Wavefront & Presbyopic Refractive Corrections

Wearable see-thru binocular simulator of multifocal and monovision presbyopic corrections

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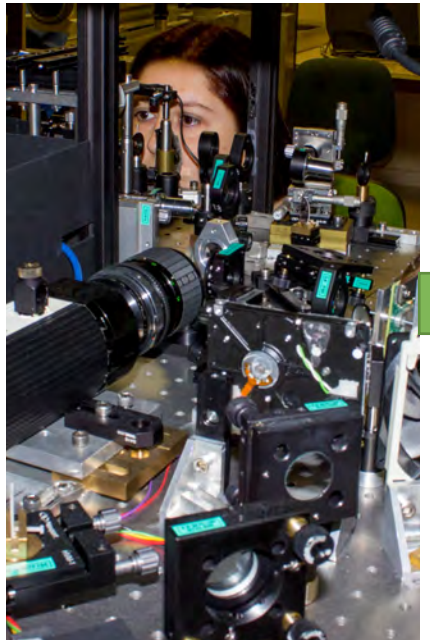
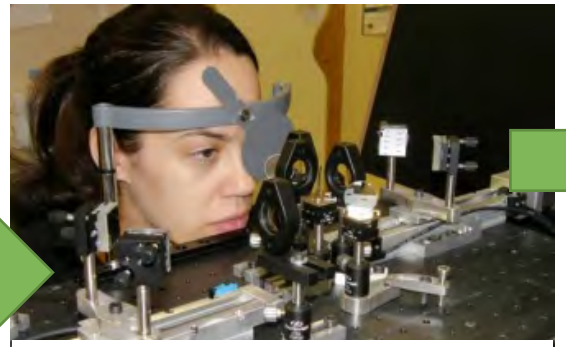
Disclosures

- ✓3 Patents on SimVis
- ✓Co-founder of spin-off 2Eyes VISION
- ✓Collaborative agreements in the context of visual simulation with Essilor International, Oculentis, Staar, Hoya, PhysIOL

