ARVO 2009 ANNUAL MEETING

Effect of Adaptive Optics Correction on Visual Performance and Accommodation

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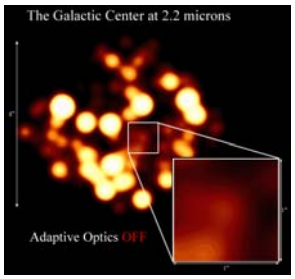
C.R: None

Adaptive optics for imaging

Astromomy

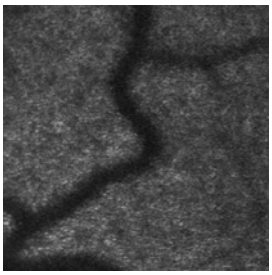
Since 1977, Hardy et al, JOSA A



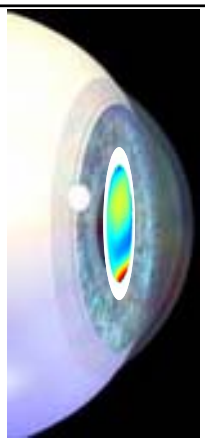
Courtesy of Galactic Center Group, UCLA

Retinal imaging

Since 1989, Dreher et al. Appl Opt

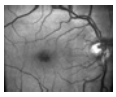


Courtesy of Austin Roorda, UC, Berkeley



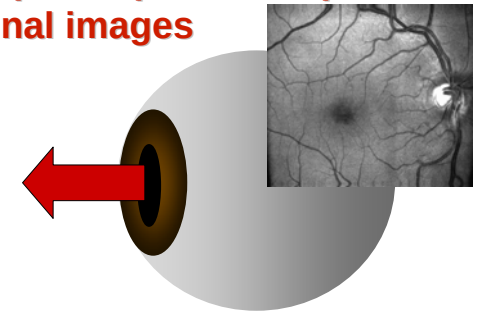
Ocular High order Aberrations (HOA)

Decrease resolution and contrast of fundus images

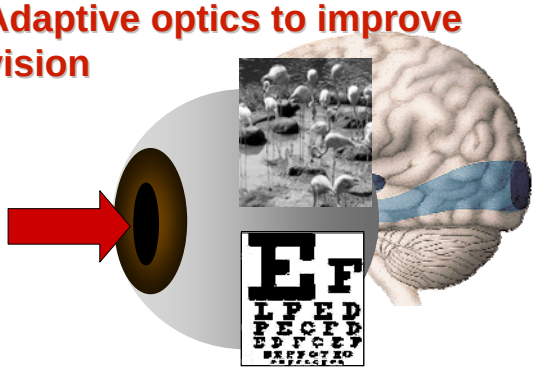


Decrease quality of images projected on the retina

Adaptive optics to improve retinal images



Adaptive optics to improve vision



Motivation

Customized refractive surgery, custom IOLs, contact lenses or ophthalmic lenses aim at correcting high order aberrations

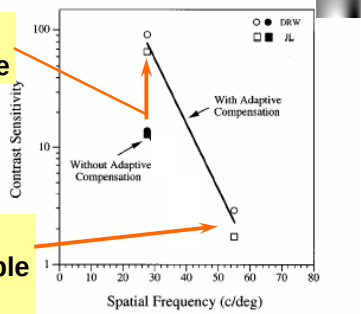
In the even that high order aberration correction was achieved, is this relevant to vision?

Adaptive Optics

First psycophysical measurements with AO

27.5 c/deg
×6 increase

55 c/deg
Not detectable
wo AO

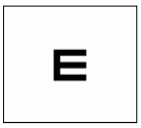


633 nm
900 Td

Liang and Williams, JOSA A 1997

Visual benefit of AO correction

✓Shown for relatively high luminances



Yoon et al. JOSA A 2002 50 cd/m²

Artal et al. JOV 2004 Fixed luminance

✓Thru-luminance with relatively large targets

Dalimier et al. JOM 2007

Change of VA with AO correction

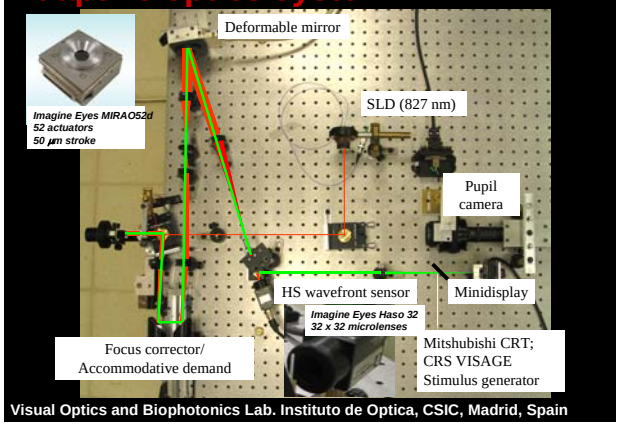
Does high contrast Visual Acuity improve with correction of HOA?

