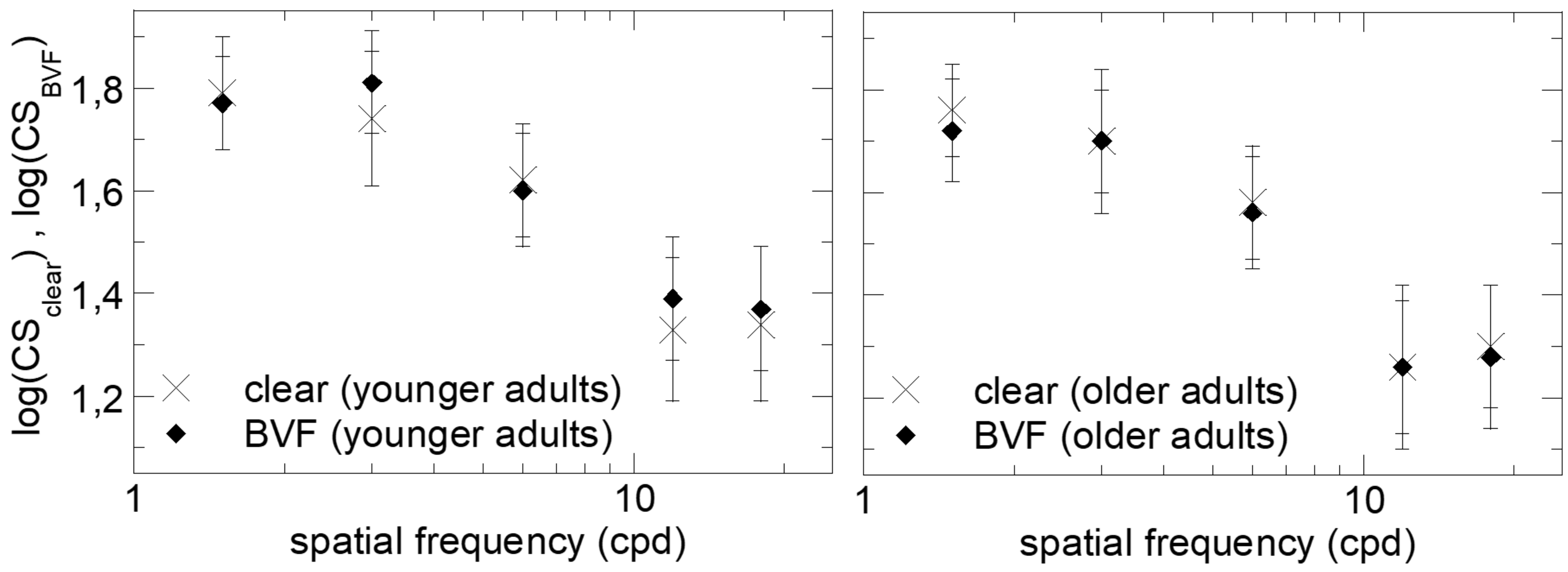
Figure 1. Distribution of CS measurements in the healthy sample.

our work (R. Rolandi)