Simultaneous Vision Simulators

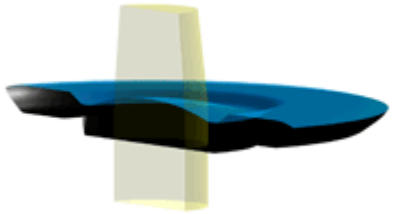


AO systems



Patent PCT 2009

Adjustable lens



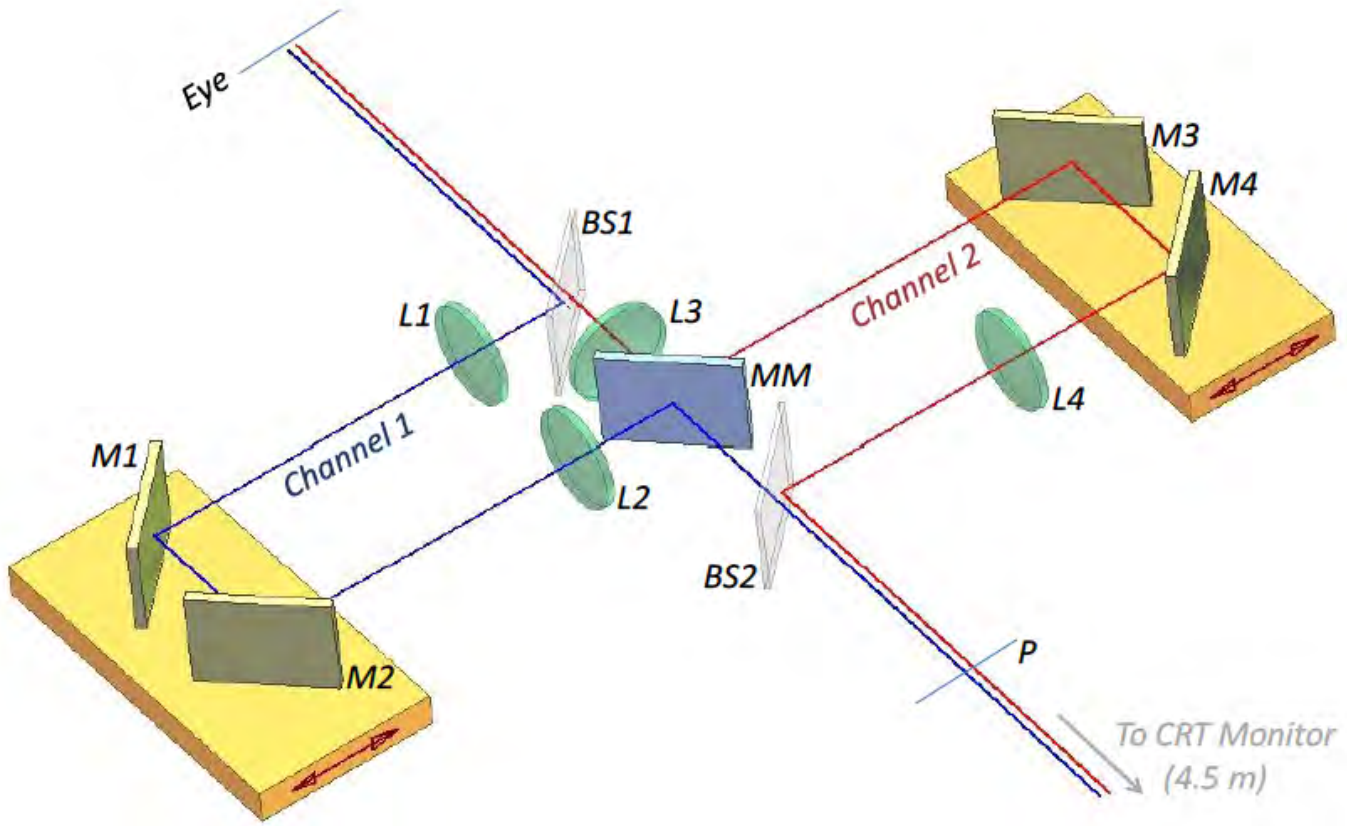
Patent OEPM 2013

Manufactured 2014

Clinical validations 2015

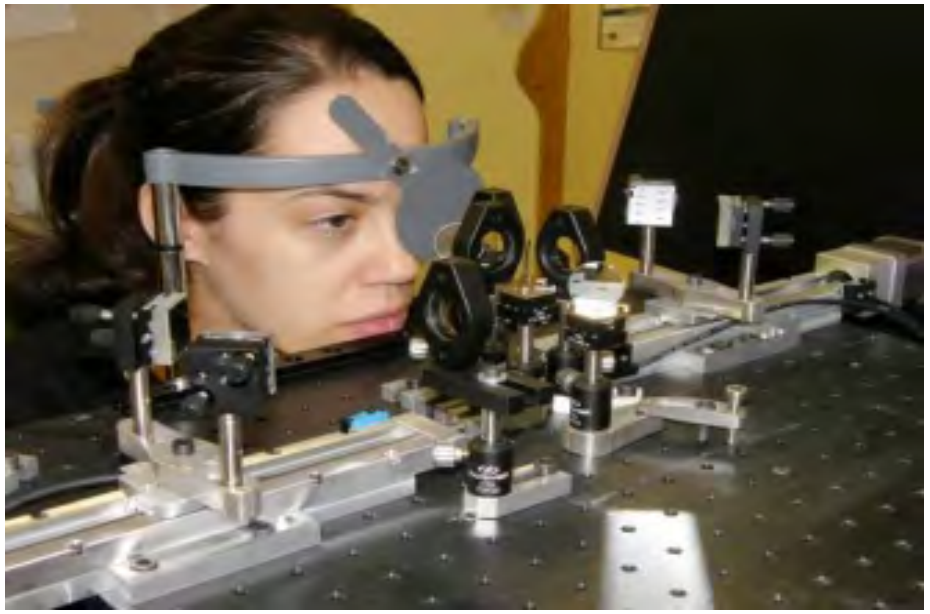
Wearable prototype 2016

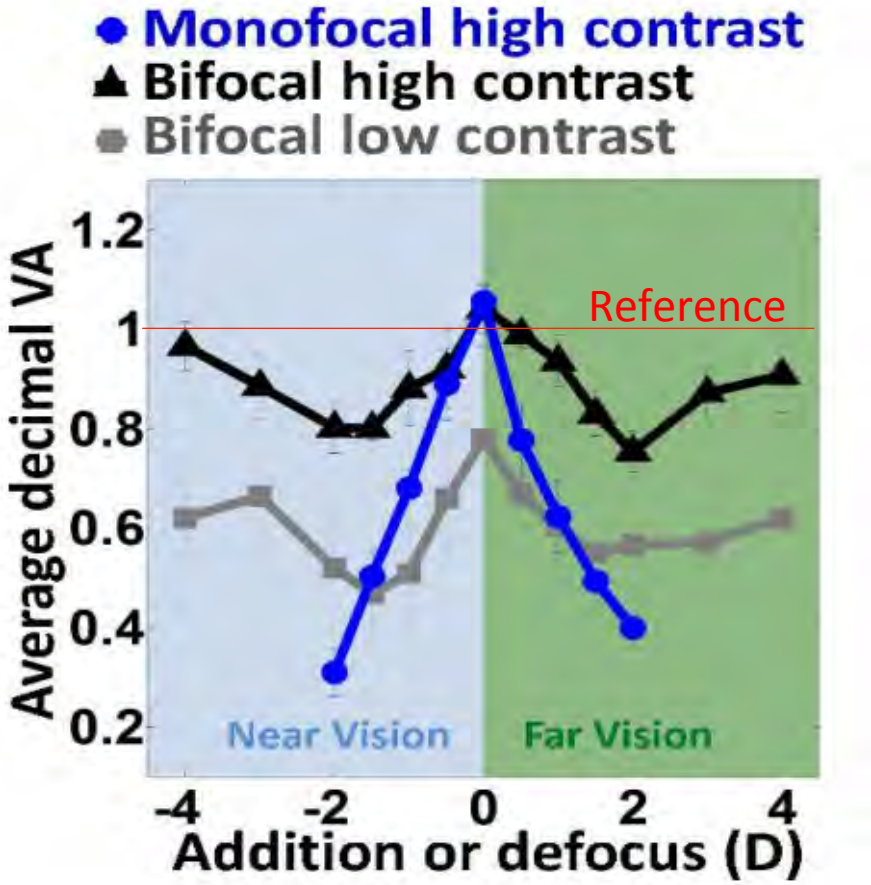
Simultaneous vision simulator



De Gracia et al. IOVS 2013
Patent applications 2011, 2013

Visual Acuity as a function of near add

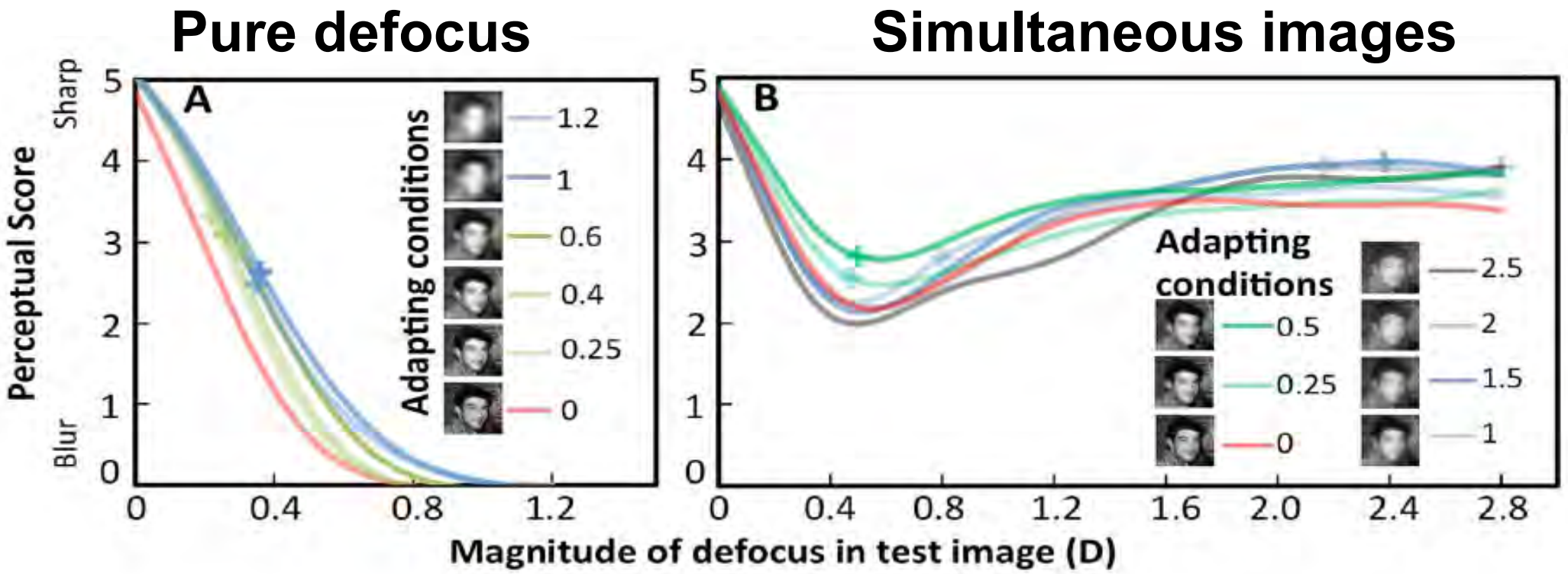




Low additions (1.5 to 2 D) result in lower visual acuities
and lower letter contrasts
than high additions (3 to 4 D)

de Gracia et al. IOVS 2013

Short adaptation to multifocal images

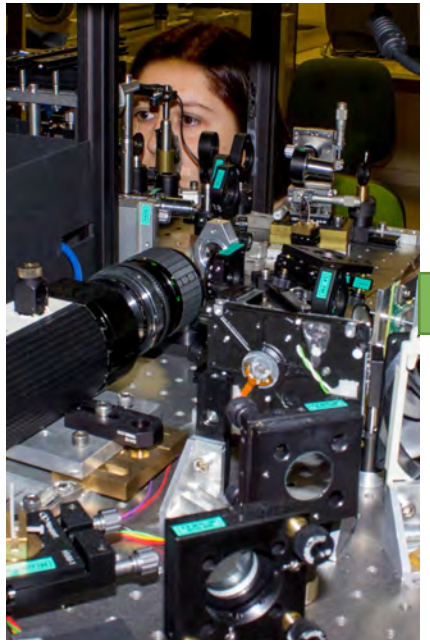


Radhakrishan, Dorronsoro, Sawides & Marcos, PLOS One 2014

Allowing patients experience multifocality & compare across lens designs

- ✓ Increase clinician & patients' confidence in multifocal solutions
- ✓ Reduce uncertainty
- ✓ Increase number of multifocal implants & patient satisfaction

Simultaneous Vision Simulators



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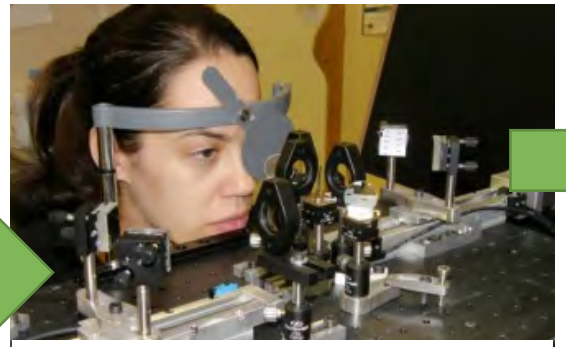

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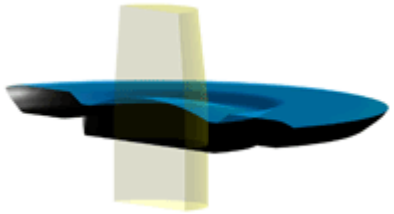

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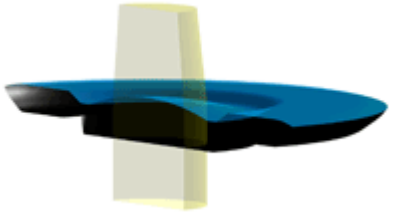
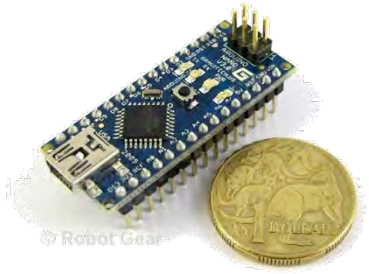
Technology behind SimVis: Temporal Multiplexing

Tunable lens (Optotune, AG)

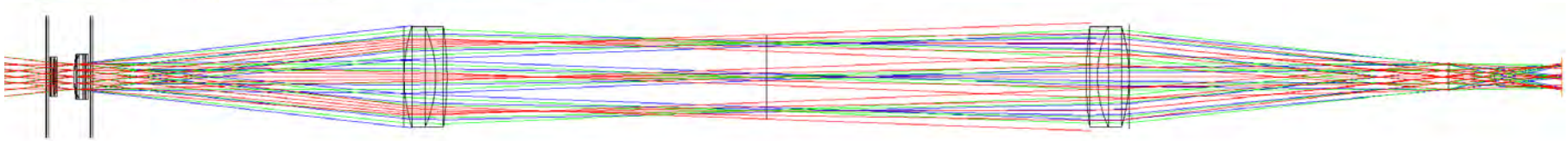
- ✓ Custom high speed
- ✓ Electronic driver



