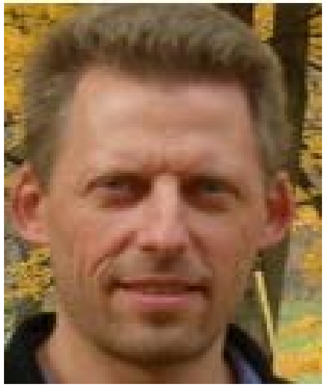
Applications of
Visual Science
Technical Group

Technical Group Leadership:

Brian Vohnsen, University College Dublin, Ireland (Chair)

Stacey Choi, Ohio State University, USA (Vice Chair)

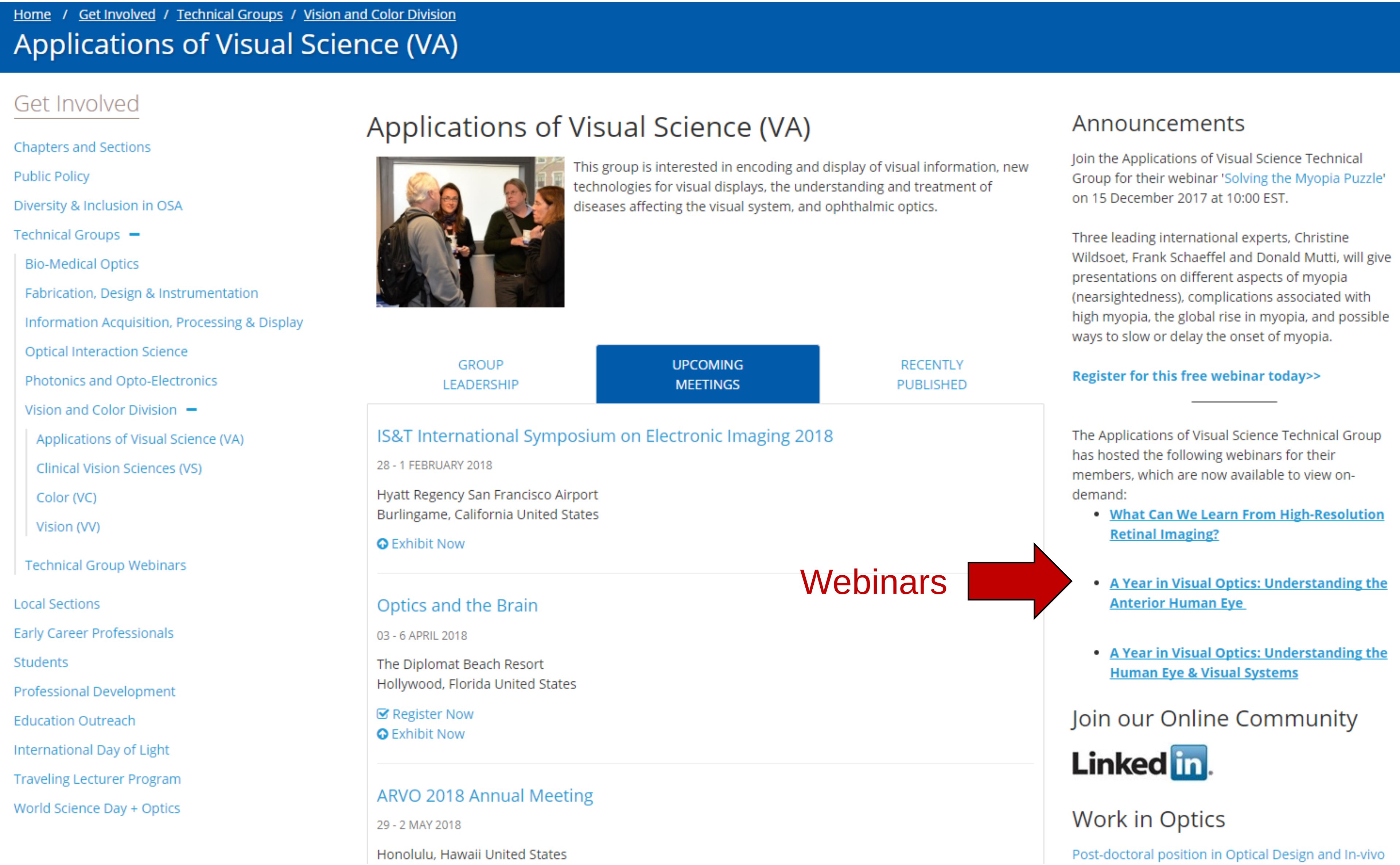


Chair-elect (2018):

Enrique-Josua Fernández, Universidad de Murcia, Spain

OSA Applications of Visual Science Technical Group

http://www.osa.org/en-us/get_involved/technical_groups/vc/applications_of_visual_science/



Home / Get Involved / Technical Groups / Vision and Color Division

Applications of Visual Science (VA)

Get Involved

- Chapters and Sections
- Public Policy
- Diversity & Inclusion in OSA
- Technical Groups –
  - Bio-Medical Optics
  - Fabrication, Design & Instrumentation
  - Information Acquisition, Processing & Display
  - Optical Interaction Science
  - Photonics and Opto-Electronics
  - Vision and Color Division –
    - Applications of Visual Science (VA)
    - Clinical Vision Sciences (VS)
    - Color (VC)
    - Vision (VV)
  - Technical Group Webinars
- Local Sections
- Early Career Professionals
- Students
- Professional Development
- Education Outreach
- International Day of Light
- Traveling Lecturer Program
- World Science Day + Optics

Applications of Visual Science (VA)

This group is interested in encoding and display of visual information, new technologies for visual displays, the understanding and treatment of diseases affecting the visual system, and ophthalmic optics.

IS&T International Symposium on Electronic Imaging 2018

28 - 1 FEBRUARY 2018

Hyatt Regency San Francisco Airport
Burlingame, California United States

Exhibit Now

Optics and the Brain

03 - 6 APRIL 2018

The Diplomat Beach Resort
Hollywood, Florida United States

☑ Register Now
Exhibit Now

ARVO 2018 Annual Meeting

29 - 2 MAY 2018

Honolulu, Hawaii United States

Announcements

Join the Applications of Visual Science Technical Group for their webinar 'Solving the Myopia Puzzle' on 15 December 2017 at 10:00 EST.

Three leading international experts, Christine Wildsoet, Frank Schaeffel and Donald Mutti, will give presentations on different aspects of myopia (nearsightedness), complications associated with high myopia, the global rise in myopia, and possible ways to slow or delay the onset of myopia.

Register for this free webinar today>>

The Applications of Visual Science Technical Group has hosted the following webinars for their members, which are now available to view on-demand:

- **What Can We Learn From High-Resolution Retinal Imaging?**
- **A Year in Visual Optics: Understanding the Anterior Human Eye**
- **A Year in Visual Optics: Understanding the Human Eye & Visual Systems**

Join our Online Community

LinkedIn.

Work in Optics

Post-doctoral position in Optical Design and In-vivo

Webinars

OSA Applications of Visual Science Technical Group

Contact your Technical Group and Get Involved!

- Linked-In site (global reach)
- Announce new activities
- Promote interactions
- Complement the OSA Technical Group Member List

Applications of Visual Science Technical Group

186 members

Start a conversation with your group

Enter a conversation title...

Conversations Jobs

Brian Vohnsen · Moderator ··· 1mo

Associate Professor, University College Dublin

OSA Webinar "Solving the Myopia Puzzle" Dec. 15th 2017 @10am EST

We are pleased to announce the 4th webinar hosted by the Applications of Visual Science Technical Group below the Optical Society of America. This webinar will have presentations by Prof. Christine Wildsoet (UC Berkeley), Prof. Frank Schaeffel (U Tübingen) and Prof. Donald Mutti (Ohio State U) who are all leading experts in myopia. The presenters will discuss current understanding of myopia, reasons why myopia is on the rise, and possible steps that can reduce or delay the onset of myopia. To register for the FREE webinar (registration is mandatory) please complete the online form: https://cc.callinfo.com/registration/#/?meeting=1kgd5ce6zz5ae&campaign=1q6ommi9n1dsm

We hope that you will be able to join this online feature from our technical group. The highly successful webinars on the human eye from the past years can still be viewed online at our Technical Group website: http://www.osa.org/en-us/communities/technical_communities/vc/applications_of_visual_science/. Show less

Technical Group activities:

OSA Applications of Visual Science Technical Group

Webinars (annual event and today's webinar is the 4th of its kind)
All our webinars are open for viewing at the OSA Technical Group website

Panel discussions, discussion forums, and social gatherings at conferences
Events at the ARVO annual meeting and the OSA Frontiers in Optics conference

Student awards at conferences
Awards at the ARVO annual meeting and at the VPO conference

Involvement in conference organization
OSA Fall Vision Meeting and OSA Frontiers in Optics meeting

OSA Applications of Visual Science Technical Group

Welcome to Today's webinar!

SOLVING THE MYOPIA PUZZLE WEBINAR

15 December 2017 • 10:00 EST

OSA Applications of Visual Science Technical Group

Christine Wildsoet, University of California Berkeley, USA

Frank Schaeffel, University of Tübingen, Germany

Donald Mutti, Ohio State University, USA

OSA Applications of Visual Science
4th Annual Webinar 2017

Myopia: Lessons from the past & unanswered questions related to eye growth regulation

Christine Wildsoet OD, PhD, FAAO, FARVO
UC Berkeley Myopia Research Group

Principal Funding: NIH/NEI (R01 EY12392 & K12 EY017296)
& fellowships for visiting clinician scientists

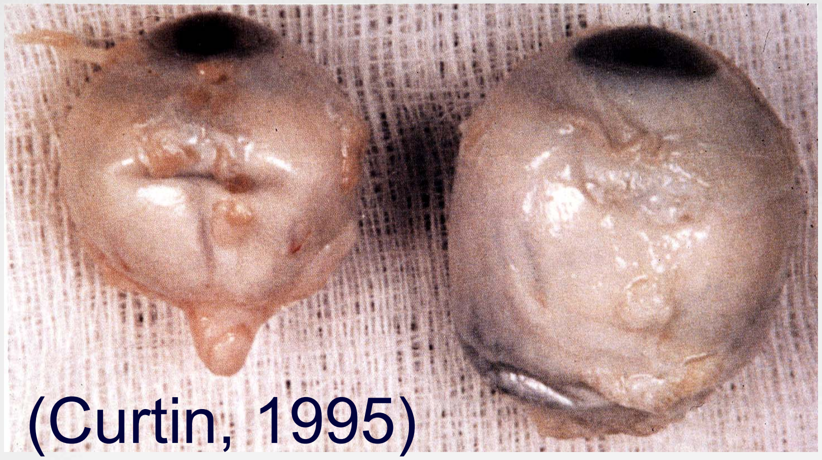
wildsoet@berkeley.edu • http:// wildsoetlab.berkeley.edu • http://vision.berkeley.edu/wildsoet

Take-home messages from today's presentation

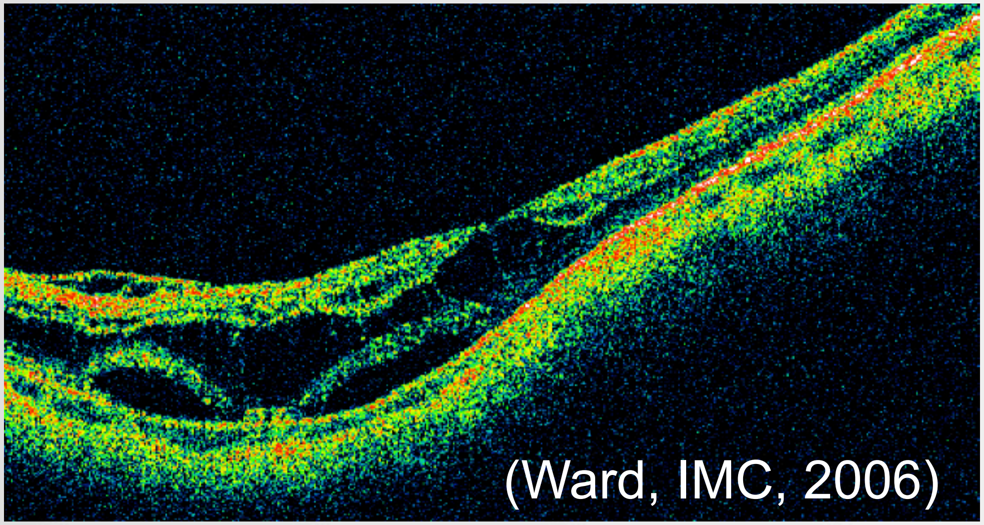
- The current global myopia epidemic is likely driven by interacting environmental and genetic factors
- Animal model studies have provided important insights into:
  - Visually-guided refractive error development & underlying mechanisms
  - Role of genetics in individual differences in myopia susceptibility
- Current optical & pharmacological interventions for slowing myopia progression can & should be refined, as understanding of underlying mechanisms improves
- There is much room & need for cross-disciplinary collaborations in the myopia research field

High myopia = Increase in complications!

