Neural Plasticity Stimulated by Improved Optics in Highly Aberrated Eyes

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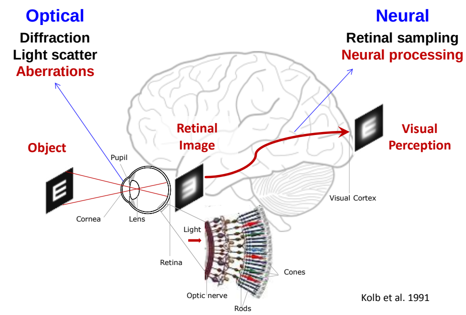
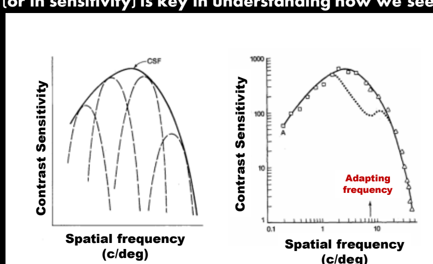
Factors Affecting Vision



Neural Adaptation

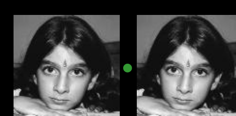
Characterizing how observers adapt to changes in environment (or in sensitivity) is key in understanding how we see.



Campbell & Robson, 1968

Neural Adjustments to Image Blur

Short-term adaptation to blur
Webster et. al., (2002)



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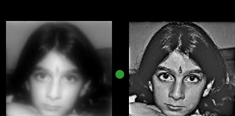


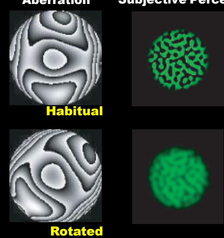
Neural Adjustments to Image Blur

Short-term adaptation to blur
Webster et. al., (2002)

Neural Adjustments to Image Blur

Short-term adaptation to blur
Webster et. al., (2002)

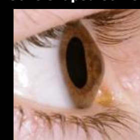
Long-term adaptation to aberrations
Artal et. al., (2004)



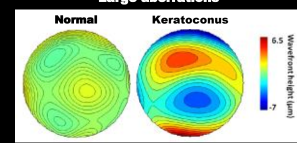
Keratoconus subjects for a study on long-term adaptation to the aberration

Pantanelli et. al., Ophthalmology (2007)
Yoon et. al., J Biomed Opt. (2006)

Cone-shaped cornea



Large aberrations



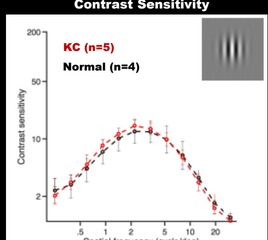
- Normally developed visual system unlike amblyopia
- Gradual progression of the disease over years
- Large magnitude of higher order aberrations

I. Phase Compensatory Mechanism

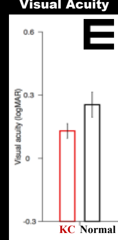
Sabesan and Yoon, Invest Ophthalmol Vis Sci. (2010)
Barbot et. al., Invest. Ophthalmol. Vis. Sci. (2015)

KC eyes with their own habitual aberration
vs
Normal eyes with KC habitual aberrations

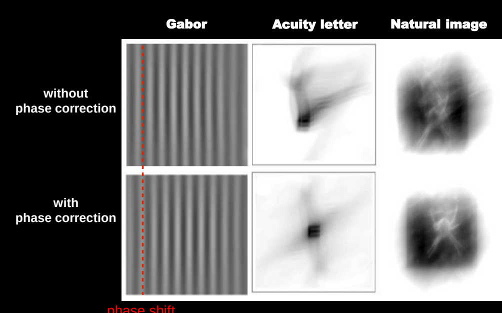
Narrowband Stimulus
(Single spatial frequency)
Contrast Sensitivity



Broadband Stimulus
(Multiple spatial frequencies)
Visual Acuity



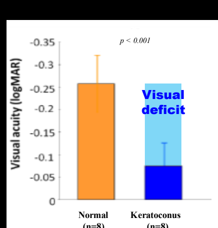
Phase Transfer Function Influences Image Quality of a Broad-band Visual Stimulus Considerably.

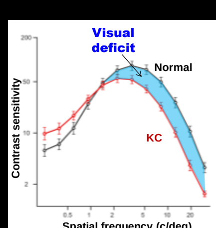


II. Gain Adjustment of Spatial Frequency Channel Mechanism

Sabesan and Yoon, J Vis. (2009)
Barbot et. al., Journal of Vision. (2016)

Full AO Correction i.e. Aberration Free Condition

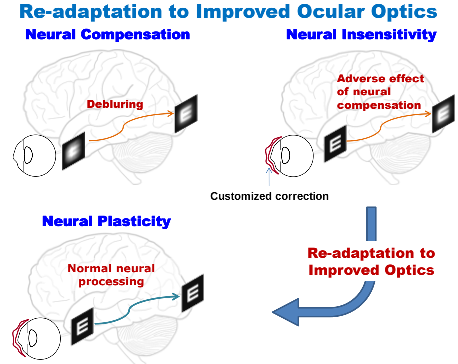




Sabesan & Yoon 2009

Neural Plasticity

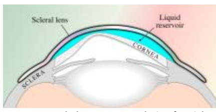
Re-adaptation to Improved Ocular Optics



"Prosthetic Replacement of the Ocular Surface Ecosystem (PROSE)" provides excellent stability of higher order aberration correction

Sabesan et. al., Optom Vis Sci (2013)