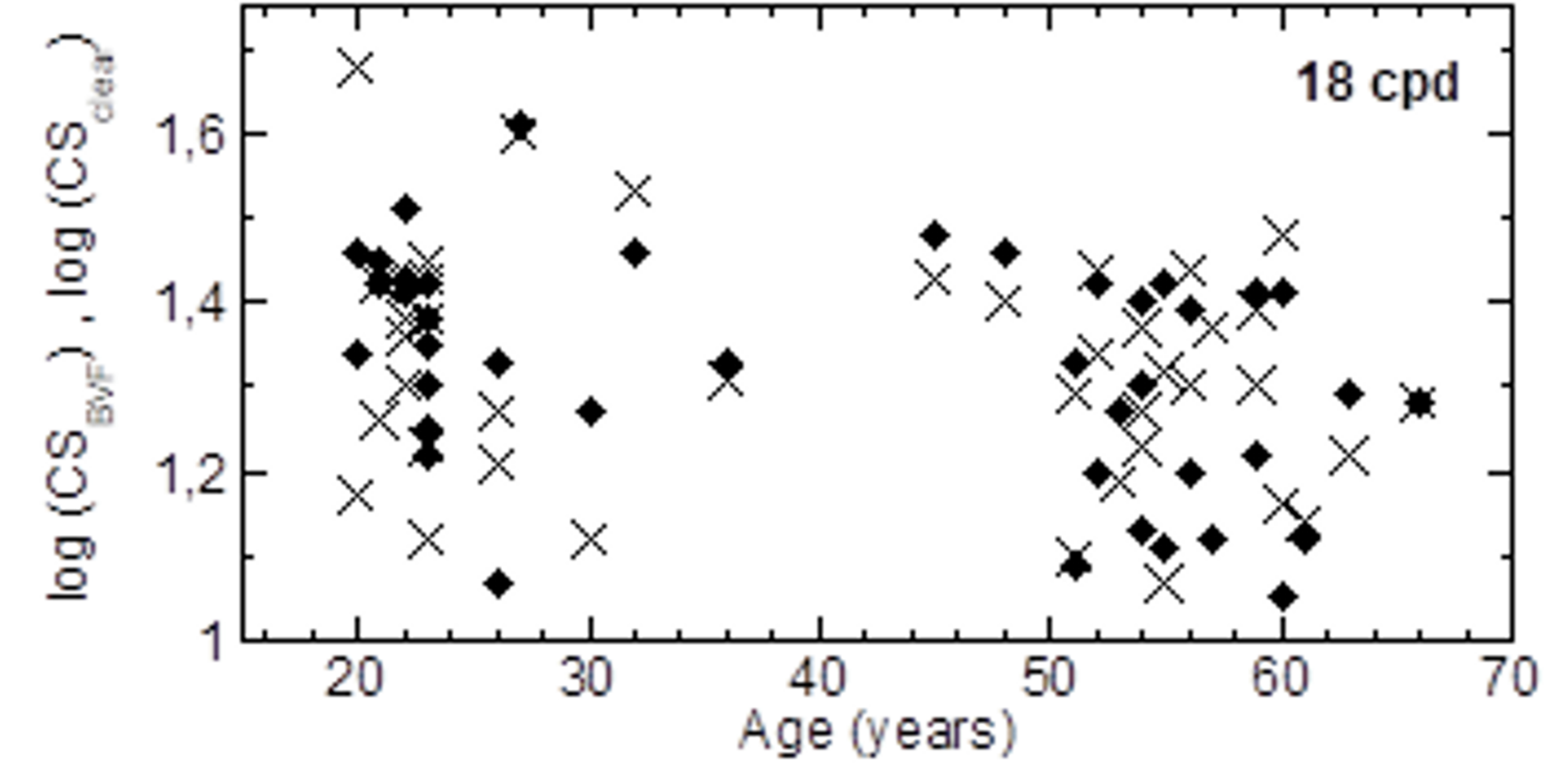
2- Does CS depend on age?