- Jung et al (2012): Korean young adult (19 yo) males
  - 96.5% myopic
  - 21.6% highly myopic



(Curtin, 1995)

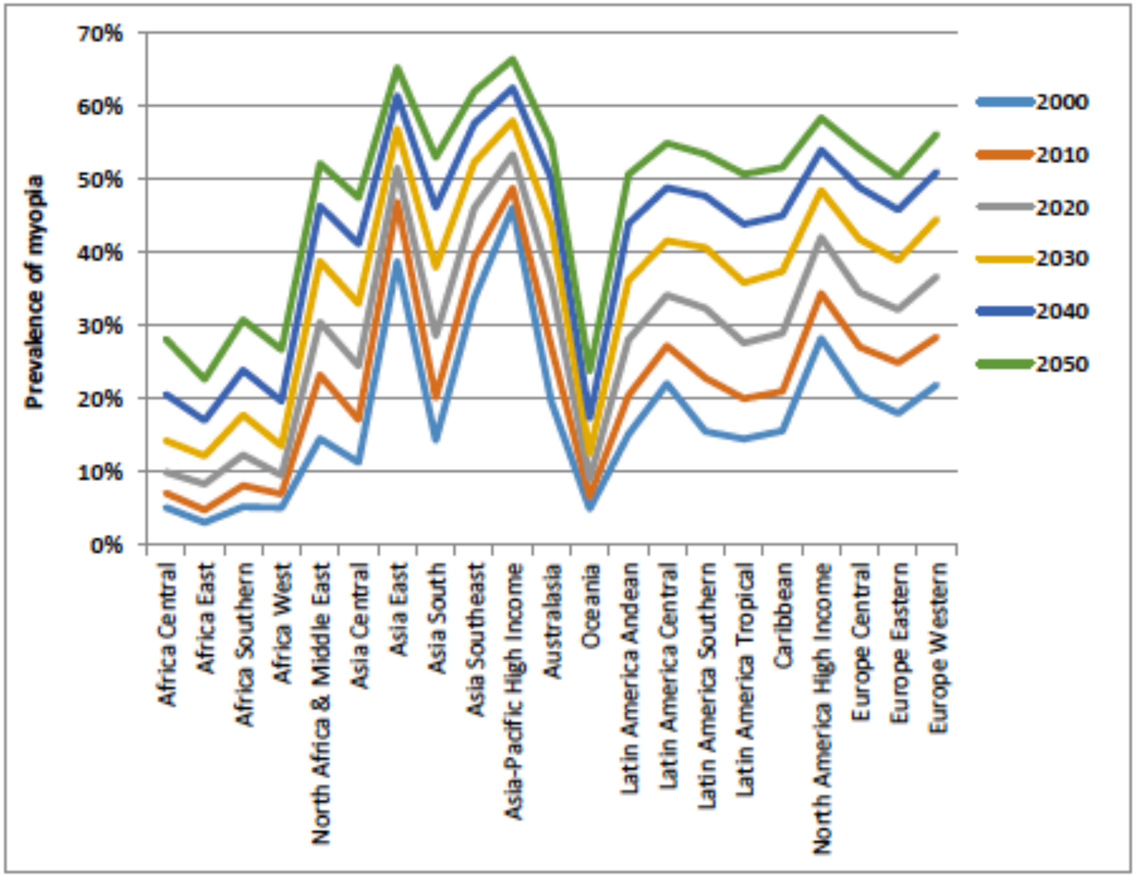


(Ward, IMC, 2006)

Projection for high myopia - 9.5% by 2050 world-wide!

Global projections for myopia:

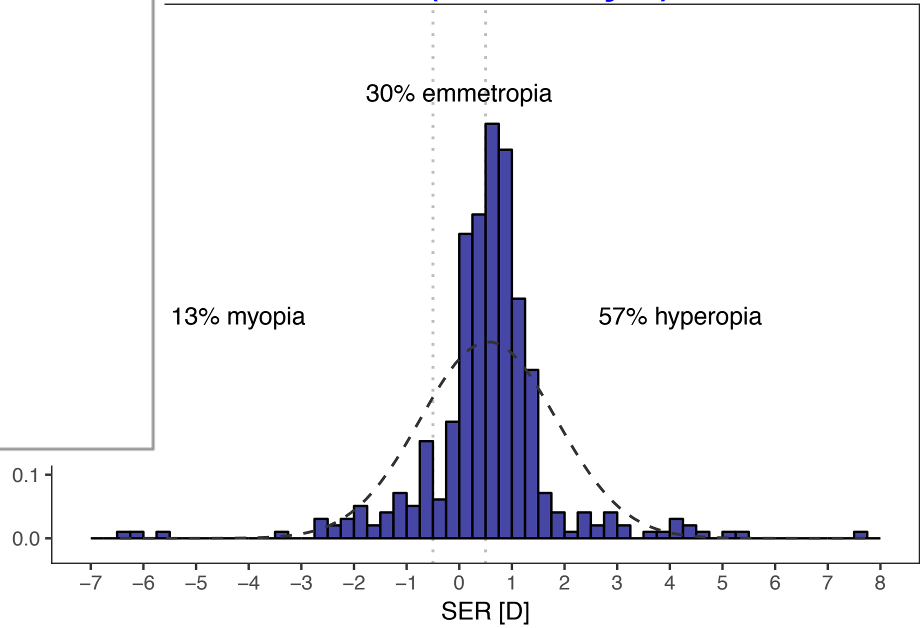
An out-of-control condition!



51.6% by 2050!

(Holden et al. 2016)

Exception: Young Norwegians!
(16–19 yo)



(Courtesy of Lene Hagan &
Rigmor Baraas, Kongsberg)

The cause of the myopia epidemic

Excessive near work?

Not a new idea!

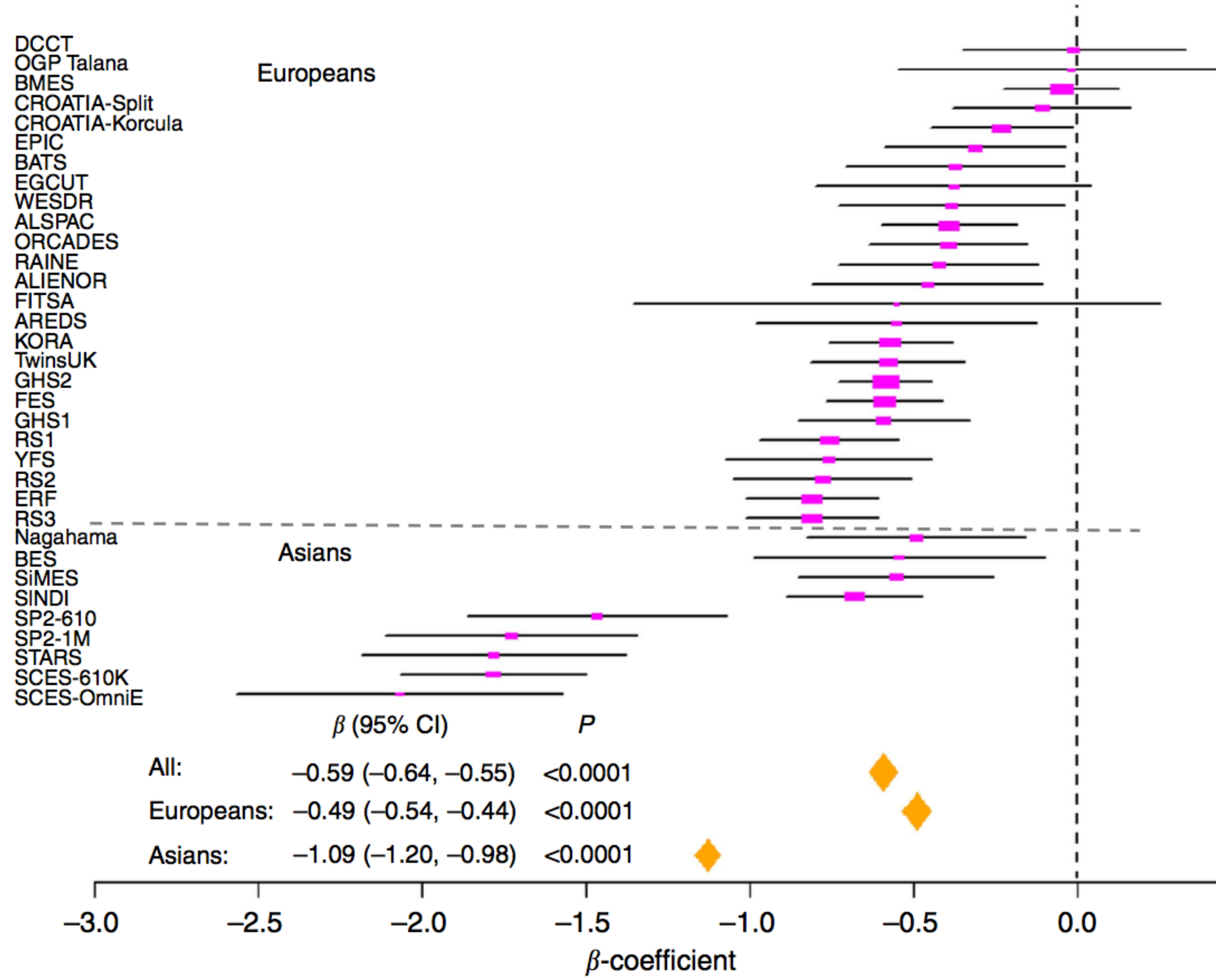
Juler (1904)

THE HYGIENIC DESK. (Patent.)

© HAP/Quirky China News/REX

Educational effect on myopia?

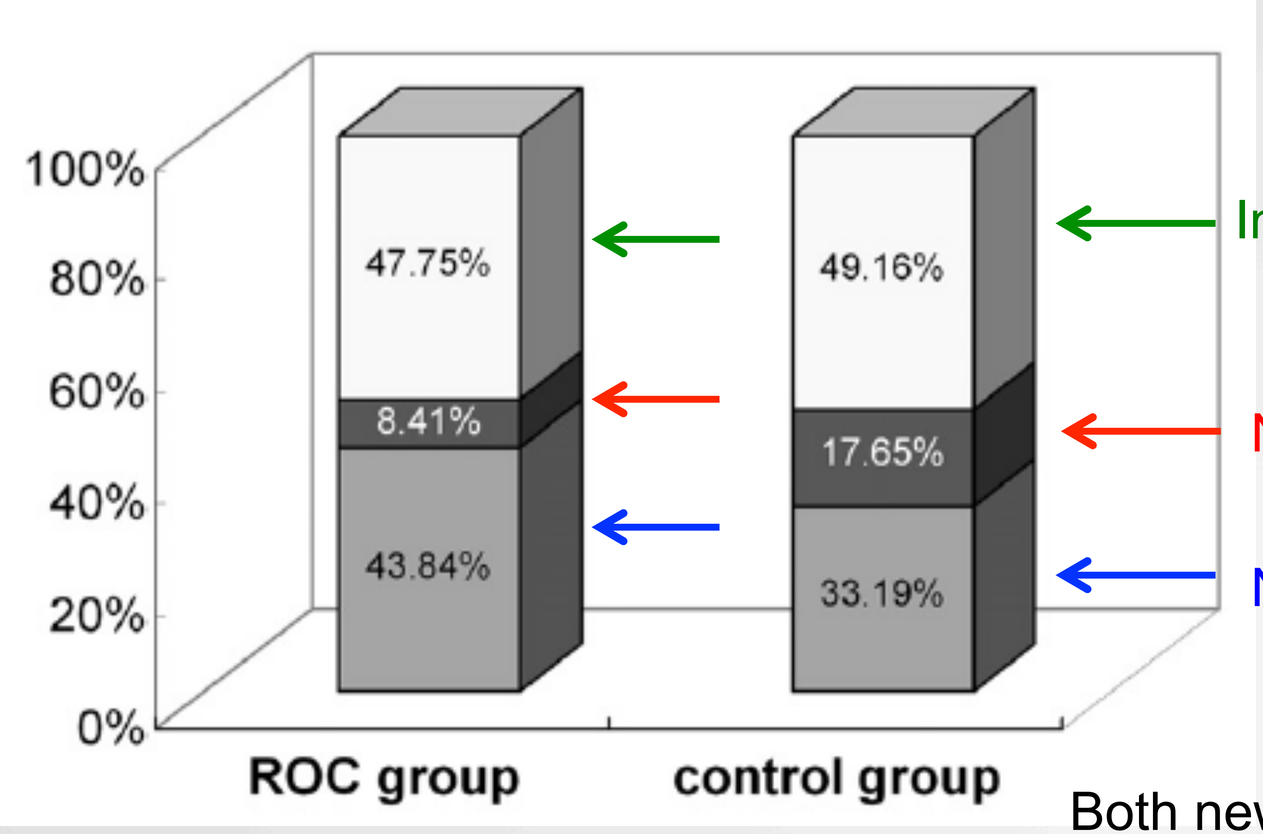
More education tied to more myopia, especially in Asians



Qiao Fan et al, 2016
(CREAM consortium)

Interrupting near work is protective

Recesses Outside the Classroom



Initial myopes

New myopes

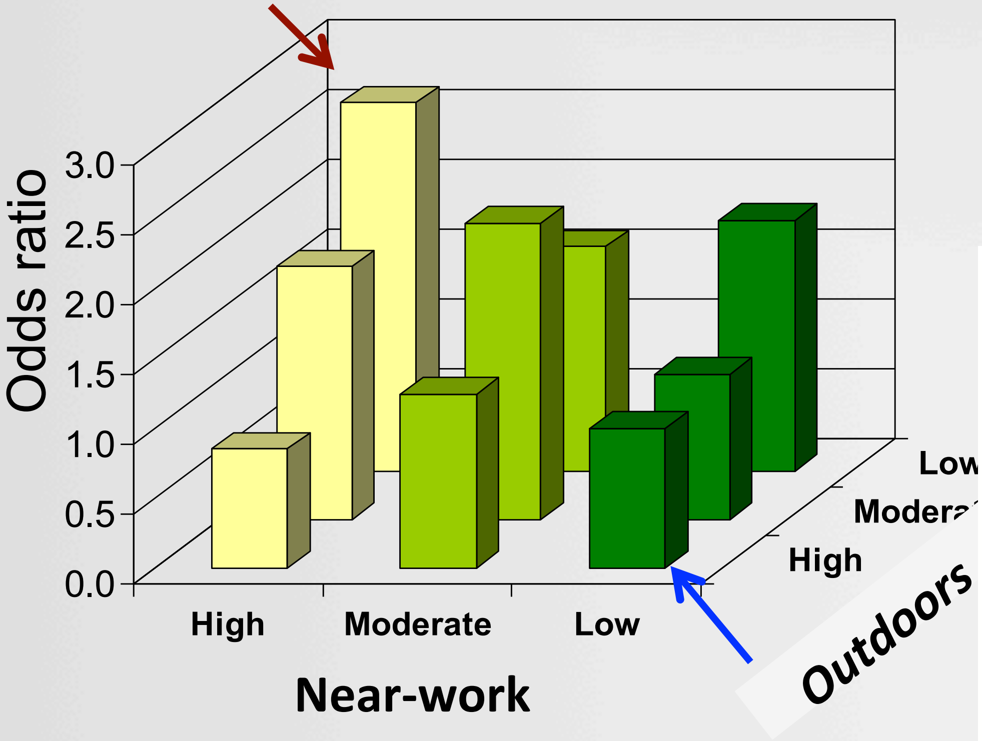
No myopia

(Wu et al, Ophthalmology, 2013)

Both new cases & progression
benefited from outdoor breaks
(10+20+10 minX2/day extra)

An alterative interpretation

Outdoor exposure is protective…



(Rose et al, 2008)


Spend **less time** on unnecessary near work activities:

- Computer games
- Hand-held & handphone games
- Blogging and internet chats

Take a break after 30 – 40 minutes of near work.