How does this depend on target luminance (50–0.8 cd/m²) and polarity?

Is the improvement in visual quality correlated with the improvement optical quality?

Marcos, Sawides, Gambra & Dorronsoro; Journal of Vision 2008

Adaptive optics system



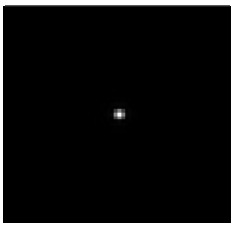
Visual Optics and Biophotonics Lab. Instituto de Optica, CSIC, Madrid, Spain

Adaptive optics correction

Close loop correction

Wave Aberration

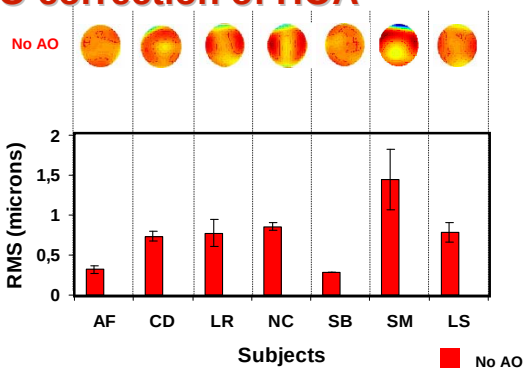
PSF



RMS =0.039 µm

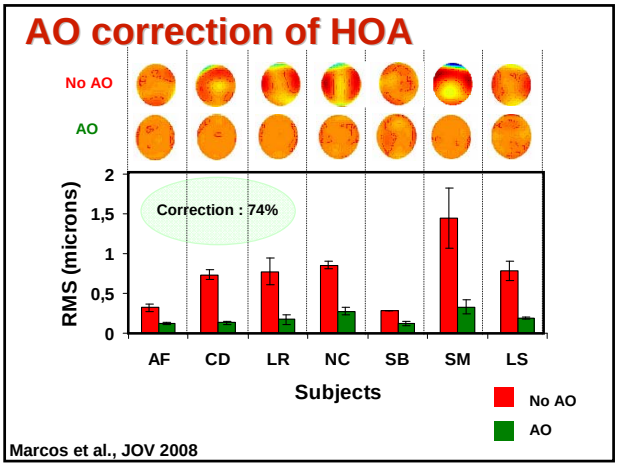
Pupil diameter: 6.6 mm

AO correction of HOA



Marcos et al., JOV 2008

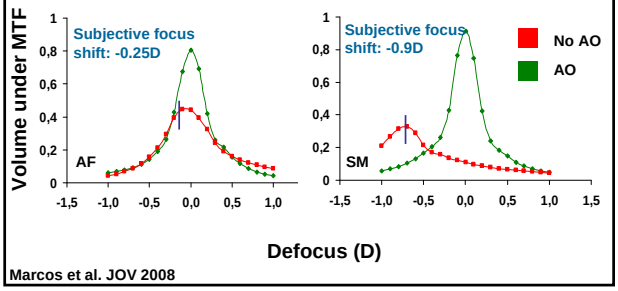
AO correction of HOA



Marcos et al., JOV 2008

Focus shift after HOA correction

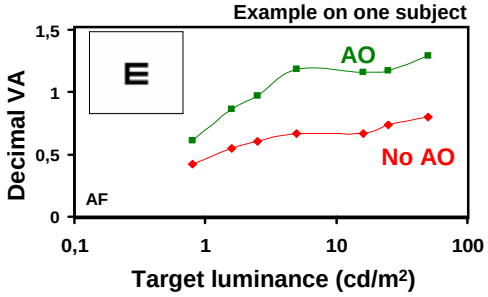
Best focus adjusted by the subject before and AO correction