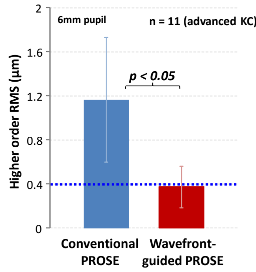
PROSE



Dr. Rosenthal, Boston Foundation for Sight

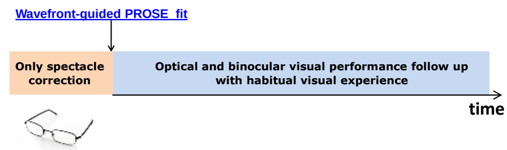
- 17-22mm diameter
- High oxygen permeability
- State-of-the-art haptic design
- Severe ocular surface treatment

Optical Performance



Habitual (Passive) visual experience with improved optics i.e. wavefront-guided PROSE

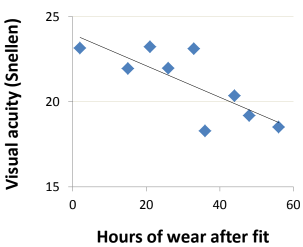
- Two advanced keratoconic patients
- Severe keratoconus in both eyes
- Spectacle correction in both eyes
- No previous advanced correction



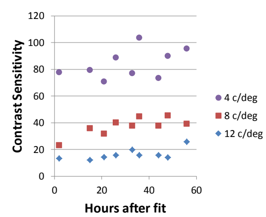
Time course improvement of visual acuity with wavefront-guided PROSE

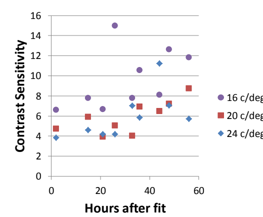
Barbot et. al., Invest. Ophthalmol. Vis. Sci. (2017)

Baseline acuity with conventional PROSE: 20/33

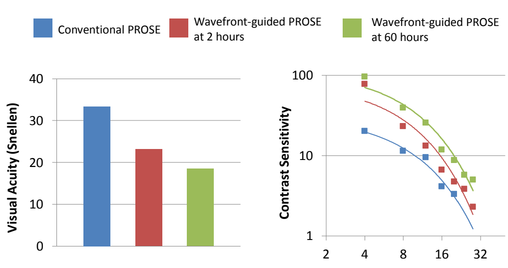


Time course improvement of contrast sensitivity with wavefront-guided PROSE

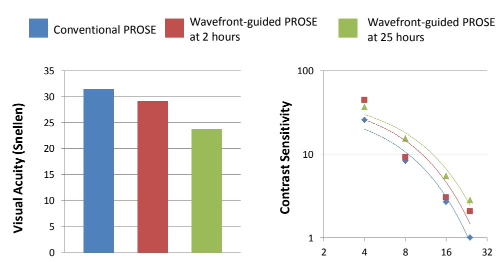




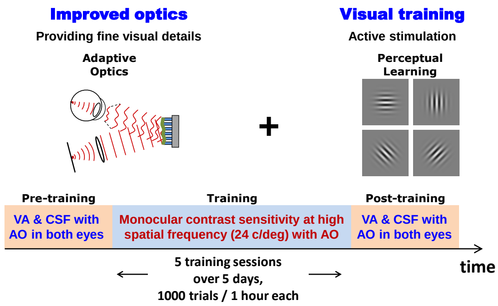
Visual performance improvement with wavefront-guided PROSE (subject #1)



Visual performance improvement with wavefront-guided PROSE (subject #2)



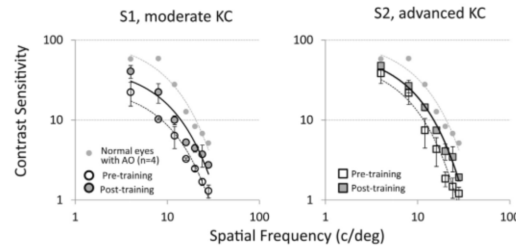
Neural Plasticity with Improved Optics and Visual Training



Visual training with adaptive optics significantly improves contrast sensitivity.

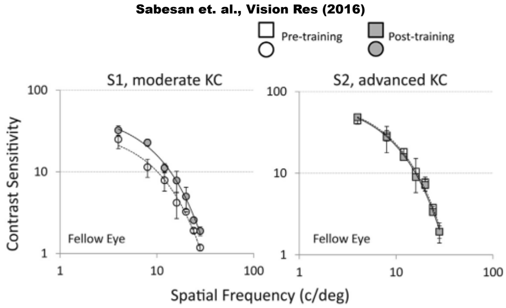
Sabesan et. al., Vision Res (2016)

- Trained eye -



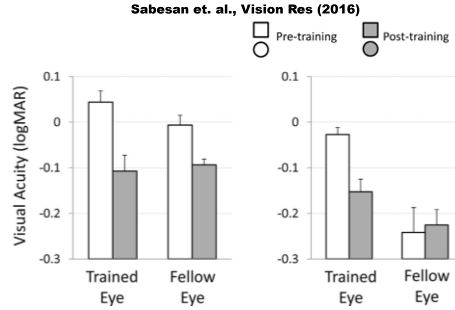
Inter-ocular transfer of the training effect

Sabesan et. al., Vision Res (2016)



Inter-visual task transfer of the training effect

Sabesan et. al., Vision Res (2016)



Conclusions

- Mechanisms underlying long-term neural adaptation to the eye's aberration are
  - ✓ Phase compensation (Phase transfer function)
  - ✓ Gain adjustment of spatial frequency channels
- The adult human visual cortex has a sufficient degree of plasticity, indicating that providing improved visual input through wavefont-guided correction and/or visual training can recover visual deficits from long-term adaptation to severe optics.

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