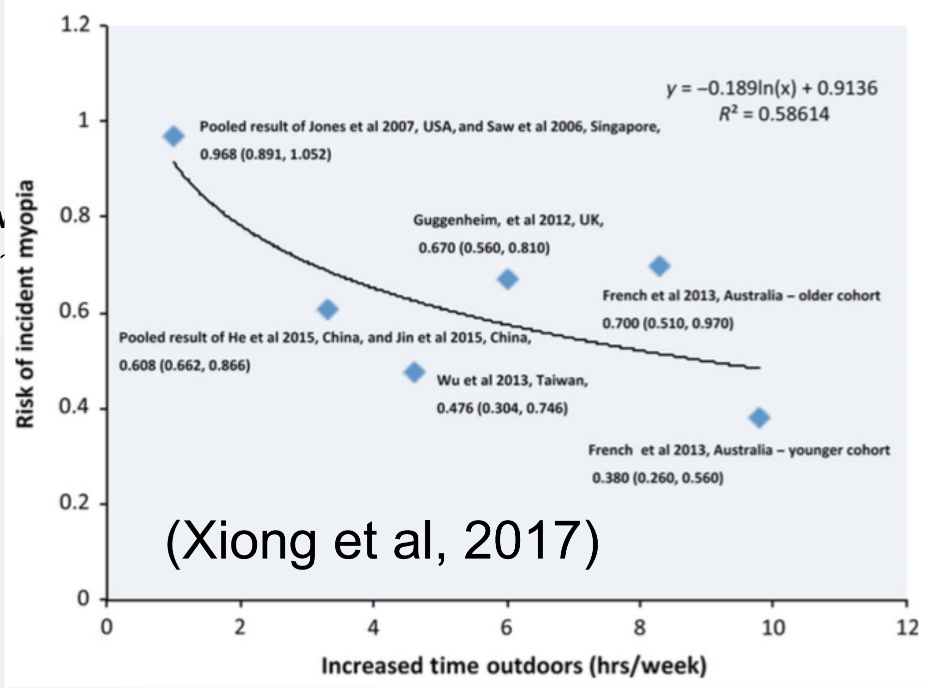
Keep Myopia at bay, go outdoors and play!

It's easy to take care of our precious eyes.

Spend **more time** every day on outdoor activities:

- Play ball games
- Take a walk
- Have fun at the playground!

Health Promotion Board

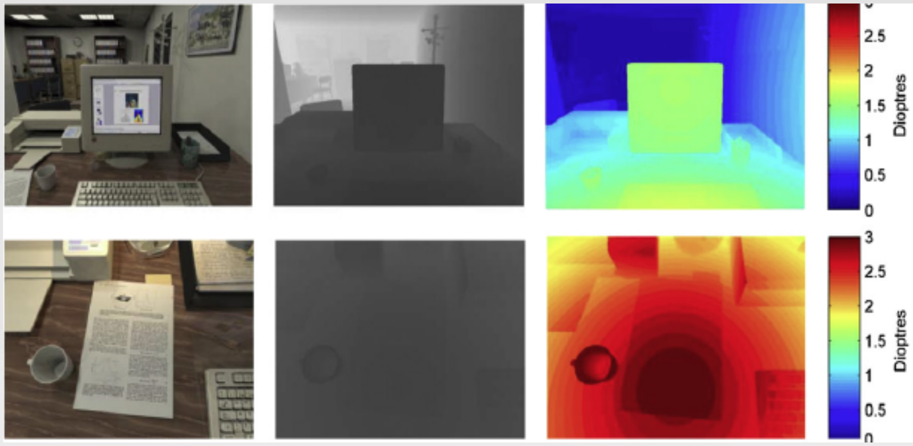


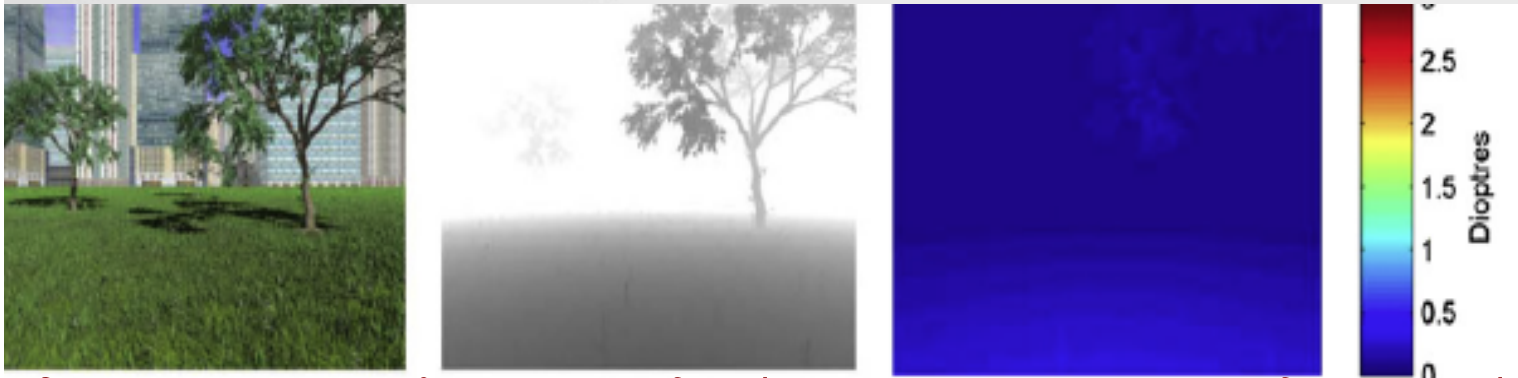
(Xiong et al, 2017)

So what is so special about outdoors cf. indoors?

The Indoor-Outdoor Effects?

Indoors dim & rich in defocus



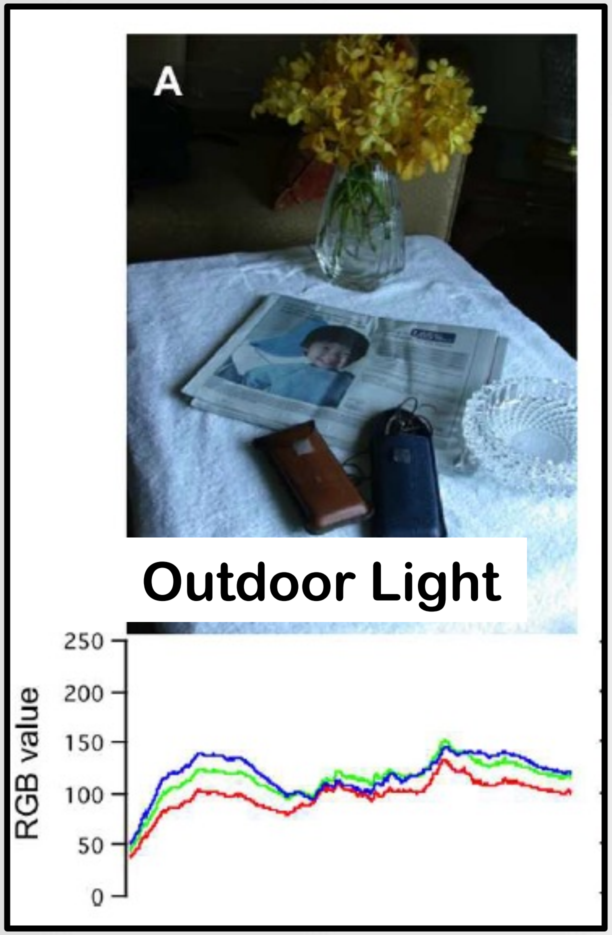


Outdoors bright & optically flat (but richer in spatial information)

Flitcroft
(2012)

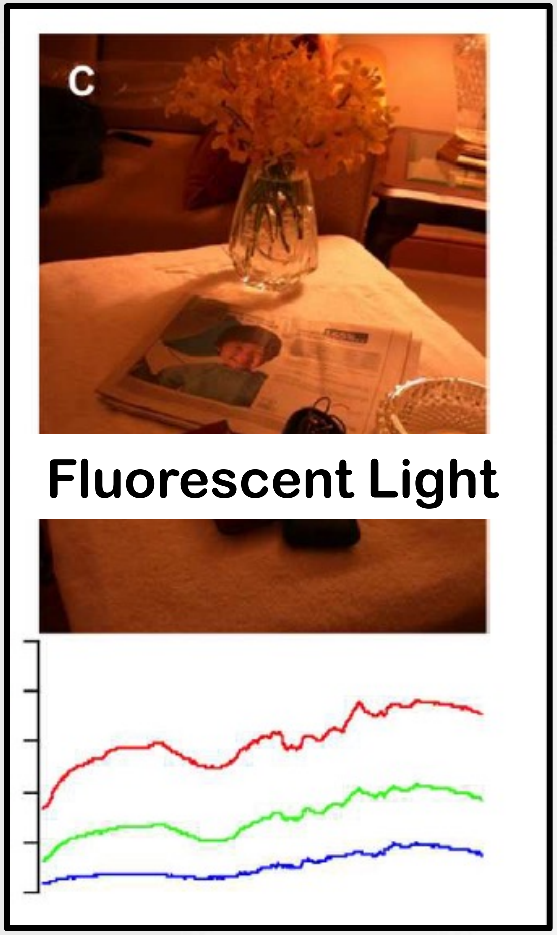
Indoors vs. Outdoors:

Other differences

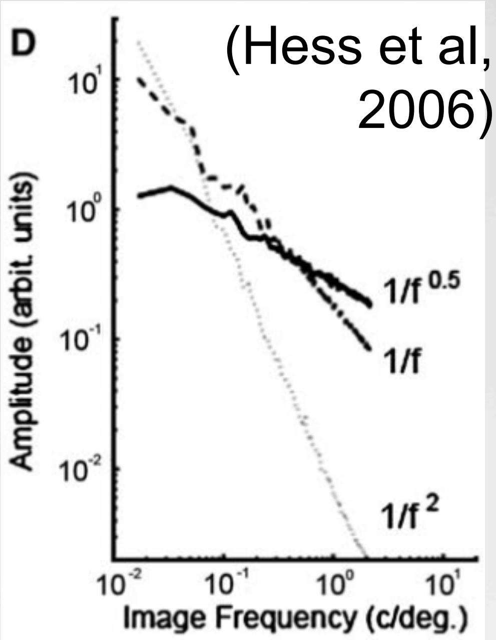


Outdoor Light

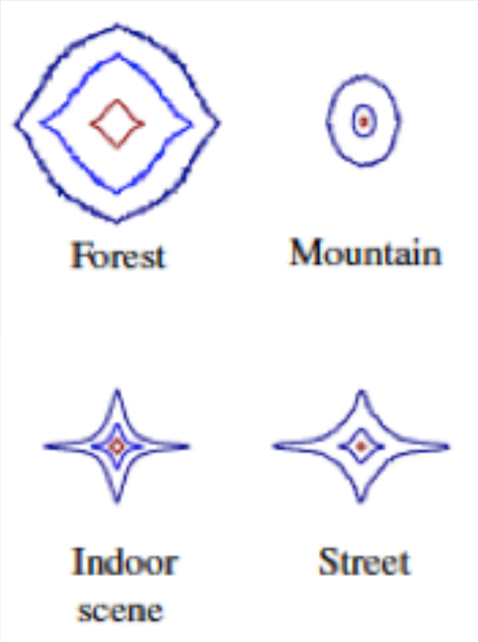
(Foulds et al., 2014)