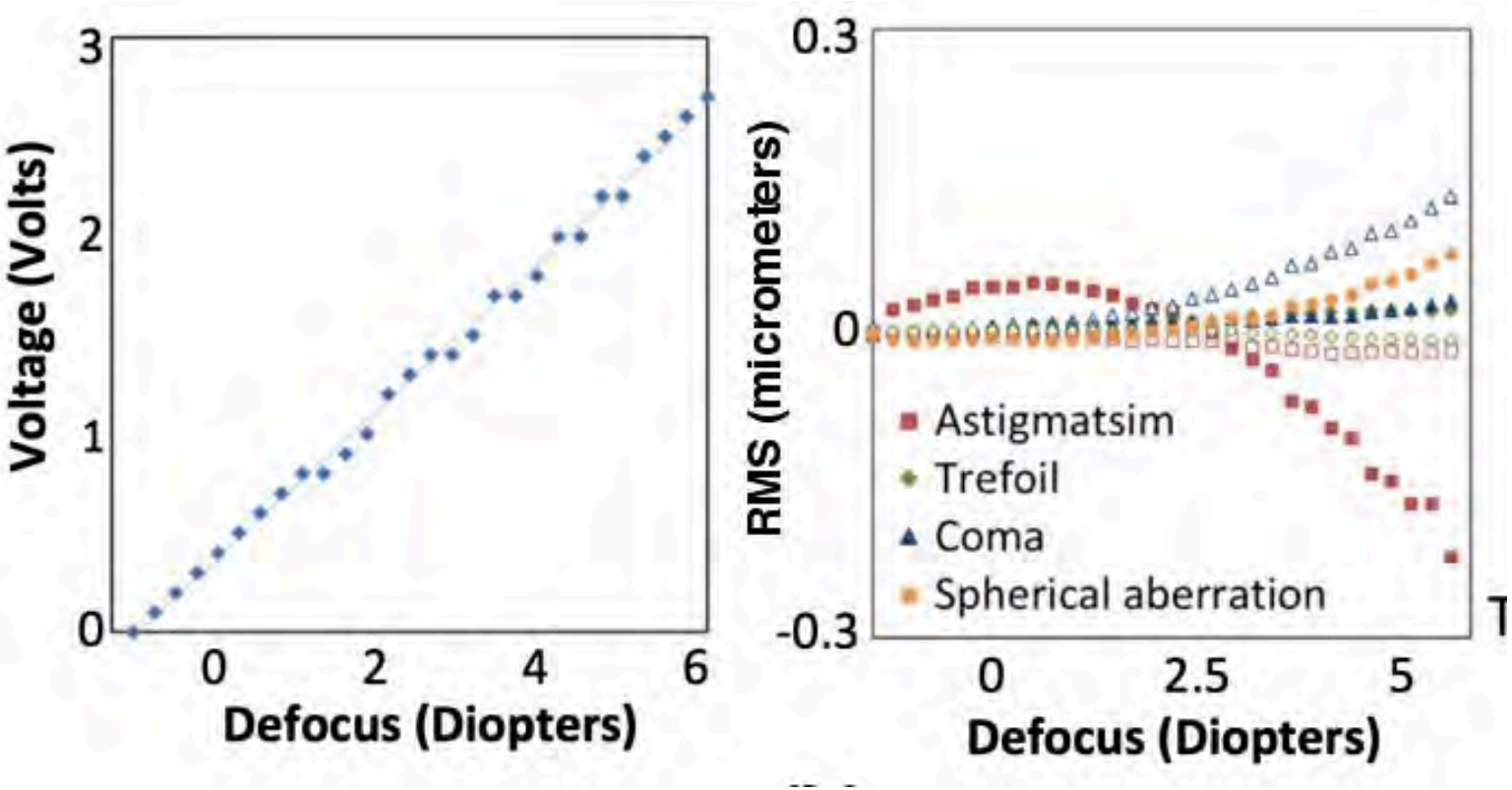


Temporal multiplexing:

- ✓ Scan a 3-diopters (D) addition focus range at 50 Hz
- ✓ Static appearance of multifocal retinal images



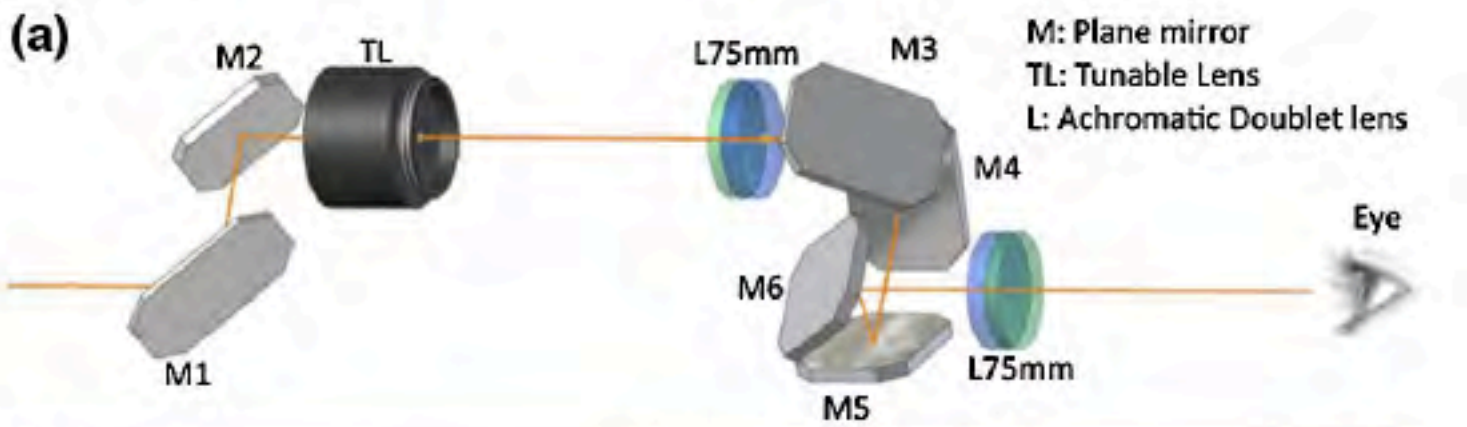
Optical characterizations



HS-aberrometry:

- ✓ Very linear response of optical power vs voltage (R=0.997)
- ✓ High optical quality (RMS<0.05 μm)

SimVis Mini (Monocular)



SimVis Mini Experiments

9 cyclopeged **subjects**

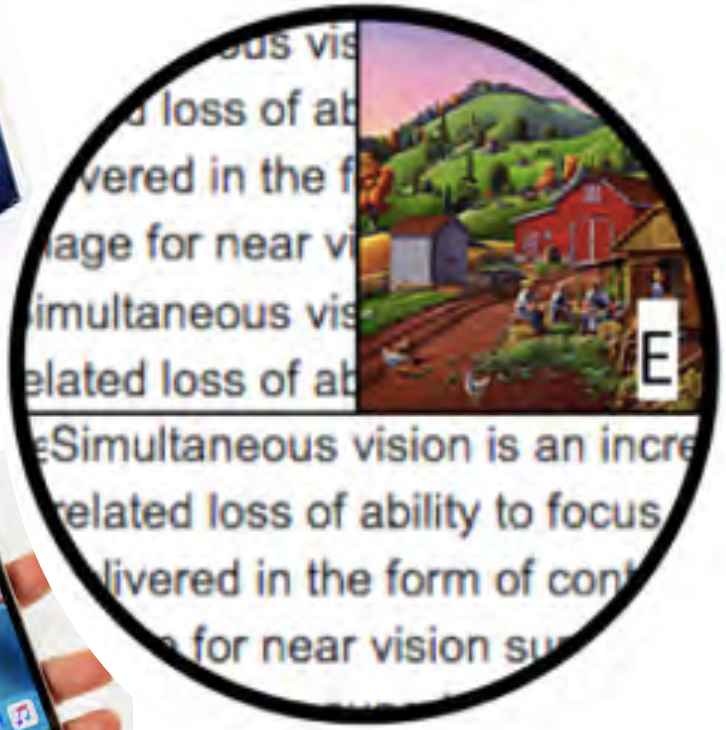
- ✓ No astigmatism
- ✓ Far Refraction corrected with instrument

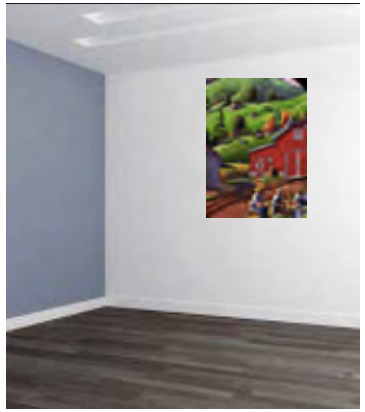
7 **corrections** simulated:

- ✓ **Monofocal**: 100F 100N 100I
- ✓ **Bifocal:** 50F 50N & 70F 30N
- ✓ **Trifocal:** 33F 33I 33N & 50F 20I 30N

Perceived Visual Score test

Visual scene containing F, I & N targets





Scene overall score (1-5) evaluated at F, I & N distances

Multifocal design preference test

Thru Design x

Thru Design y

or

?