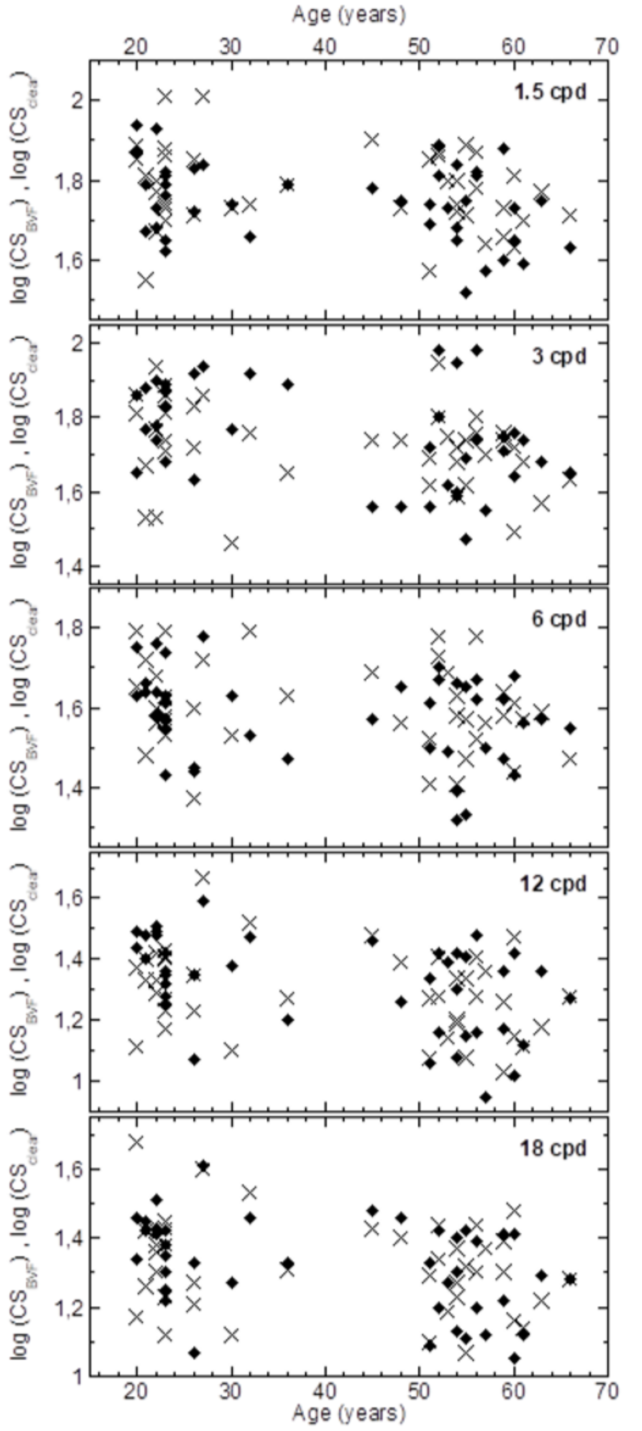
YONGER OLDER



NO age dependence

2- Does CS depend on age?





NO age dependence

2- Does CS depend on age?

- comparison between two age subgroups (Mann-Whitney U test)

Table 3
p-Values obtained by the Mann-Whitney U Test for the comparison between the two age subgroups (younger and older adults) both for $\log(CS_{clear})$ and for $\log(CS_{BVF})$.

	1.5 cpd	3 cpd	6 cpd	12 cpd	18 cpd
$\log(CS_{BVF})$	0.62	0.32	0.72	0.42	0.46
$\log(CS_{clear})$	0.93	0.59	0.63	0.60	0.83

NO age dependence

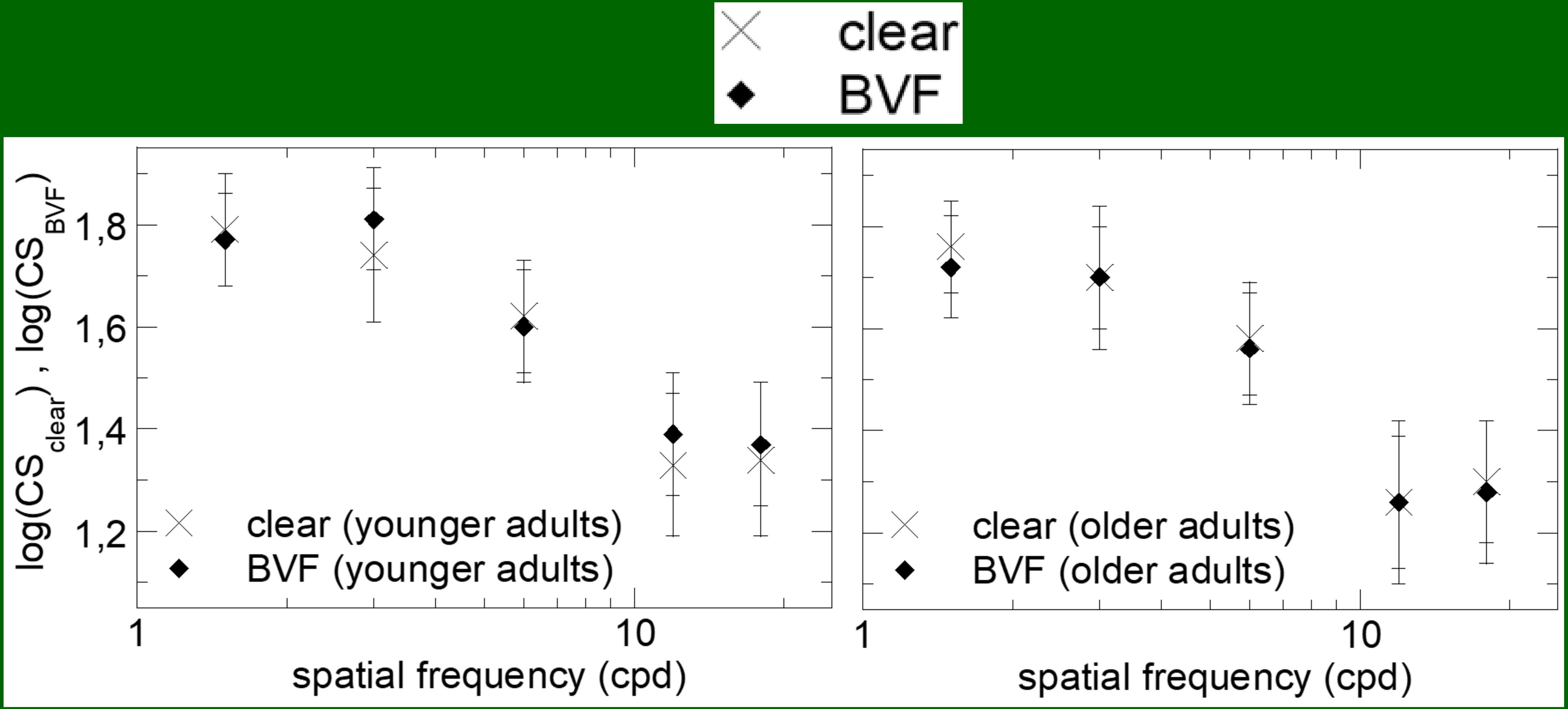
NO age dependence: agreement with the literature