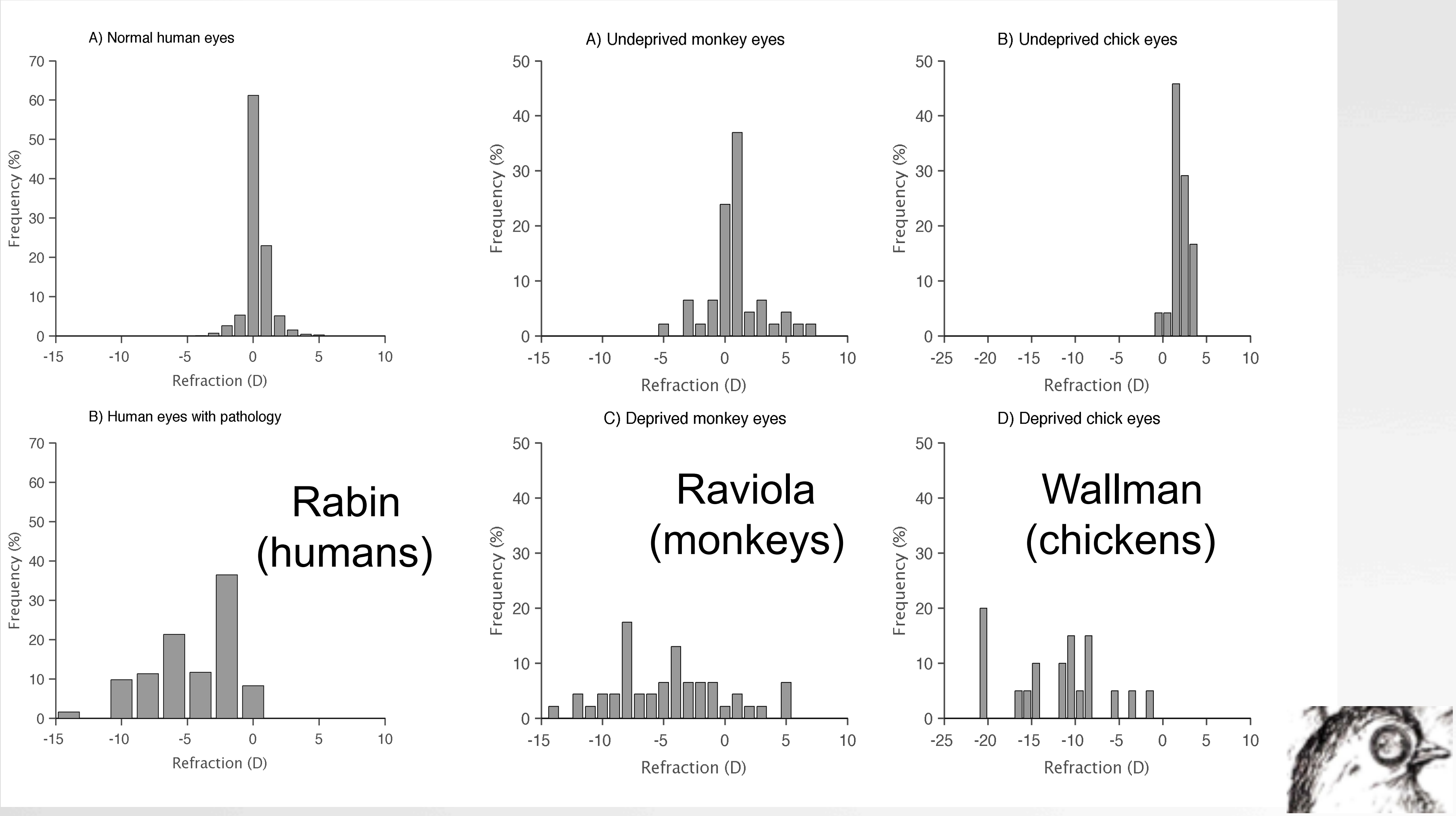
Fluorescent Light



(Hess et al, 2006)

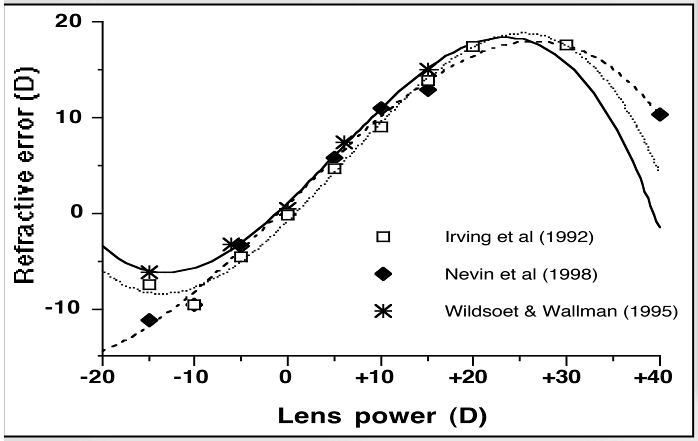


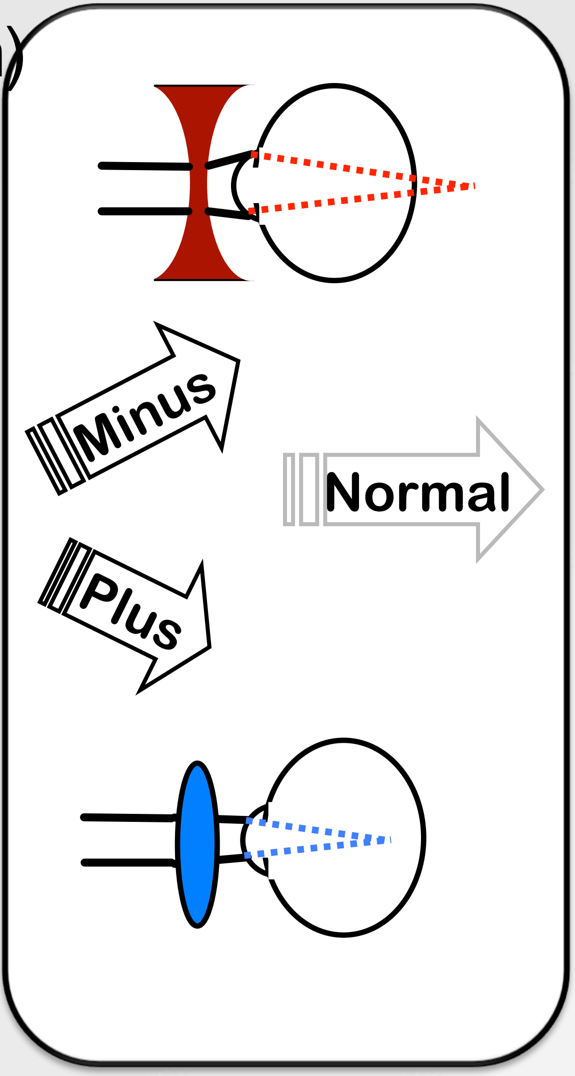
Evidence for visual influences on eye growth is old!

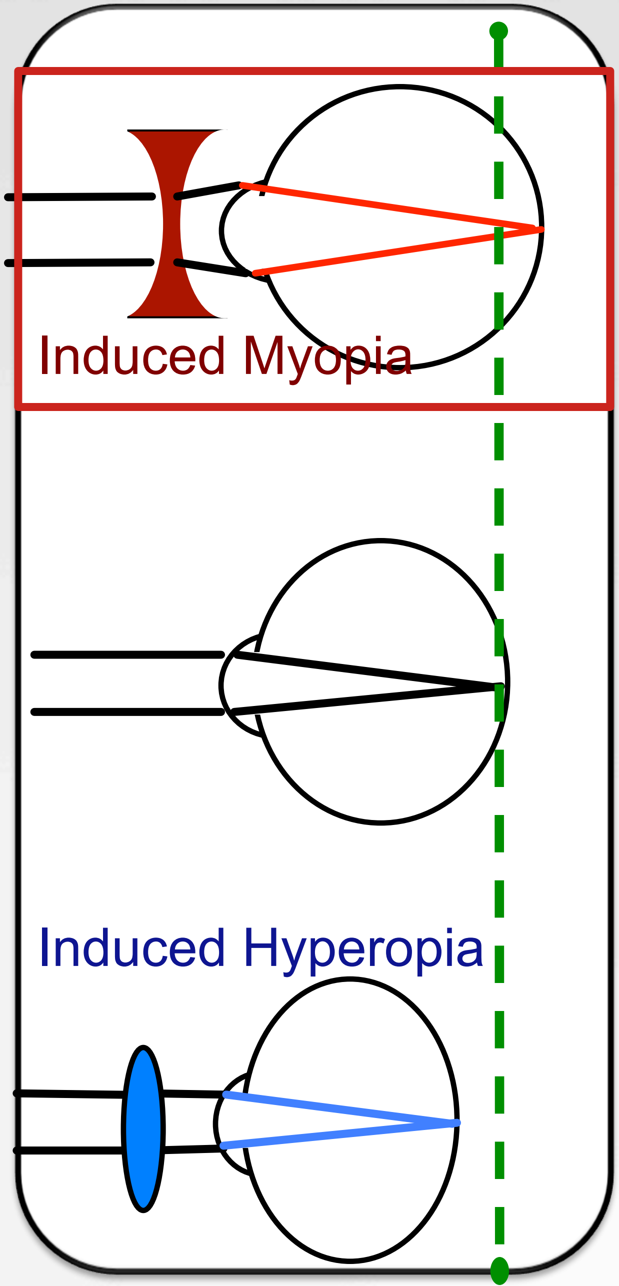


Real major break-through

Demonstration of bidirectional defocus-guided eye growth regulation (active emmetropization)

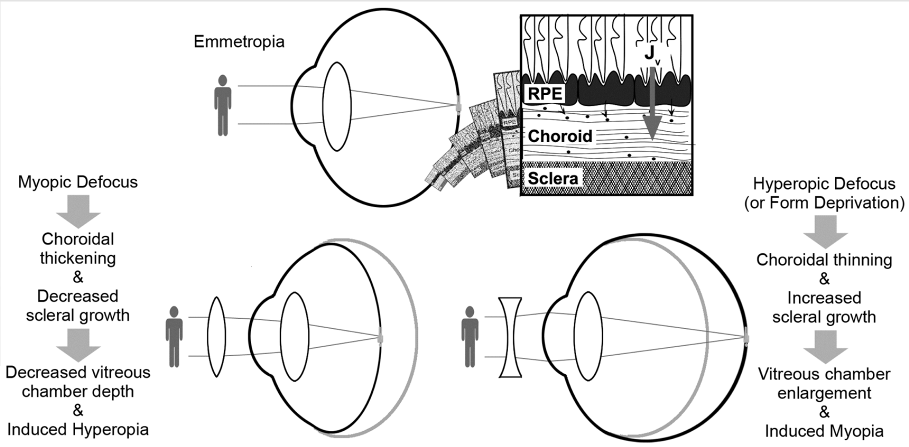






RPE gene expression changes

Evidence of local (retinal) decoding of defocus



Myopic Defocus

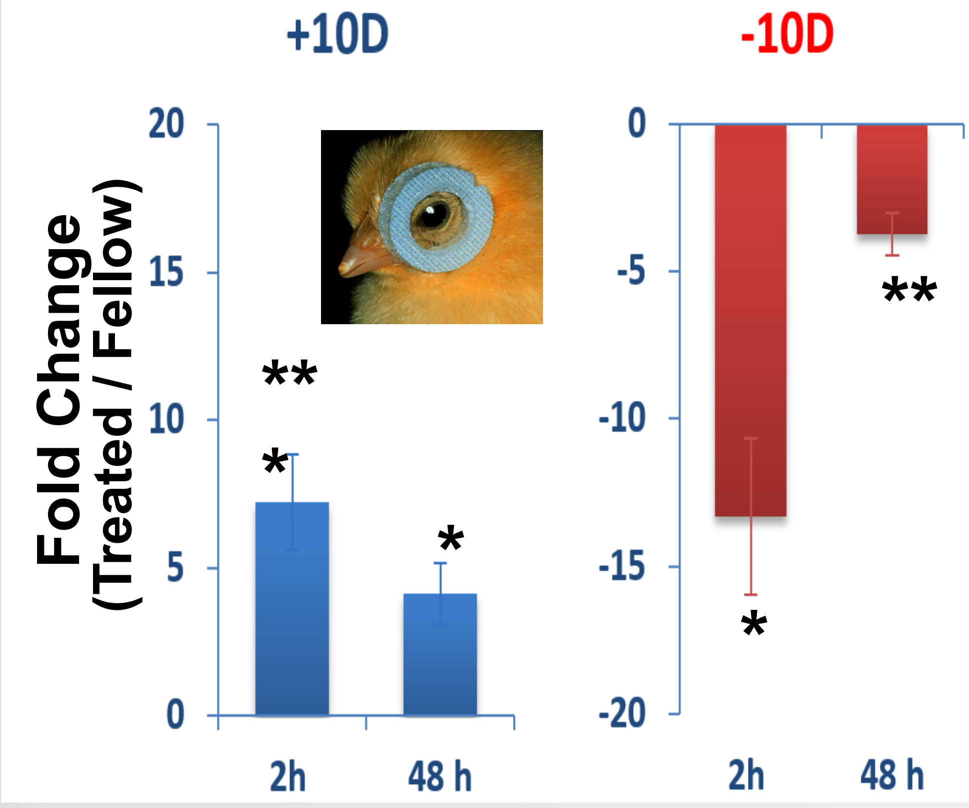
Choroidal thickening
&
Decreased scleral growth

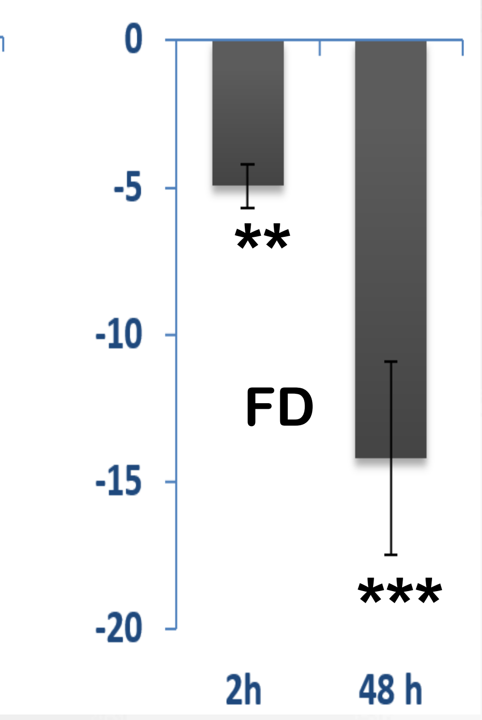
Decreased vitreous chamber depth
&
Induced Hyperopia

Hyperopic Defocus
(or Form Deprivation)