…

6 designs

10 random repetitions

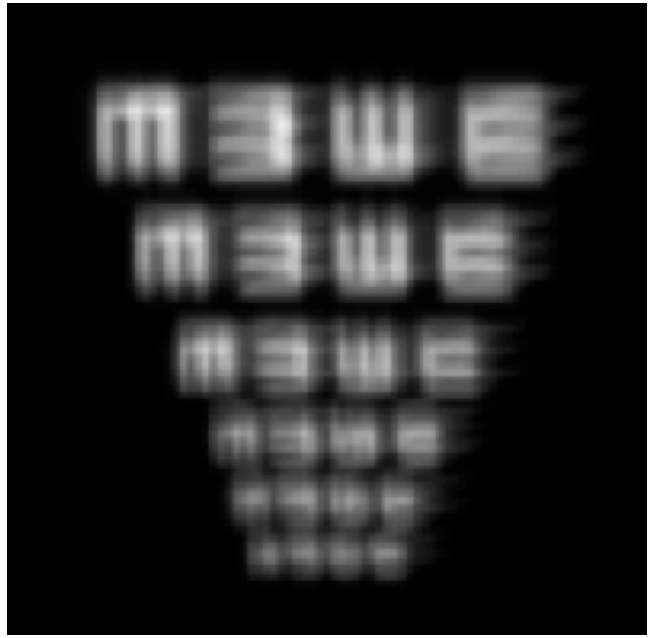
2 AFC

Accepted: +1; Rejected: -1

Summed Score

Bernouilli Statistics

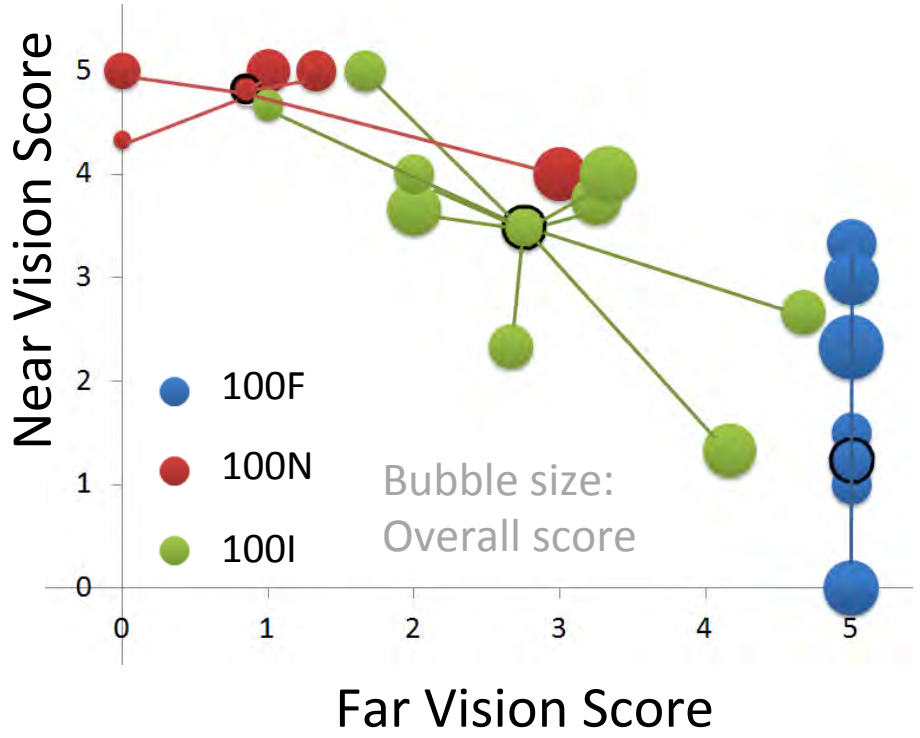
High Contrast Visual Acuity test



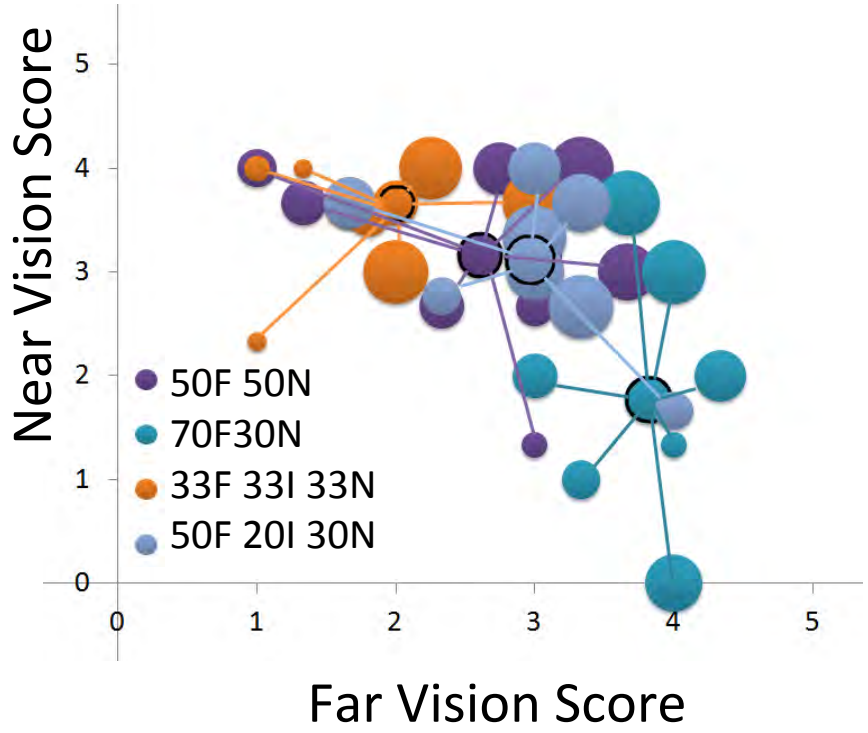
At F, I & N
Randomized E Optotypes
High Resolution Display