Marcos et al. JOV 2008

Visual Acuity *vs* luminance: Effect of AO correction

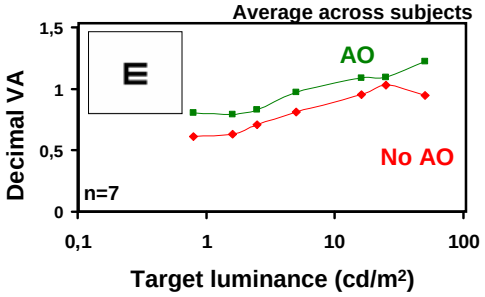
Example on one subject



Marcos et al. JOV 2008

Visual Acuity *vs* luminance: Effect of AO correction

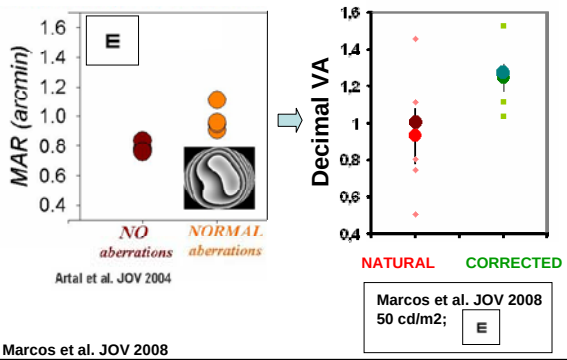
Average across subjects



Marcos et al. JOV 2008

Comparison with previous literature

Effect of AO-correction on VA

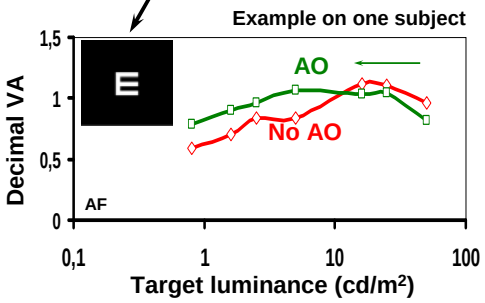


Marcos et al. JOV 2008

Visual Acuity *vs* luminance

Reversed polarity

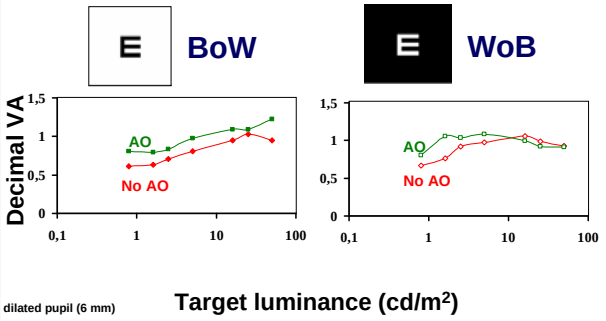
Example on one subject



Marcos et al. JOV 2008

Visual Acuity *vs* luminance

Average across subjects

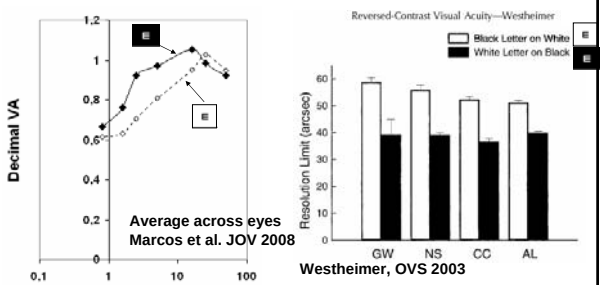


dilated pupil (6 mm)

Marcos et al. JOV 2008

Comparison with previous literature

Effect of contrast polarity on VA (natural aberrations)

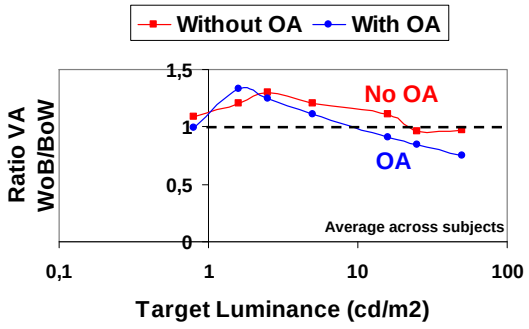


1.12 (JOV 2008)

Ratio VA = WoB/BoW

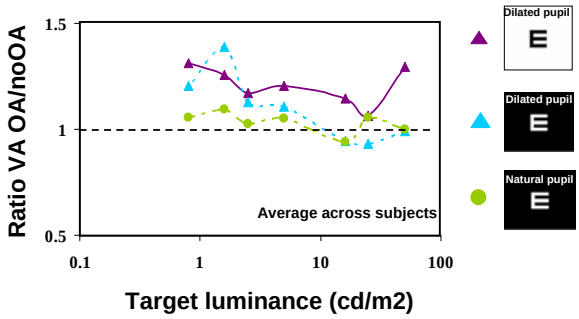
1.38 (OVS 2003 I)
1.045 (OVS 2003 II)