Choroidal thinning
&
Increased scleral growth

Vitreous chamber enlargement
&
Induced Myopia

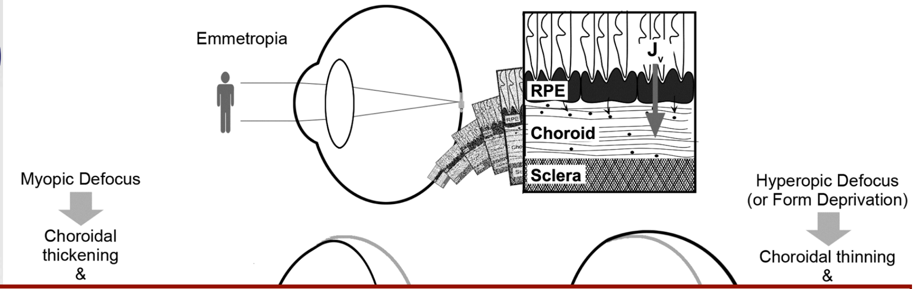




(Yan Zhang)

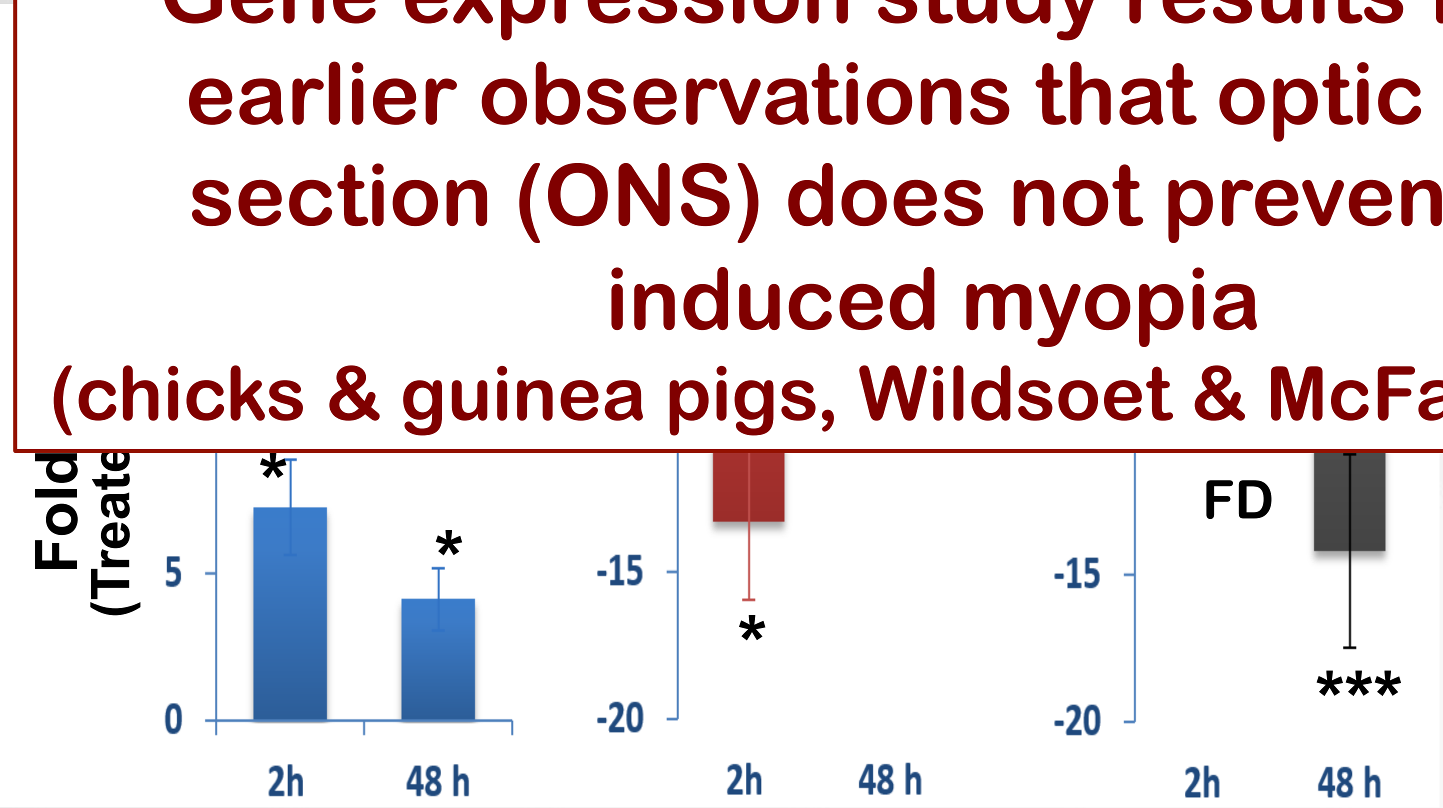
RPE gene expression changes

Evidence of local (retinal) decoding of defocus



Gene expression study results fit with earlier observations that optic nerve section (ONS) does not prevent lens-induced myopia

(chicks & guinea pigs, Wildsoet & McFadden labs)



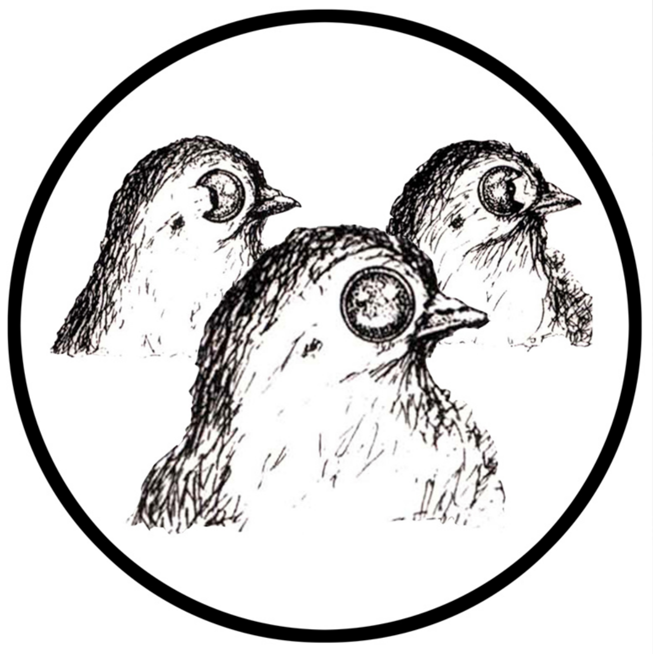
(Yan Zhang)

Implications of local control

Local (retinal) control allows for local (regional) ocular growth regulation

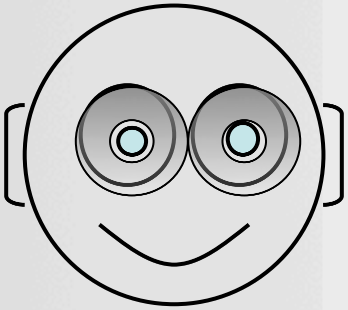
- Local defocus (half lenses) induces local changes (chicks, Schaeffel lab)

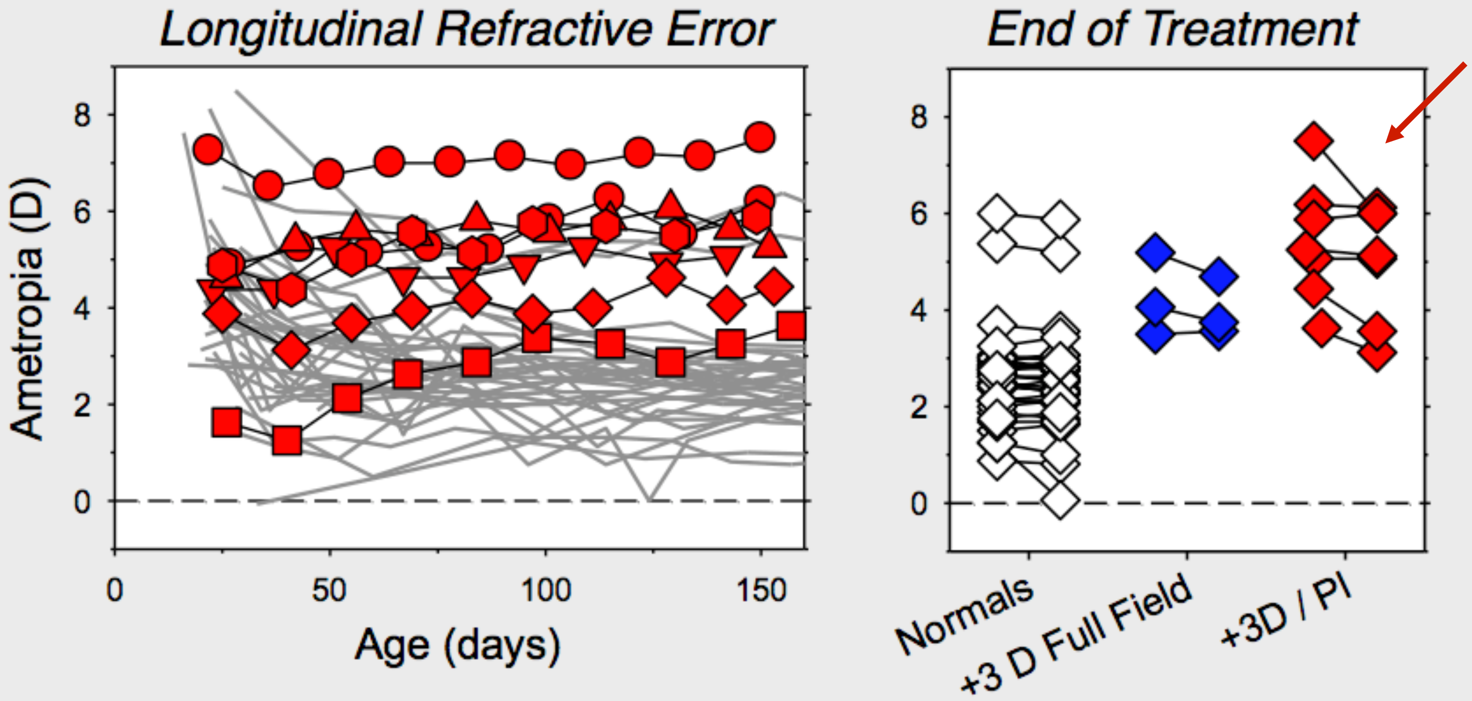
The first evidence for local regional regulation came from studies using same paradigm & form deprivation (FD) (Wallman lab)



2-Zone Multifocal (MF) +ve Lenses

Monkeys behave like Chicks:
Peripheral defocus sufficient to slow eye growth
without obstructing vision!





Longitudinal Refractive Error

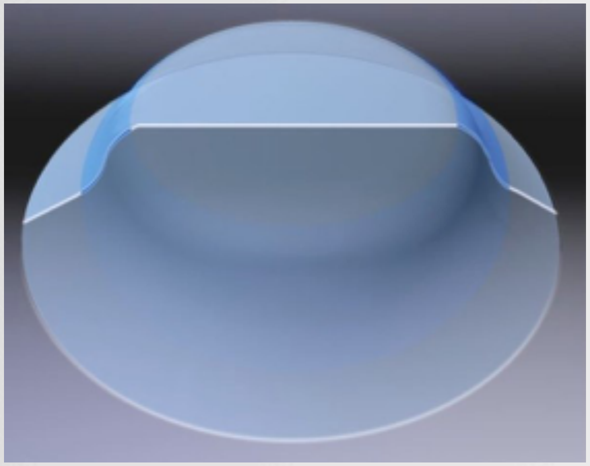
End of Treatment

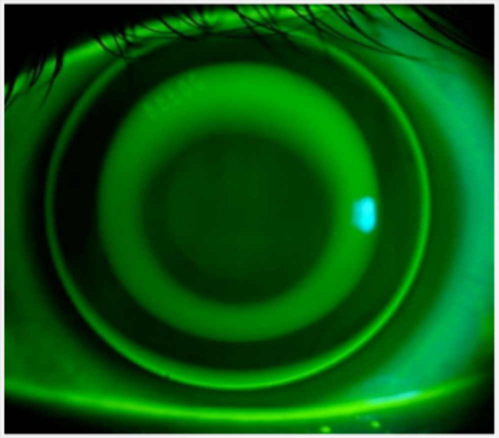
Refractive development was dominated by the ***positive-powered*** *portion of the lens.*

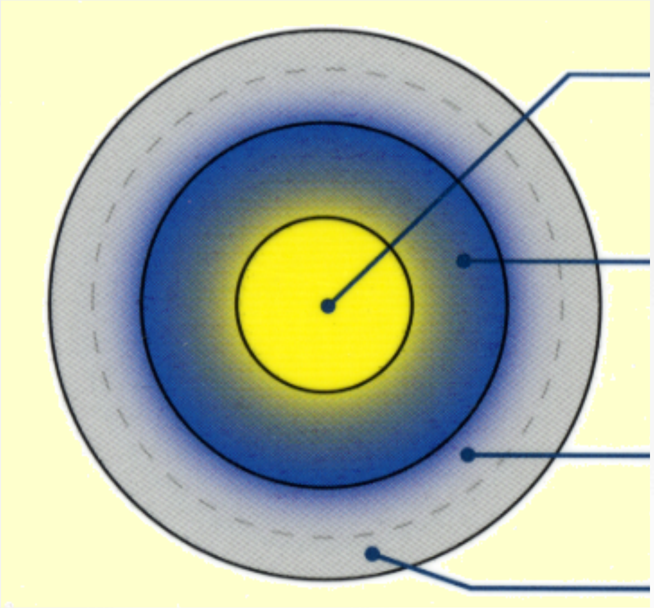
Courtesy of Earl Smith

Translation to humans:

Parallel results (myopia control) with multifocal & CRT lenses?