Perceptual Score: Individual subjects

Monofocal designs



Multifocal designs

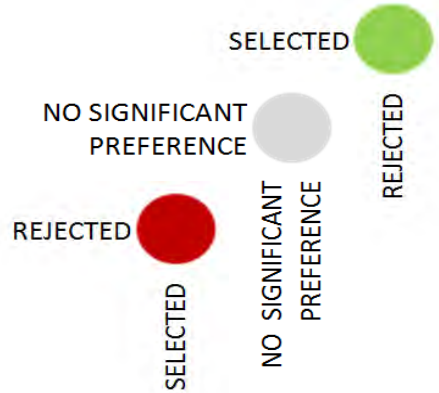


9 subjects, paralyzed accommodation

Dorronsoro, Radhakrishan, Alonso-Sanz, Velasco-Ocana, Perez-Merino, Optica 2016

Multifocal design preference

Legend

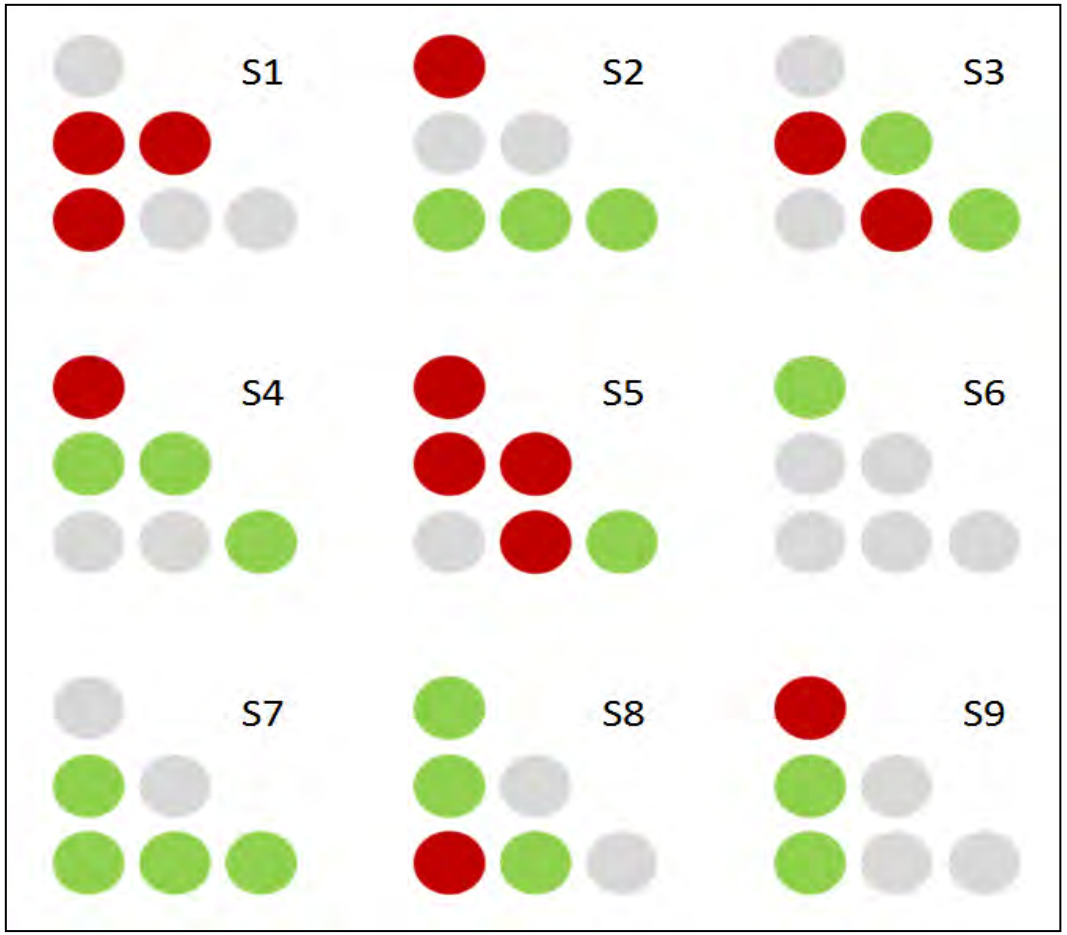


Average Preference

✓On average, Trifocal 50-20-30 higher preference

Dorronsoro et al. Optica 2016

Preference: individual subjects



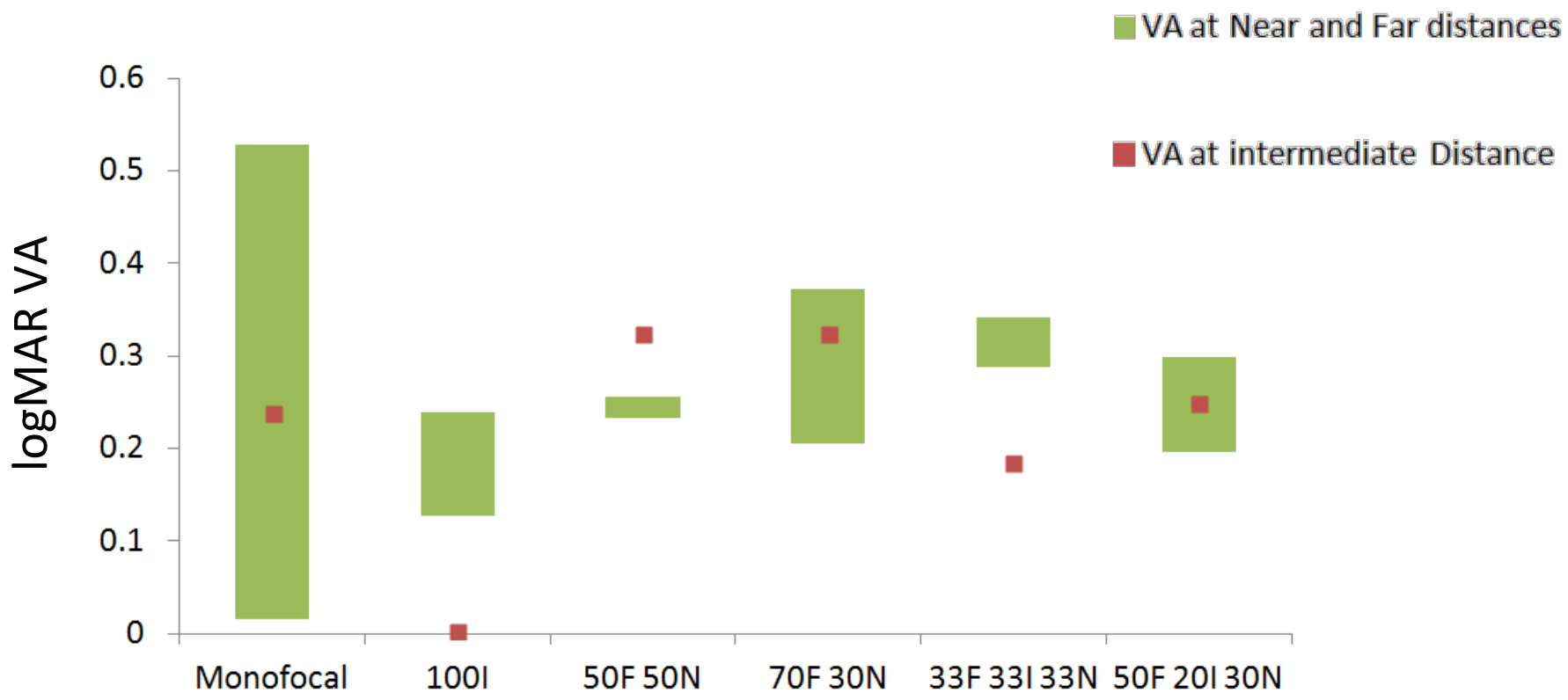
Visual Acuity at different distances

Monofocal

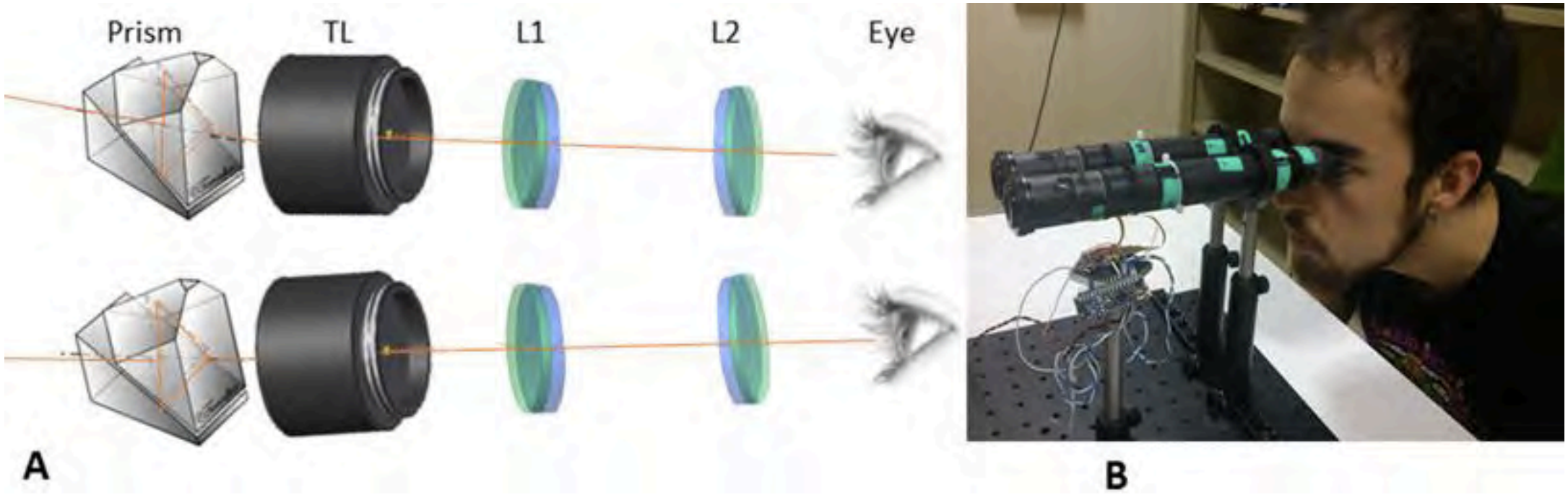
In focus *0.015*
Out of focus (3D) *0.51*