Effect of AO on WoB/BoW ratio



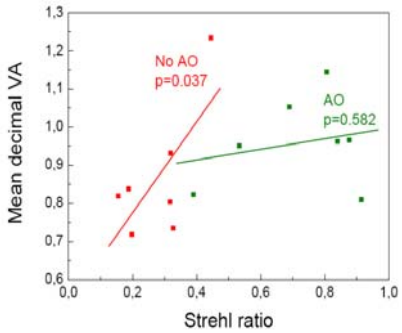
Marcos et al. JOV 2008

Benefit AO on VA: Summary



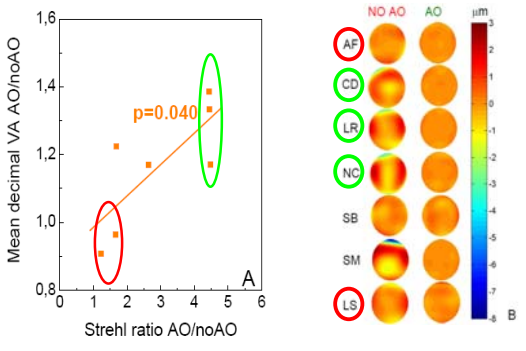
Marcos et al. JOV 2008

Correlation of optical/visual performance



Marcos, Sawides, Gambra and Dorronsoro. Journal of Vision 2008

Improvement in optics & vision:correlated



Marcos, Sawides, Gambra and Dorronsoro. Journal of Vision 2008

Effect of AO on visual performance with real-world targets

Subjective quality preference of natural images

Familiar face Recognition

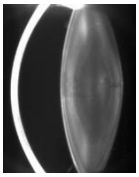
Facial expression recognition

Tuesday, May 5, 2009 1:45 - 2:00 PM
3044 - Visual Performance With Real-Life Tasks Under Adaptive-Optics Ocular Aberration Correction

L. Sawides, E. Gambra, C. Dorronsoro, S. Marcos.
Instituto de Óptica, C.S.I.C., Madrid, Spain.

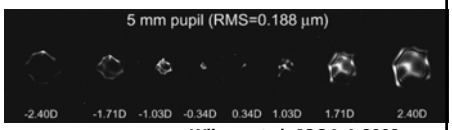
Paper Session
344. Vision in the Presence of Blur
Tuesday, May 5, 2009 1:45 - 3:30 PM

Effect of aberrations on accommodation



Rosales et al JOV 2006

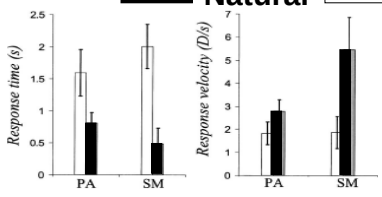
Are monochromatic aberrations a cue for the direction of accommodation?



Wilson et al. JOSA A 2002

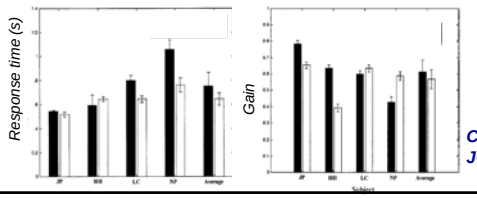
.... Investigated using AO

Natural **AO**



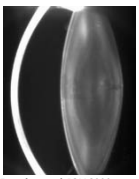
Depends on the subject

Fernández & Artal JOSA A, 2005



Chen et al JOSA A, 2006

Effect of aberrations on accommodation



Rosales et al JOV 2006

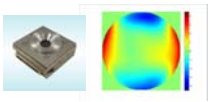
Is the accommodative lag (or the accuracy of accommodative response) influenced by the absence –or presence- of certain types of HOA?

Do the fluctuations of accommodation depend on the presence/absence of HOA?

Approaches

Simulated targets

Allows testing the effect of retinal blur on the accommodative response



Adaptive Optics

Also allows possible interactions between defocus and accommodation-induced HOA

Wednesday, May 6, 2009 2:45 - 3:00 PM
4293 - Dynamic Accommodation With High Order Aberrations Blurred Simulated Targets

E. Gambra[1], J. Yuan[2], Y. Wang[2], S. Marcos[1], P.B. Kruger[2]. [1]Instituto de Optica, Consejo Superior de Investigaciones Cien, Madrid, Spain; [2]Schnurmacher Institute for Vision Research,

Paper Session
439. Accommodation: In Vivo and In Vitro
Wednesday, May 6, 2009 1:45 - 3:30 PM