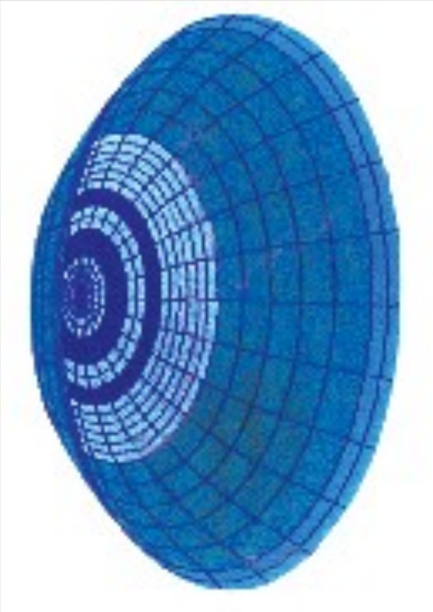


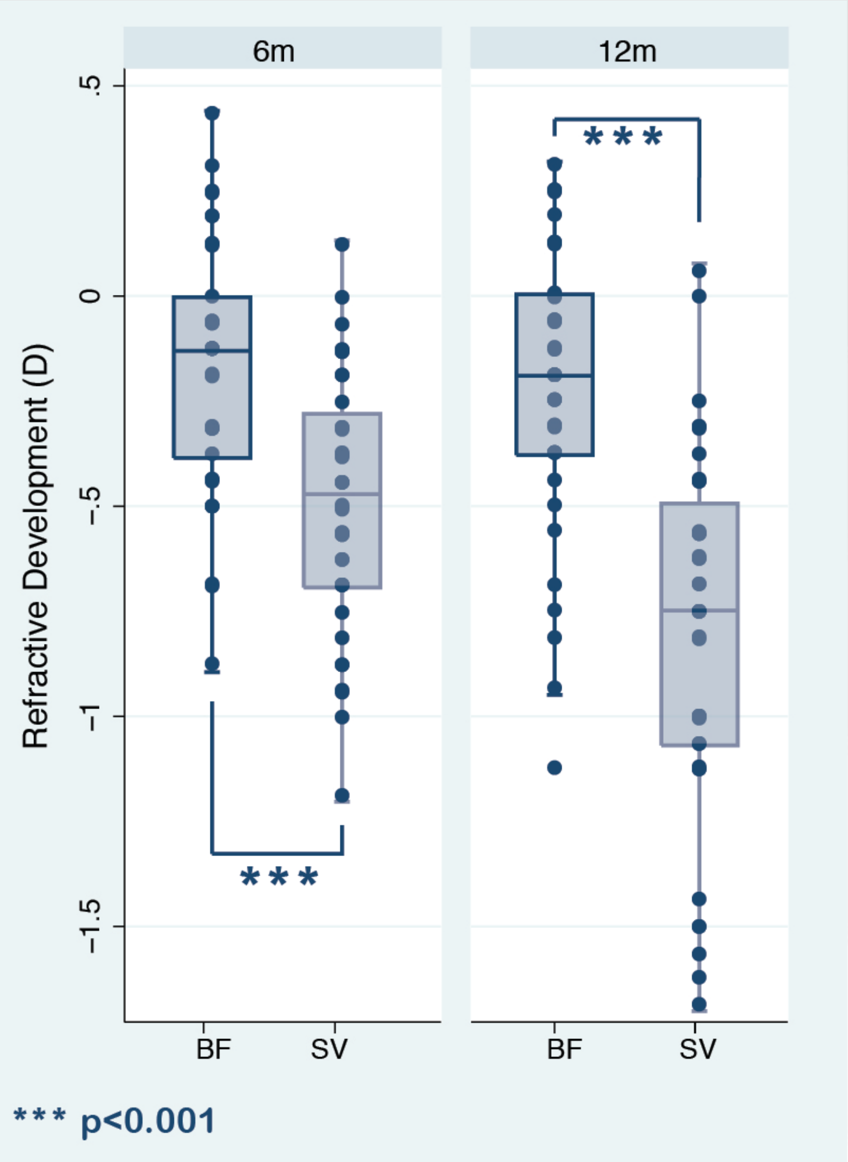




Results from one human study:

Myopia control with MF soft contact lenses

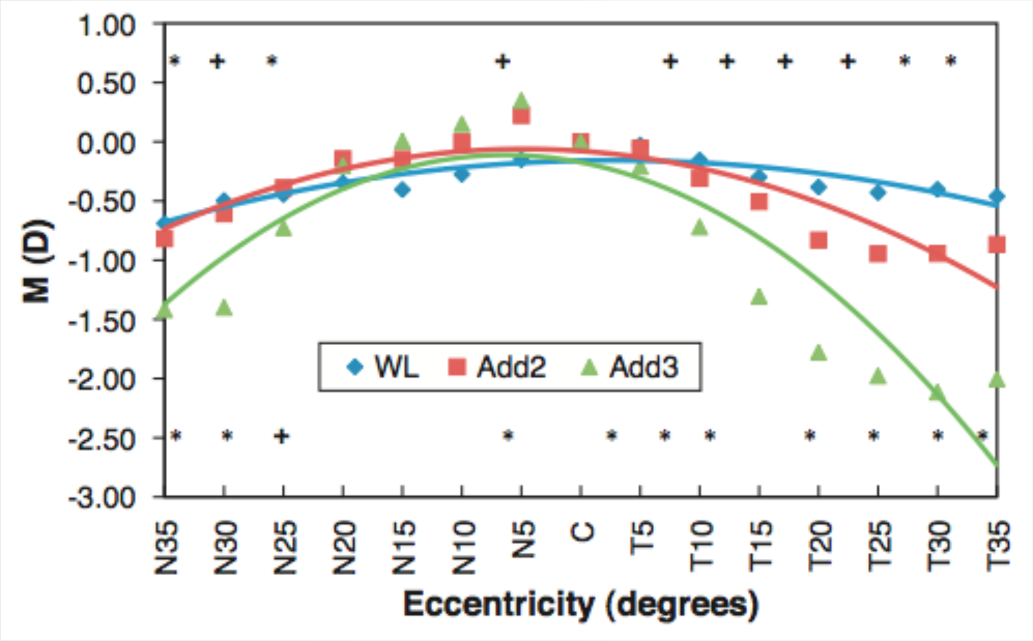




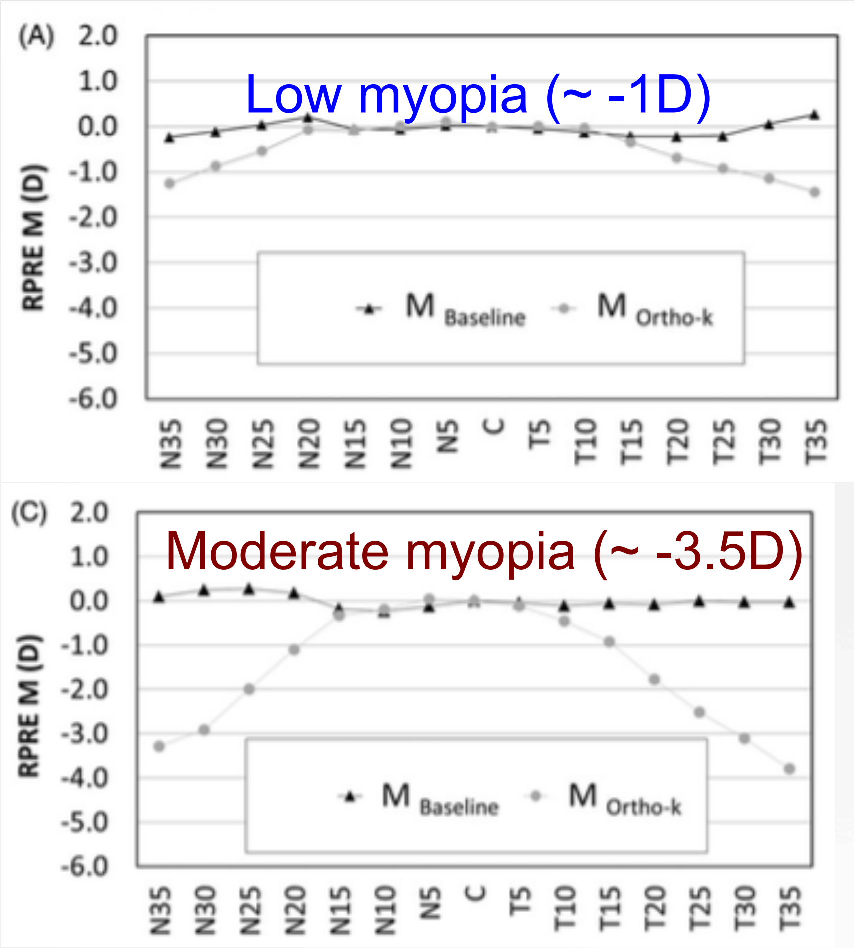
(Aller, Lui & Wildsoet 2016)

MF Contact Optics & Ortho-K
impose relative peripheral myopia

Proclear MF soft CL vs. no lens



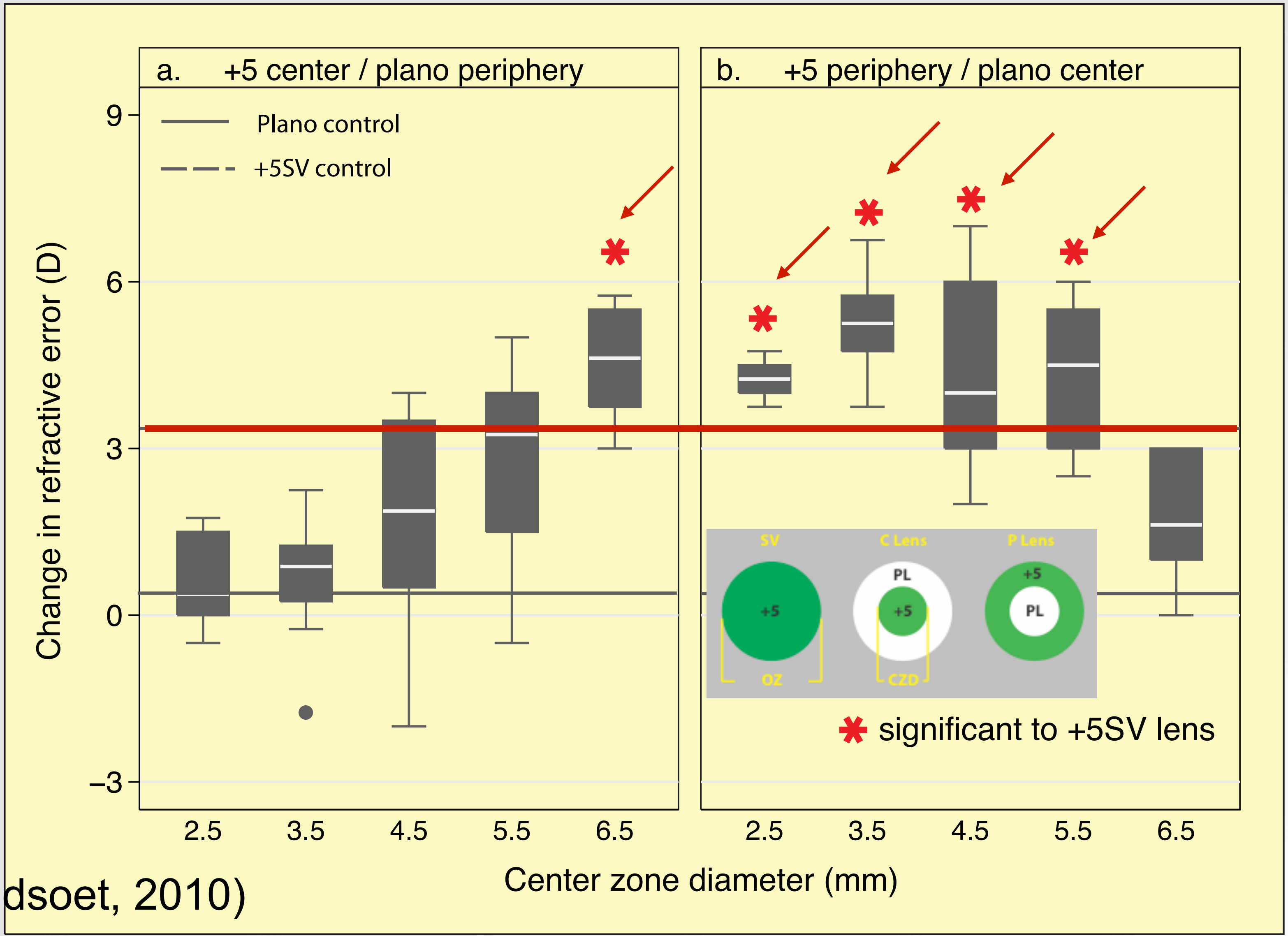
Ortho-K



(Lopes-Ferreira et al., 2013;
González-Méijome et al., 2016)