Multifocal

0.21-0.37

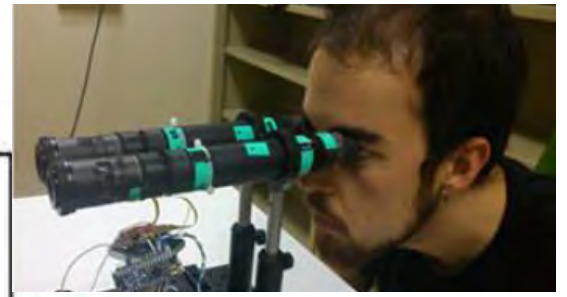


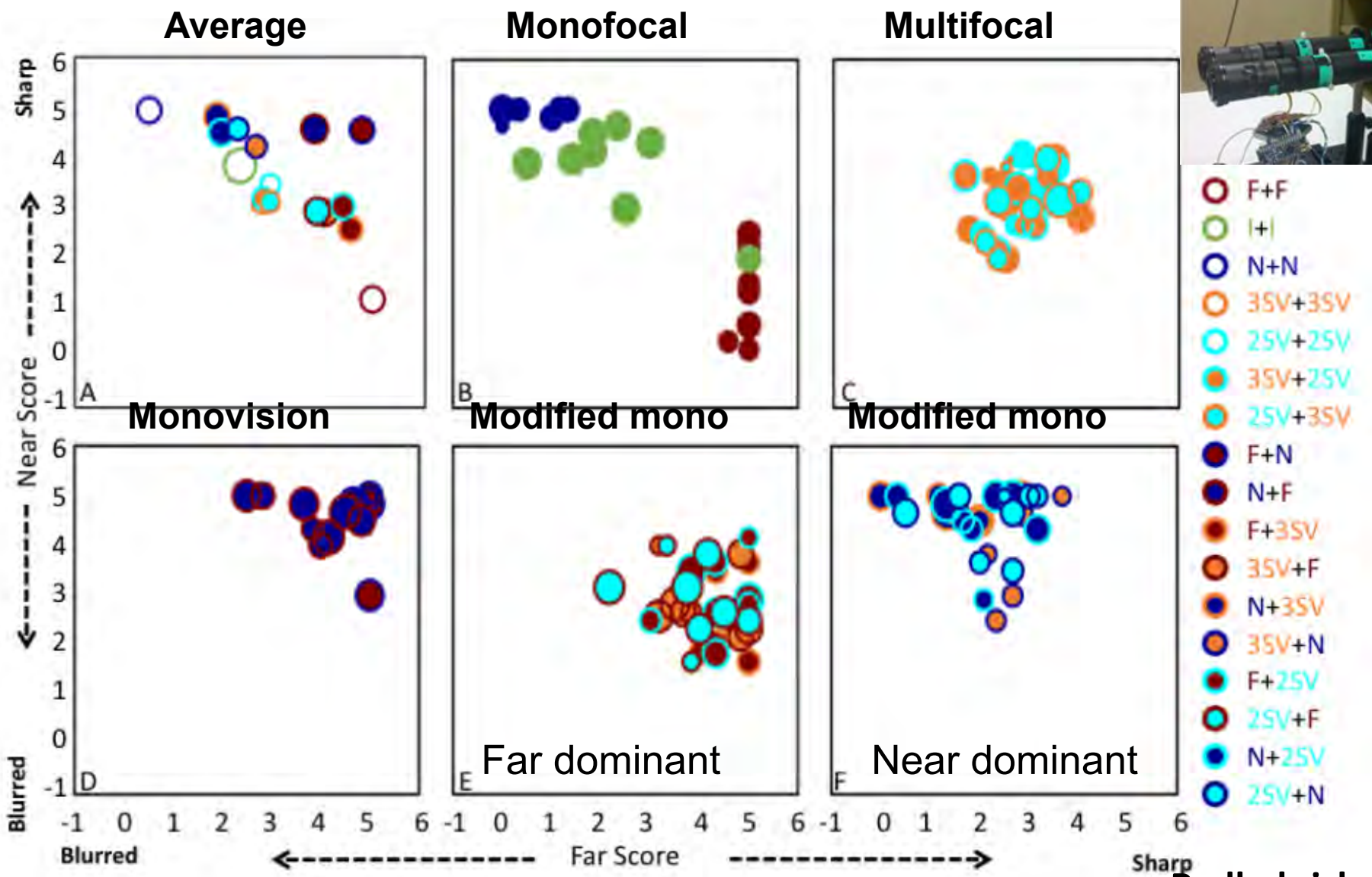
Binocular SimVis



Radhakrishan et al. 2016

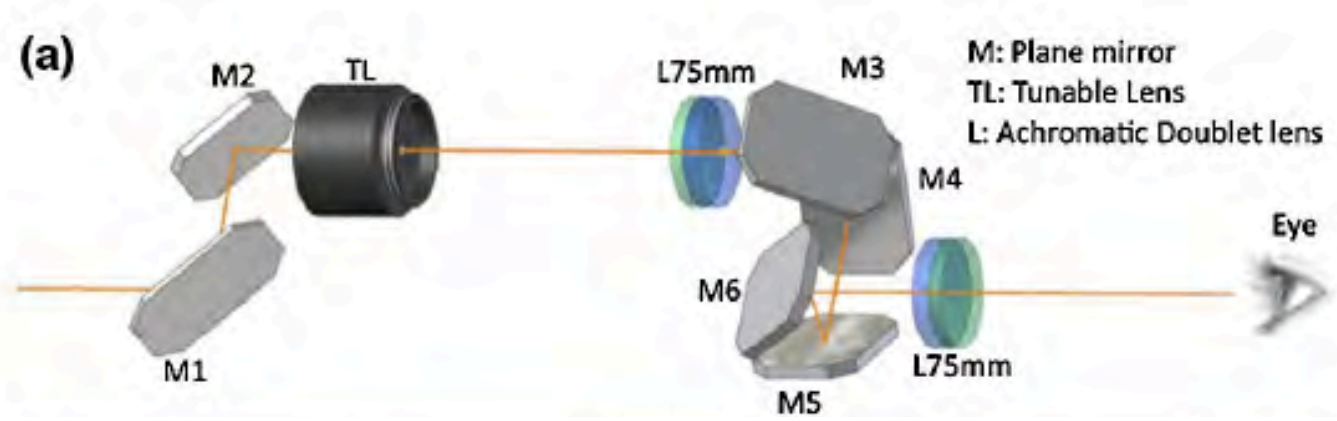
Binocular corrections (monocal, multifocal, monovision, extended monovision)





Radhakrishan et al. 2016

SimVis simulation of real IOLs



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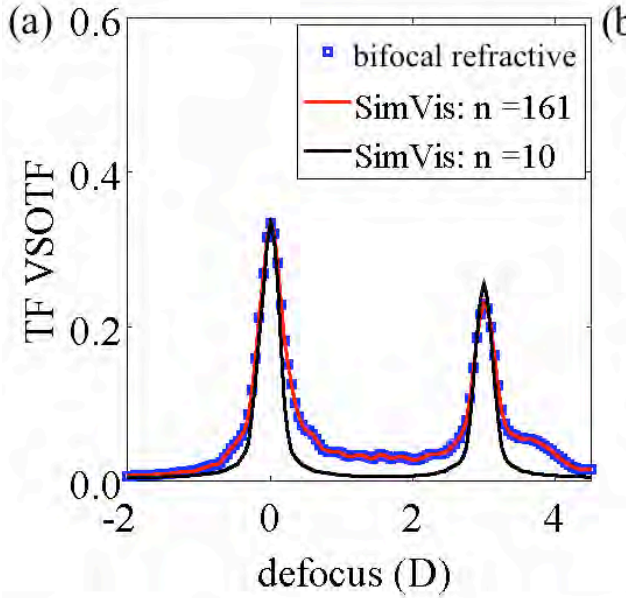
Real lenses

?

- ✓ **Bifocal refractive lens**
- ✓ **Trifocal diffractive lens**
- ✓ **Aspheric lens**