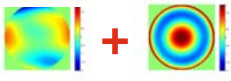
Gambra et al. JOV 2009 (submitted)

Conditions

(1) natural aberrations,

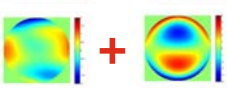
(2) corrected aberrations (of the unaccommodated state)

(3) adding 1 µm of spherical aberration,

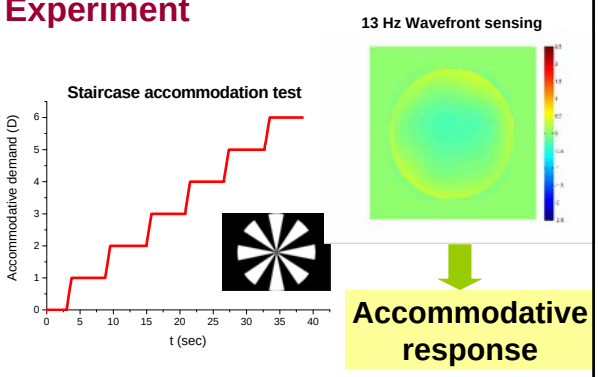


(4) adding - 1 µm of spherical aberration

(5) - 2 µm of vertical coma.

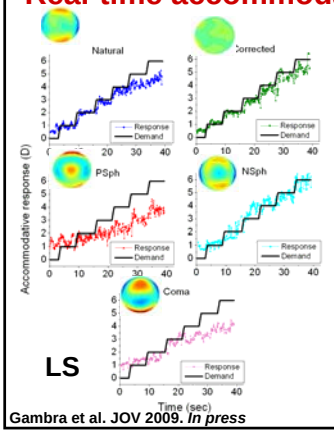


Experiment



Gambra, Sawides, Dorronsoro & Marcos. JOV 2009. *In press*

Real-time accommodative response



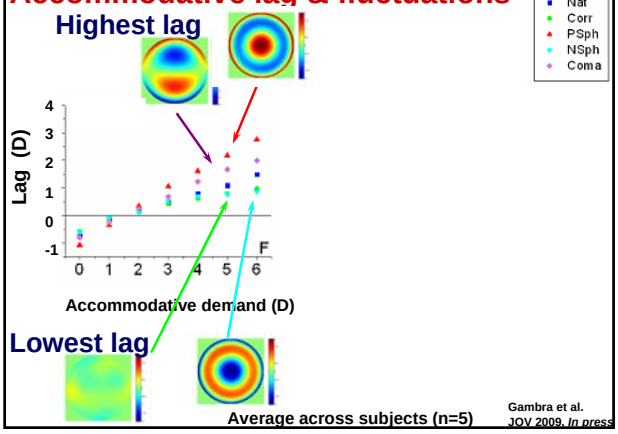
✓Correcting HOA aberrations improves accommodation accuracy

✓Inducing Positive Sph Ab. Or Coma increases lag

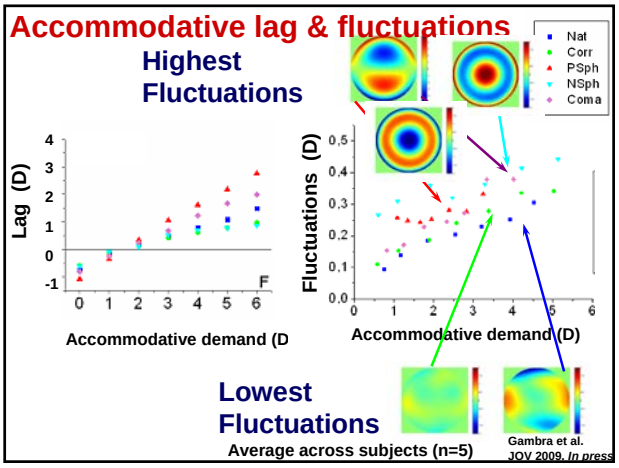
✓Favorable contribution of negative spherical aberration

Gambra et al. JOV 2009. *In press*

Accommodative lag & fluctuations



Accommodative lag & fluctuations



Conclusions

1.- Adaptive optics allows to test relationships between optical and visual performance.

2.- Correcting aberrations improves visual acuity in most conditions, at least in subjects that experience significant correction.

3.- Aberrations play a role in the accommodative response and fluctuations. Correction of higher order aberrations reduced accommodative lag. Induction of HOA increases fluctuations.

Visual Optics and Biophotonics Lab

http://www.vision.csic.es

Funding

FIS2005-04382; PET-2006-0478;
FIS2008-02065

http://www.vision.csic.es