BUT with +ve MF lens designs in chicks

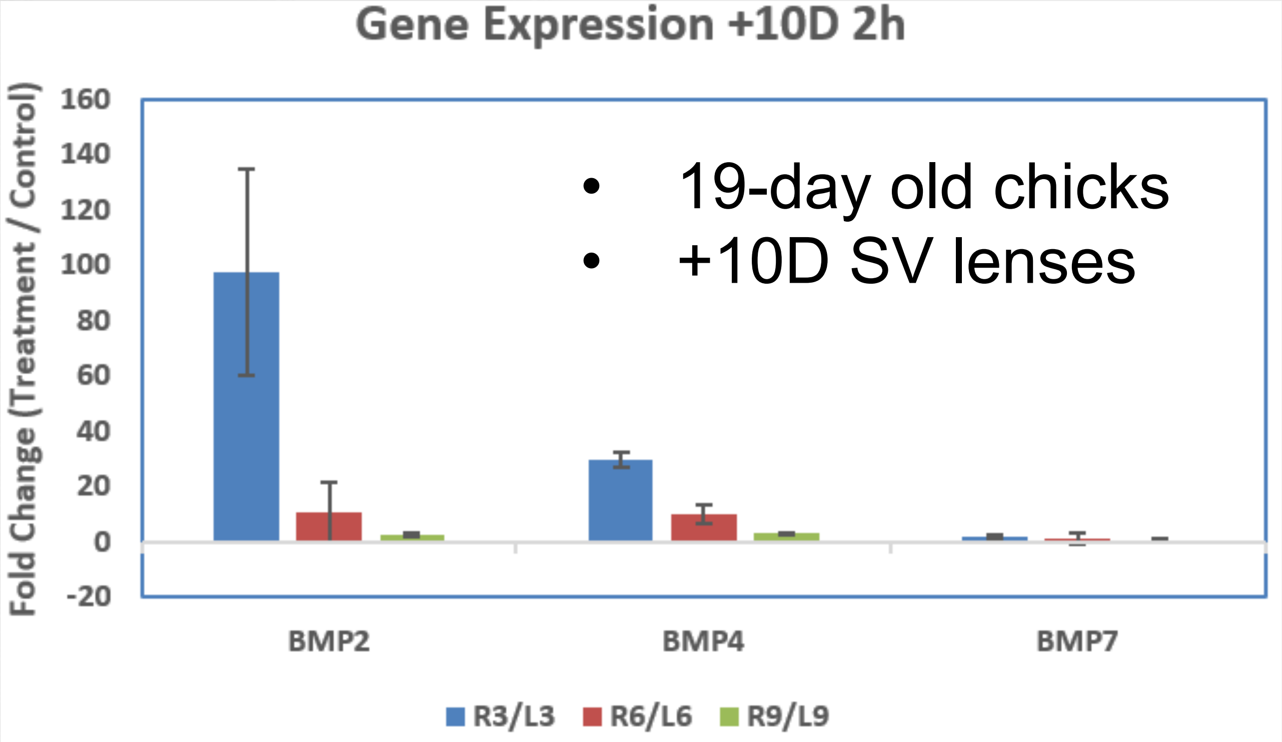
“Local” defocus outperforms full-field defocus!



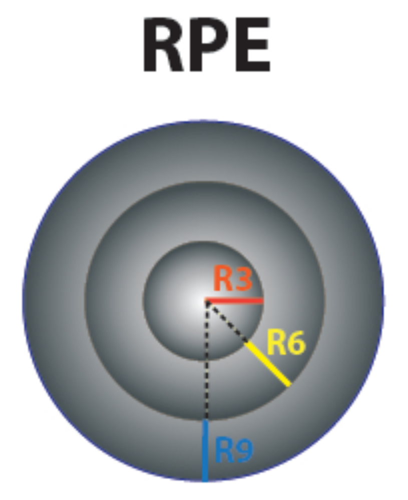
(Liu & Wildsoet, 2010)

YET central retina dominates BMP RPE gene expression & likely growth of vitreous chamber

at least for +ve lenses, when whole retina is exposed to similar defocus



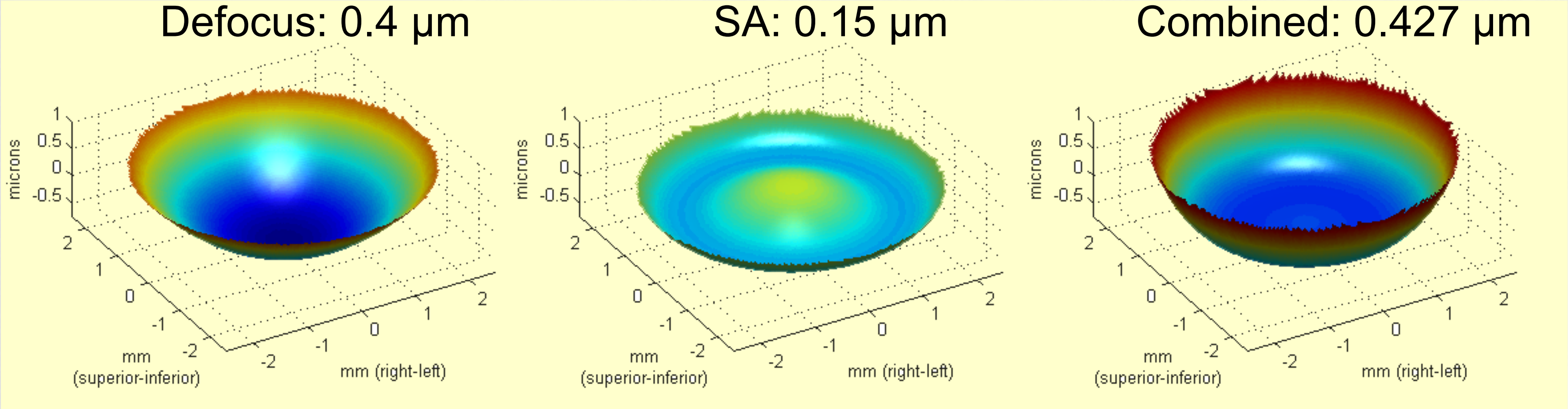
- 19-day old chicks
- +10D SV lenses



(Yan Zhang)

Altered spherical aberration (SA) as possible explanation for MF lens effect?

Interactions with ocular SA affect optimal plane of focus, even for on-axis images


Defocus: 0.4 μm

SA: 0.15 μm

Combined: 0.427 μm

Combinations of defocus & SA, in the correct proportions, decrease the wavefront error over the pupil center

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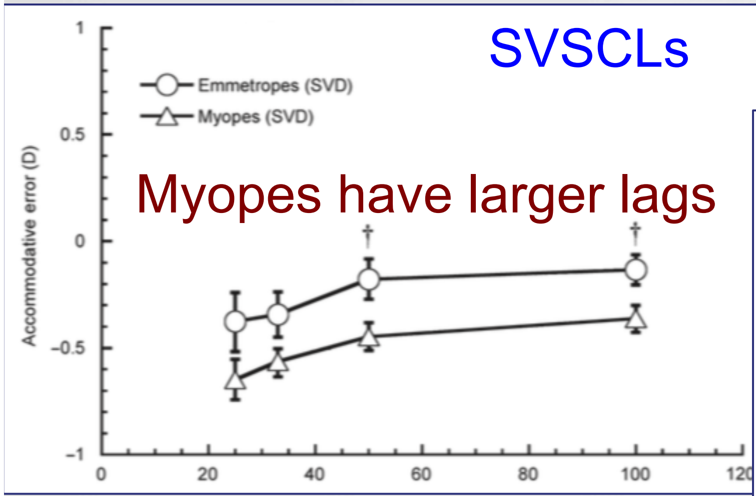
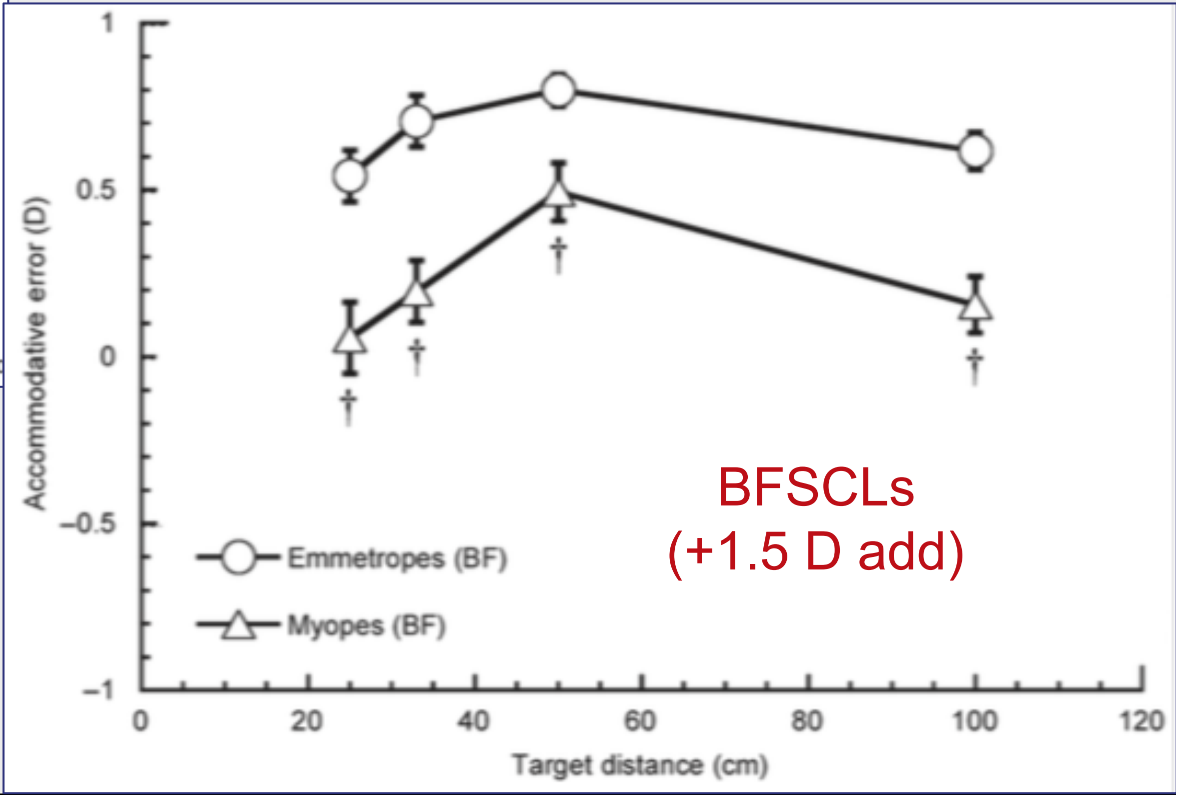
Accommodation lags – a forgotten part of the myopia story

Do MFSCLs correct them?



SVSCLs

Myopes have larger lags



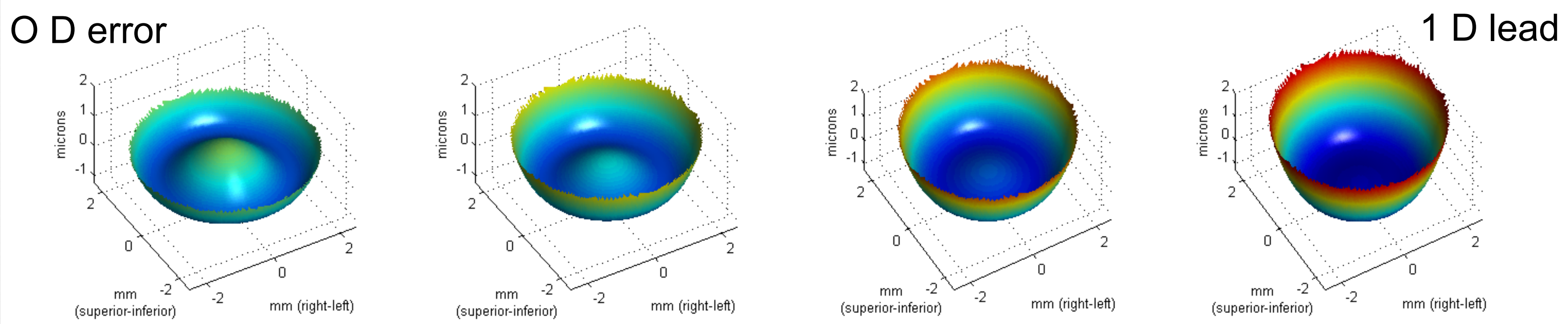
BFSCLs
(+1.5 D add)

(Tarrant et al, 2008)

Other influences on ocular SA (& optimal plane of focus)

Ocular SA becomes more -ve with <u>accommodation</u>, more so in myopes; distance-center BFSCLs add neutralizing +ve SA

SA influence increases with <u>pupil size</u>



(Tarrant et al)

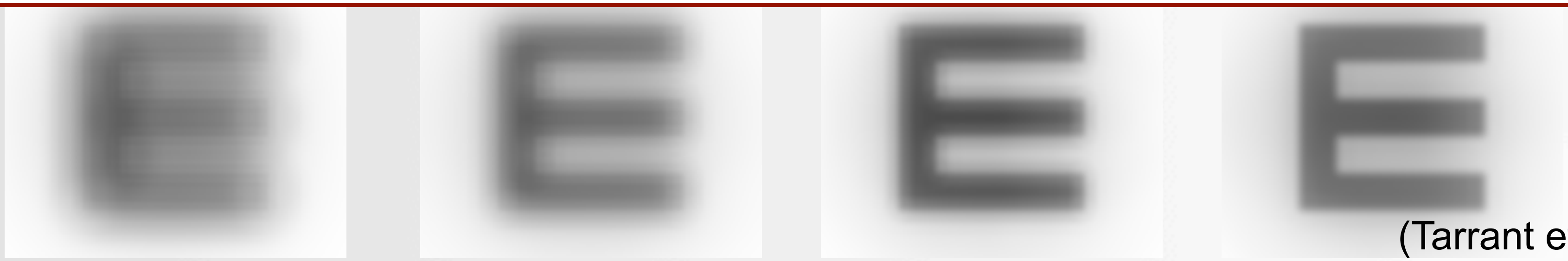
Other influences on ocular SA (& optimal plane of focus)

Ocular SA becomes more -ve with accommodation, more so in myopes; distance-center BFSCLs add neutralizing +ve SA

Topical atropine, even in low concentration, increases pupil size & reduces accommodation

(although some tolerance develops over time)

Implications for myopia control effects?