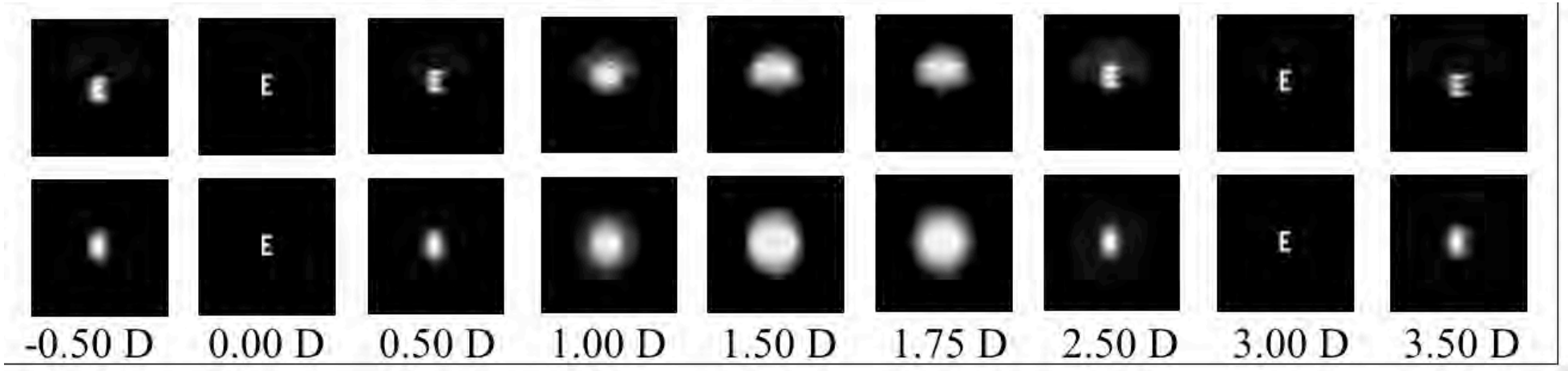
SimVis simulation of real IOLs

Bifocal segmented refractive IOL



IOL

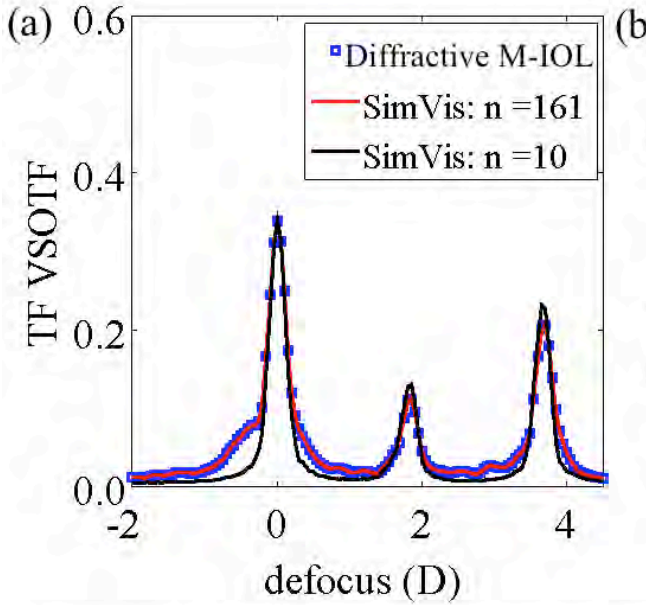
SimVis



Akondi et al. VPO 2016

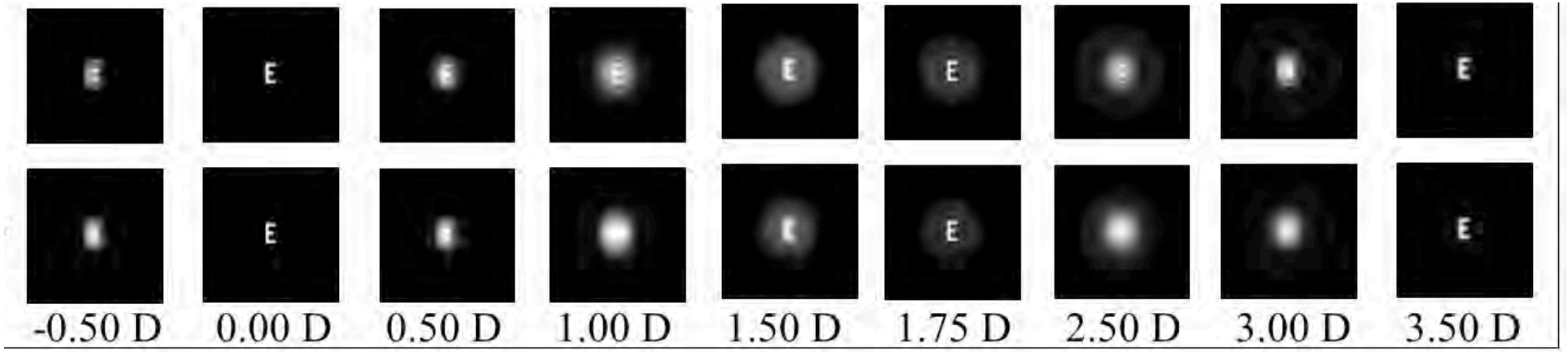
SimVis simulation of real IOLs

Trifocal diffractive IOL



IOL

SimVis



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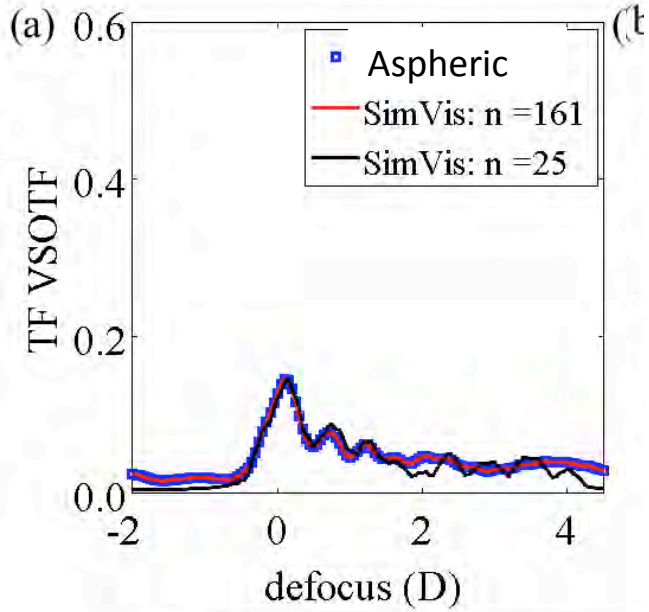
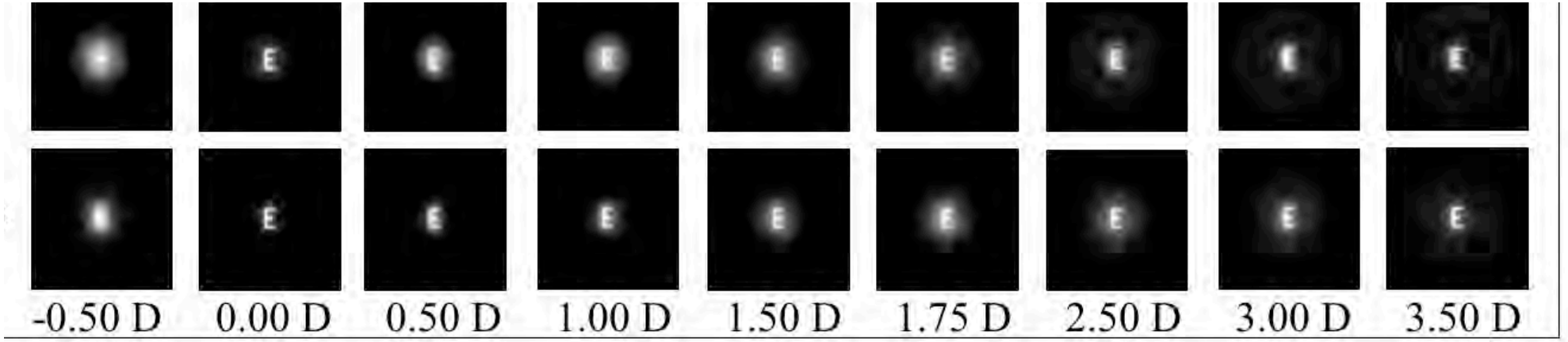
SimVis simulation of real IOLs