Some studies report an average decay of CS beyond about 60 years:

- Derefeldt et al., CS of three groups: 6–10, 20–40, and 60–70 years. The older group showed significantly lower CS than younger subjects for most spatial frequencies above 4 cpd.

- Elliott found that relatively old subjects (72 ± 4.3 years) had significantly lower CS at 4 cpd and >10 cpd compared to young subjects (21.5 ± 2.7 years). As suggested by the author, **this decrease in CS could be ascribed to retinal and neural changes**, with optical factors having a slight effect at the highest spatial frequency only.

3- Is CS different between clear and BVF lenses?



NO differences between clear and BVF lenses

3- Is CS different between clear and BVF lenses?

- comparison between $\log(CS_{clear})$ and $\log(CS_{BVF})$ (Wilcoxon Signed-Ranks test)

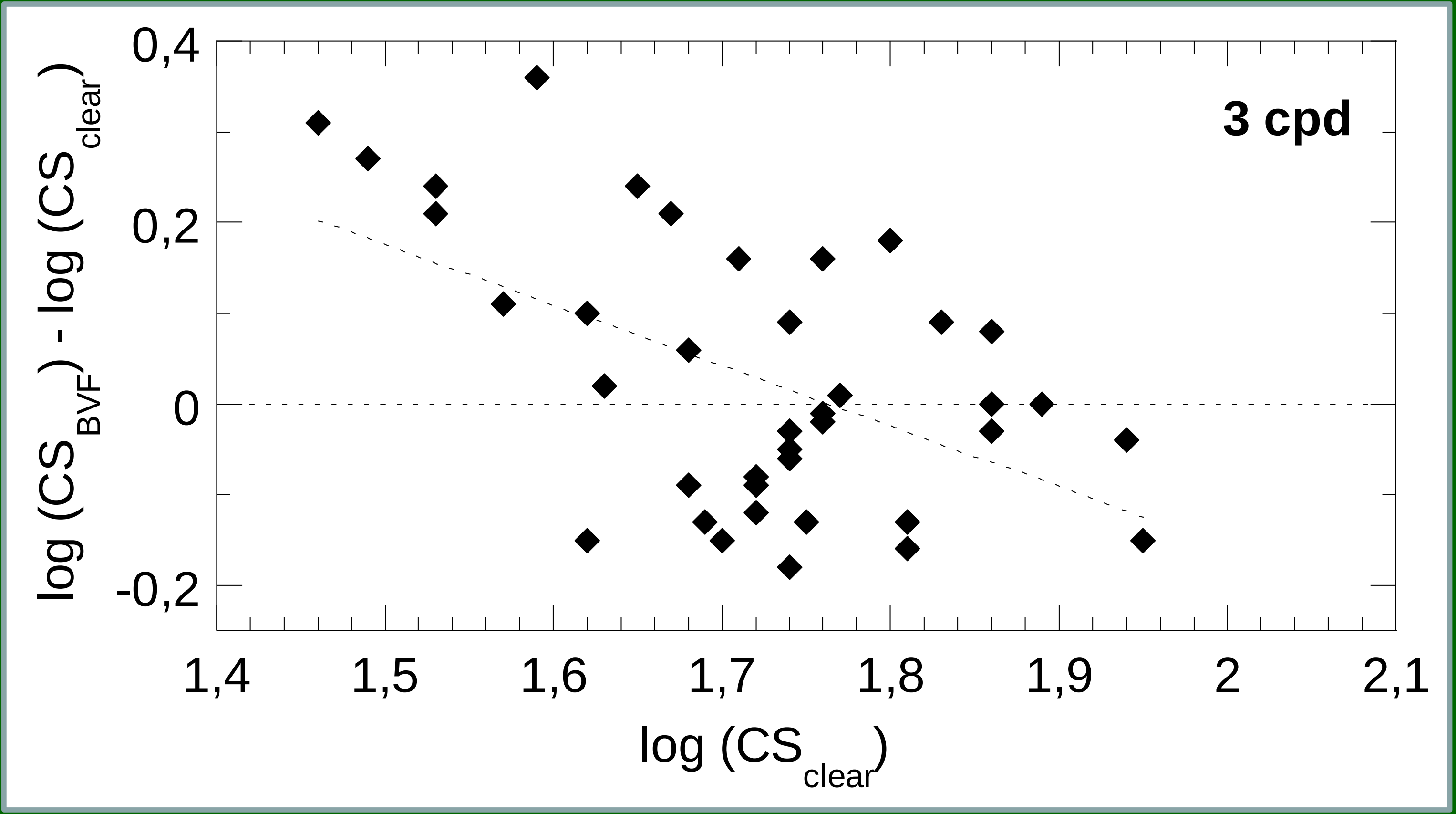
Table 4
p-Values obtained by the Wilcoxon Signed-Ranks Test for the paired comparison between $\log(CS_{BVF})$ and $\log(CS_{clear})$ for the whole sample of forty-one subjects.

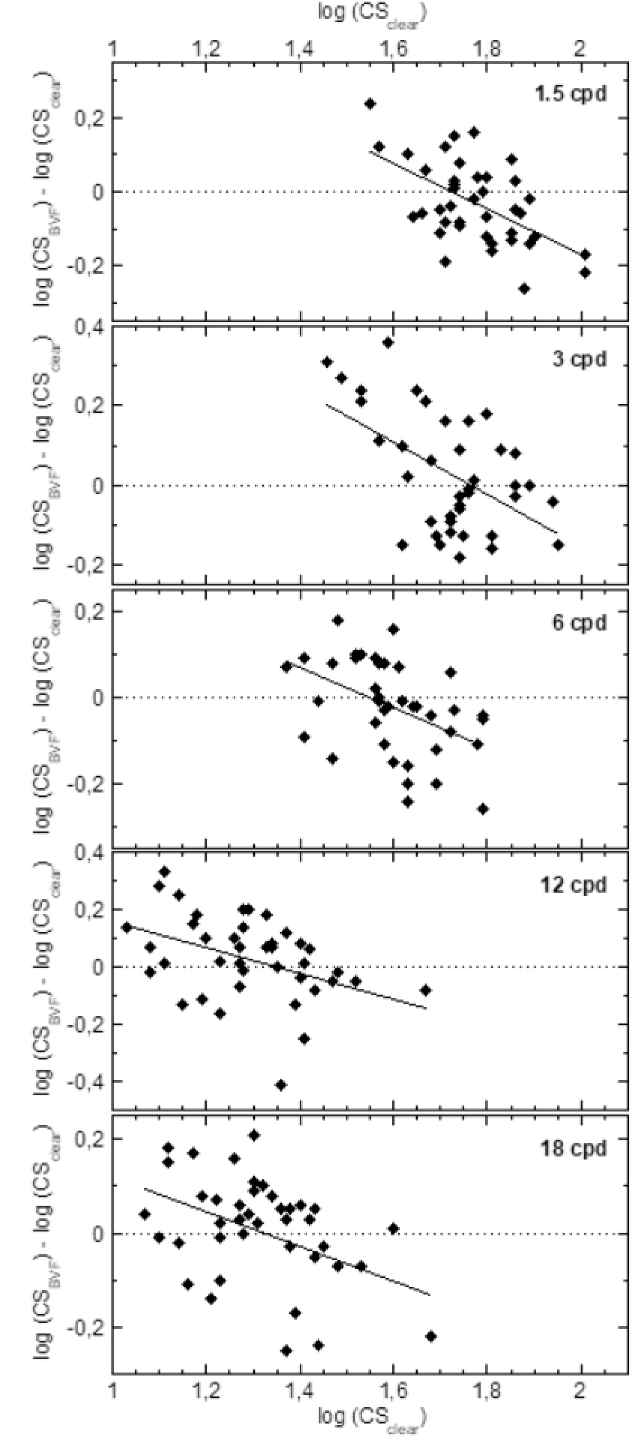
	1.5 cpd	3 cpd	6 cpd	12 cpd	18 cpd
p-value	0.37	0.35	0.23	0.06	0.48

NO differences between clear and BVF lenses

4- Does the baseline CS (with the clear lens) play a role?

negative correlation between
change in CS with BVF respect to clear lenses
and the baseline CS with clear lenses





4- Does the baseline CS (with the clear lens) play a role?

negative correlation between change in CS with BVF compared to clear lenses and the baseline CS with clear lenses

Table 5

Correlation coefficients obtained by Spearman's Rho test between the difference [$\log(CS_{BVF}) - \log(CS_{clear})$] and the CS obtained with the clear CL ($\log(CS_{clear})$), for each spatial frequency. The corresponding p-values are also reported.

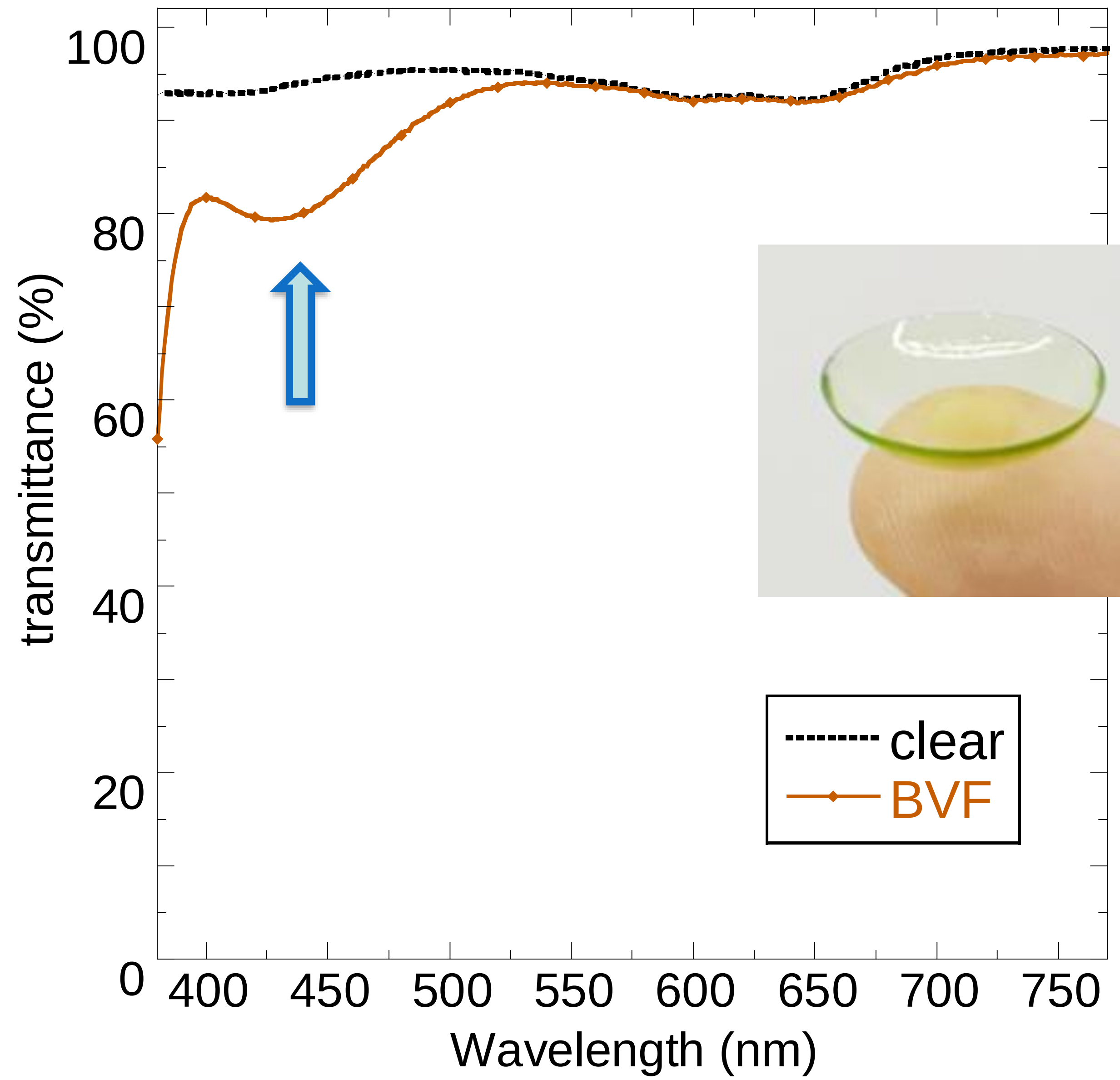
Spatial frequency (cpd)	Spearman's Rho	p-value
1.5	0.83	<0.01
3	0.80	<0.01
6	0.85	<0.01
12	0.87	<0.01
18	0.88	<0.01

WHAT AFFECTS THE BASELINE CS

THAT CAN BE IMPROVED / WORSENED BY BLUE-VIOLET ATTENUATION

?

- Chromatic aberration: ONLY PARTIAL BVF ATTENUATION
- Transmission of the ocular media: NO AGE DEPENDENCE OF CS
- Response of photo-receptors (cones and rods): TO BE MEASURED on each subject
- Macular pigment density: TO BE MEASURED on each subject
- Neural response: TO BE MEASURED on each subject


100
80
60
40
20
0
transmittance (%)
400
450
500
550
600
650
700
750
Wavelength (nm)
clear
BVF

WHAT AFFECTS THE BASELINE CS

THAT CAN BE IMPROVED / WORSENED
BY BLUE-VIOLET ATTENUATION

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- ❑ Chromatic aberration: ONLY PARTIAL BVF ATTENUATION
- ❑ Transmission of the ocular media: NO AGE DEPENDENCE OF CS
- ❑ Response of photo-receptors (cones and rods): TO BE MEASURED on each subject
- ❑ Macular pigment density: TO BE MEASURED on each subject
- ❑ Neural response: TO BE MEASURED on each subject

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- Transmission of the ocular media: NO AGE DEPENDENCE OF CS
- Response of photo-receptors (cones and rods): TO BE MEASURED on each subject
- Macular pigment density: TO BE MEASURED on each subject
- Neural response: TO BE MEASURED on each subject

- Does a ceiling effect occur?

NOT RELEVANT FOR OUR PURPOSES

- Does CS depend on age?

24±4 years VS 55±5 years: NO DEPENDENCE

- Is CS different between clear and BVF lenses?

NO DIFFERENCES BETWEEN MEAN VALUES

- Does the baseline CS (with the clear lens) play a role?

NEGATIVE CORRELATION BETWEEN VARIATION AND BASELINE

The «Dream Team»

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Erika PONZINI
Alessandro DUSE
Giulia RIZZO
Federica MIGLIO
Riccardo ROLANDI

Federica COZZA
Gabriele NIGROTTI
Chiara BRAGA

Thank you for your attention