Aspheric multifocal IOL



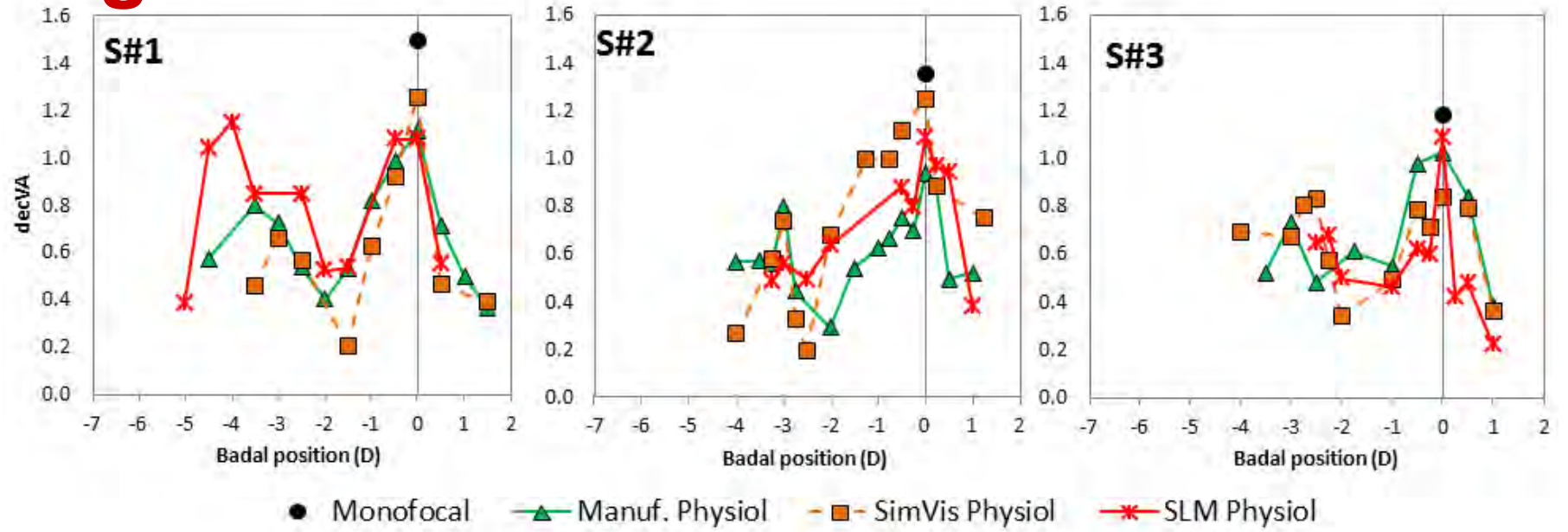
IOL

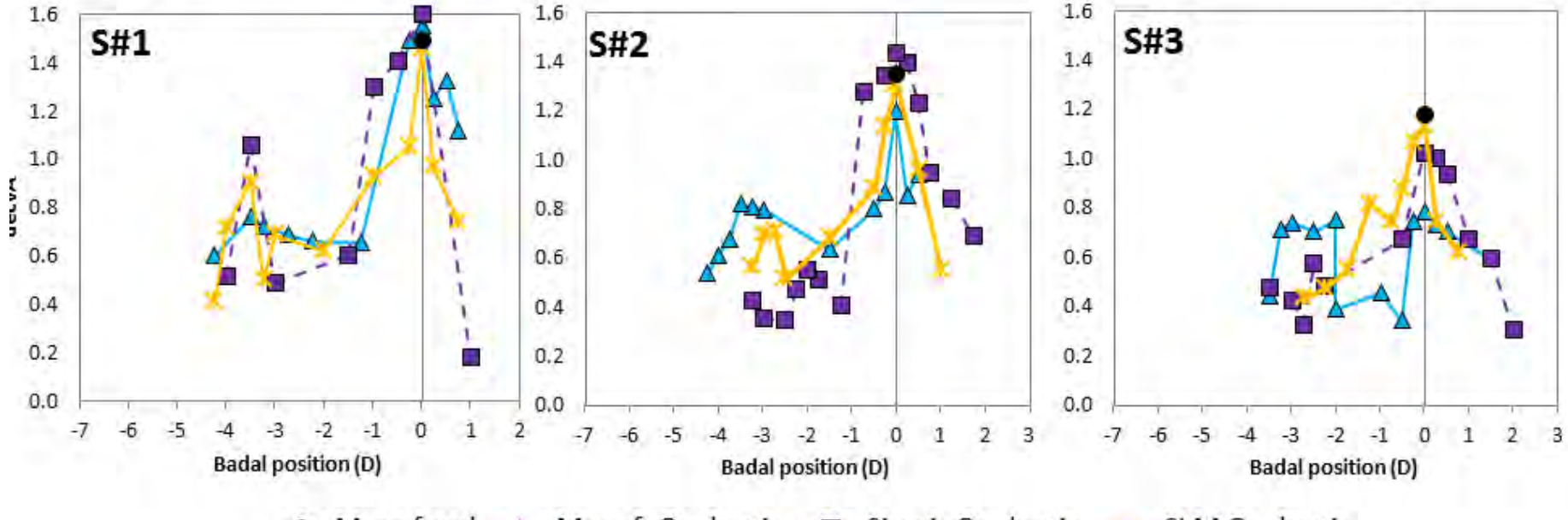
SimVis

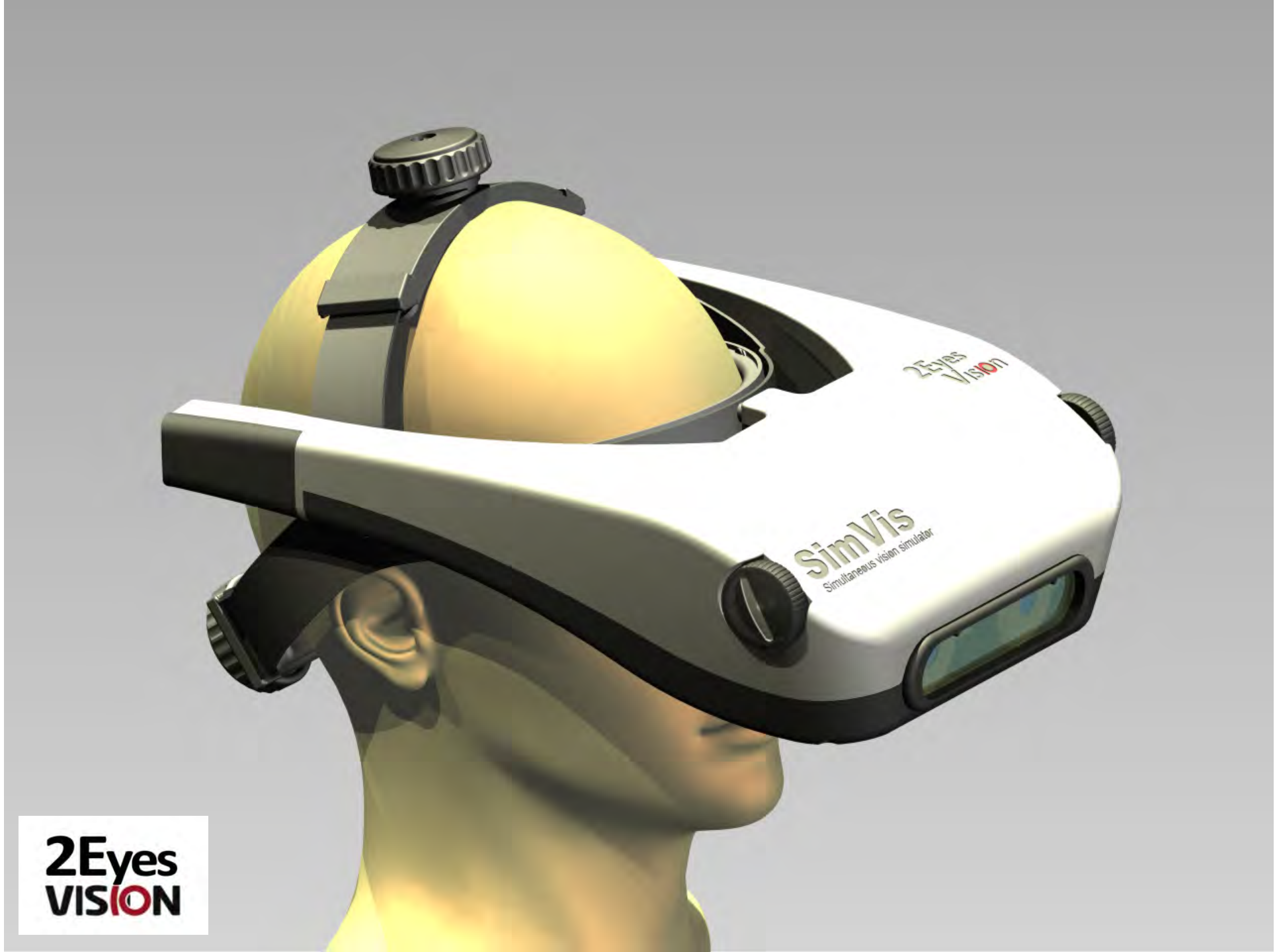


Akondi et al. VPO 2016

Through-focus VA with real and simulated IOLs







2Eyes VISION

Towards a rapid test in the clinic

Day/Night street scenes

3-D steroacuity

Day/Night reading scene

Conclusion

- ✓ **Simultaneous Vision by temporal multiplexing allows Simulation of real multifocal designs**
- ✓ **Light, see-through, large field of view, binocular, affordable**
- ✓ **Effective way for the patient to experience multifocality and select correction prefernece**

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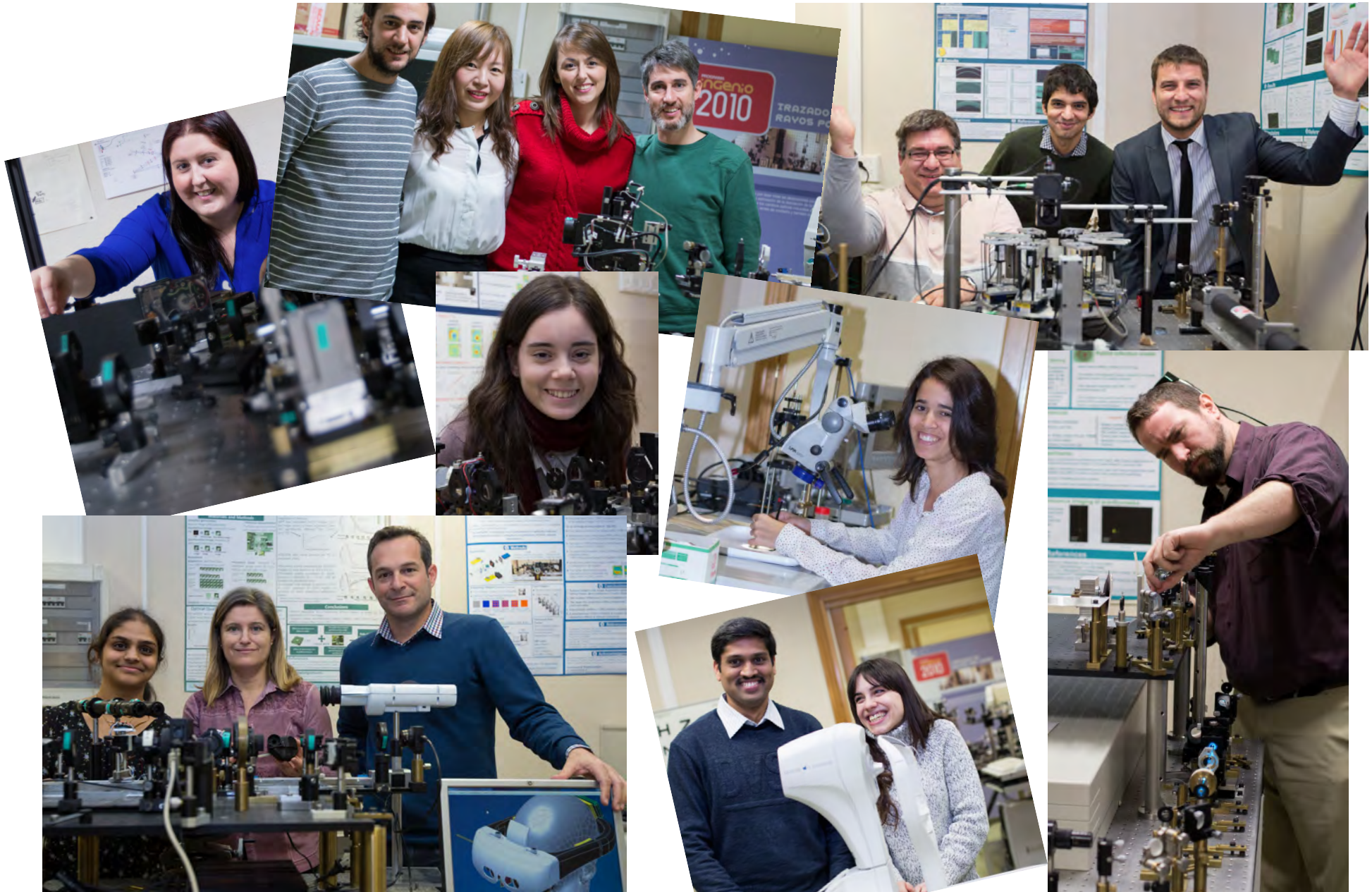

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Funding

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Paris, France

Liège, Belgium

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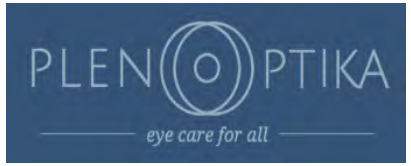
Berlin, Germany



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