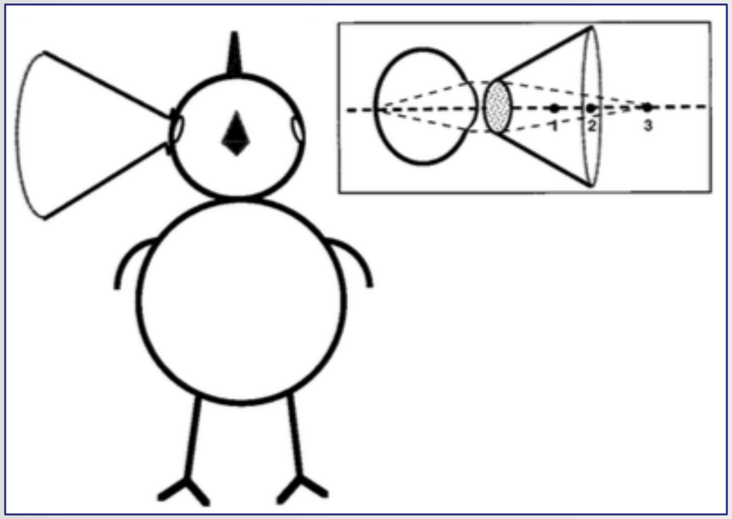


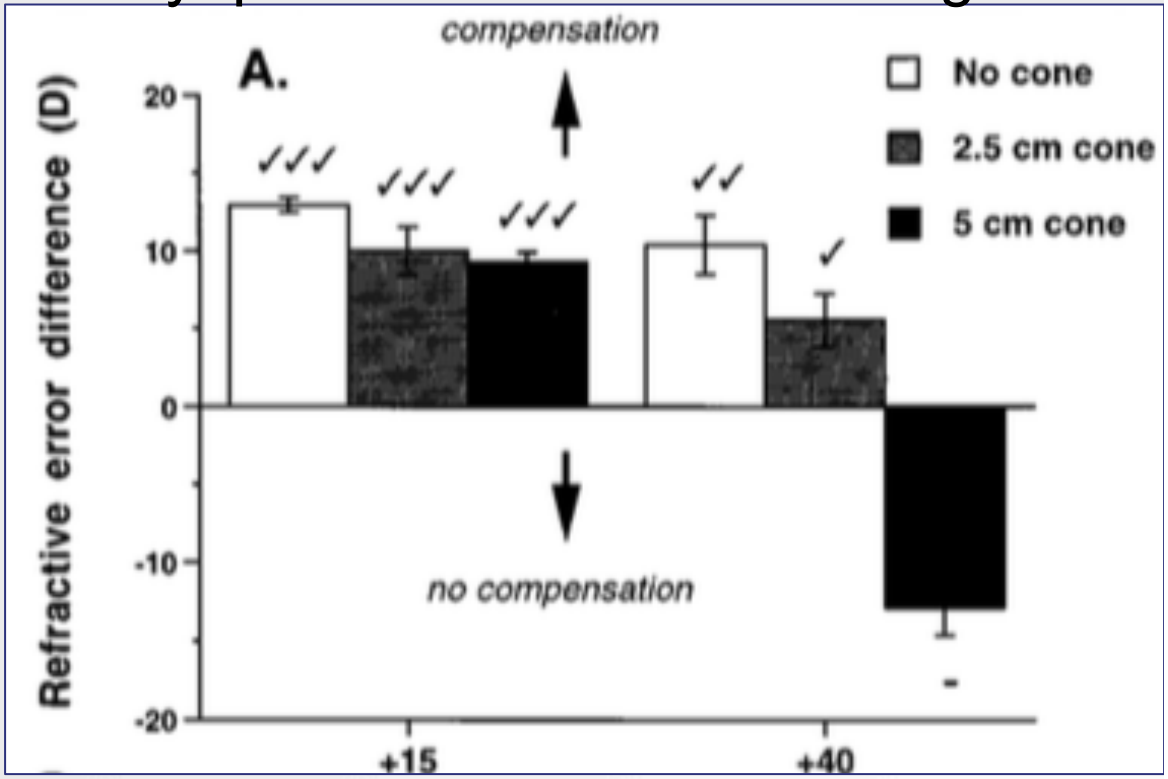
(Tarrant et al)

Decoding of sign of optical defocus critical to optical treatment effects –

Is there a limit & what are the cues?

Limit is species-dependent;
myopia is default direction of growth





Chicks out-perform everyone else!

(Nevin et al., 1998)

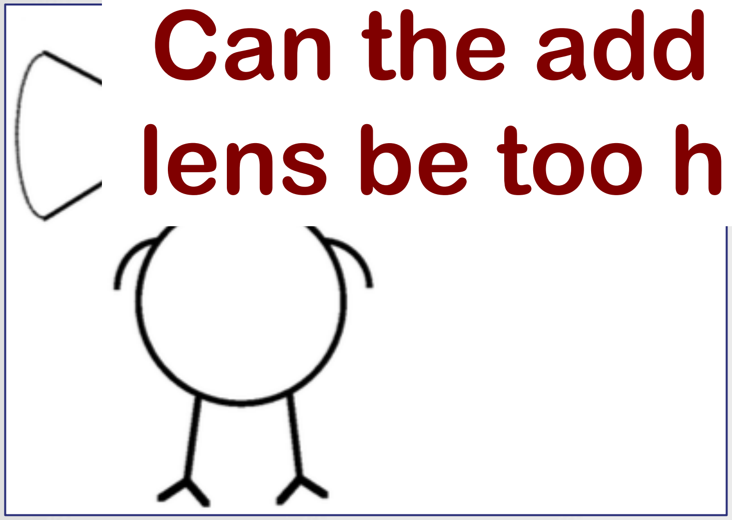
Decoding of sign of optical defocus critical to optical treatment effects –

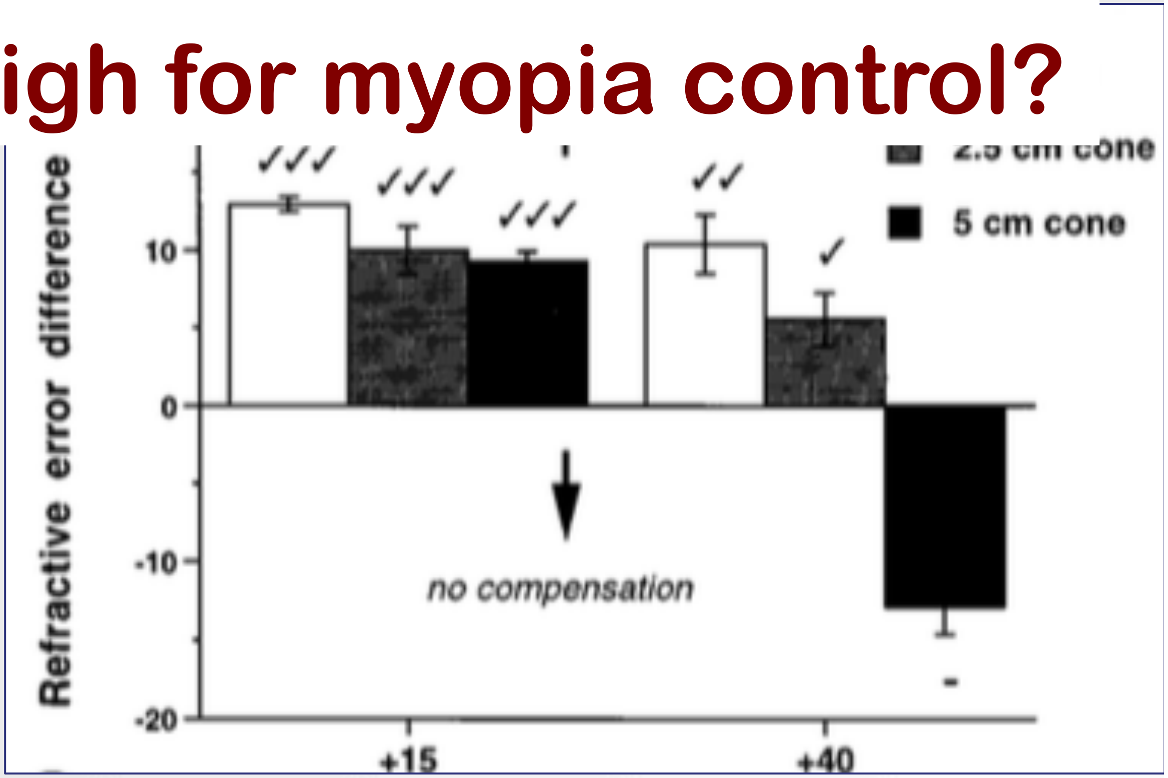
Is there a limit & but what are the queues?

Limit is species dependent:

h

Can the add in a multifocal contact lens be too high for myopia control?



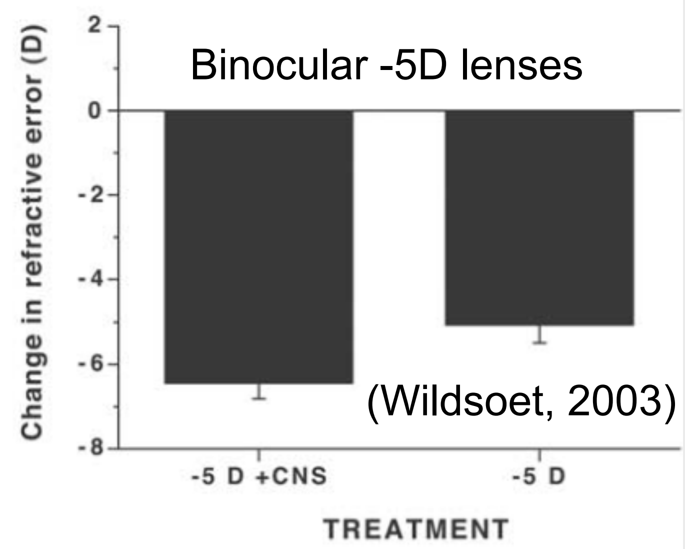


Chicks out-perform everyone else!

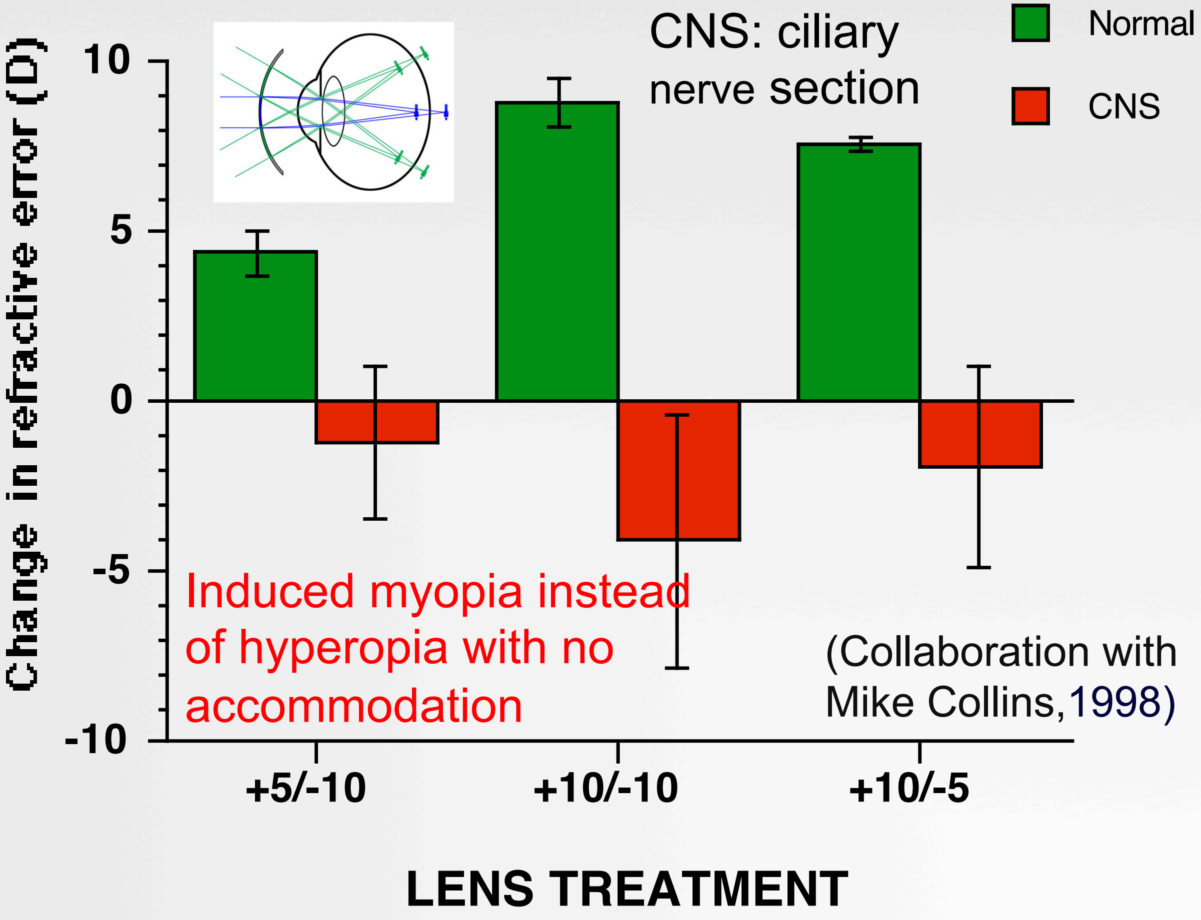
(Nevin et al., 1998)

Accommodation activity is integrated into growth signals & helps to decode complex defocus

Lens-induced myopia either when an eye is forced to accommodate continuously or has no accommodation



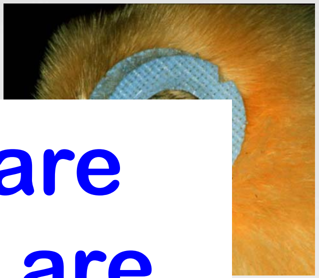
(Wildsoet, 2003)



Induced myopia instead of hyperopia with no accommodation

(Collaboration with Mike Collins,1998)

Accommodation activity is integrated into growth signals & helps to



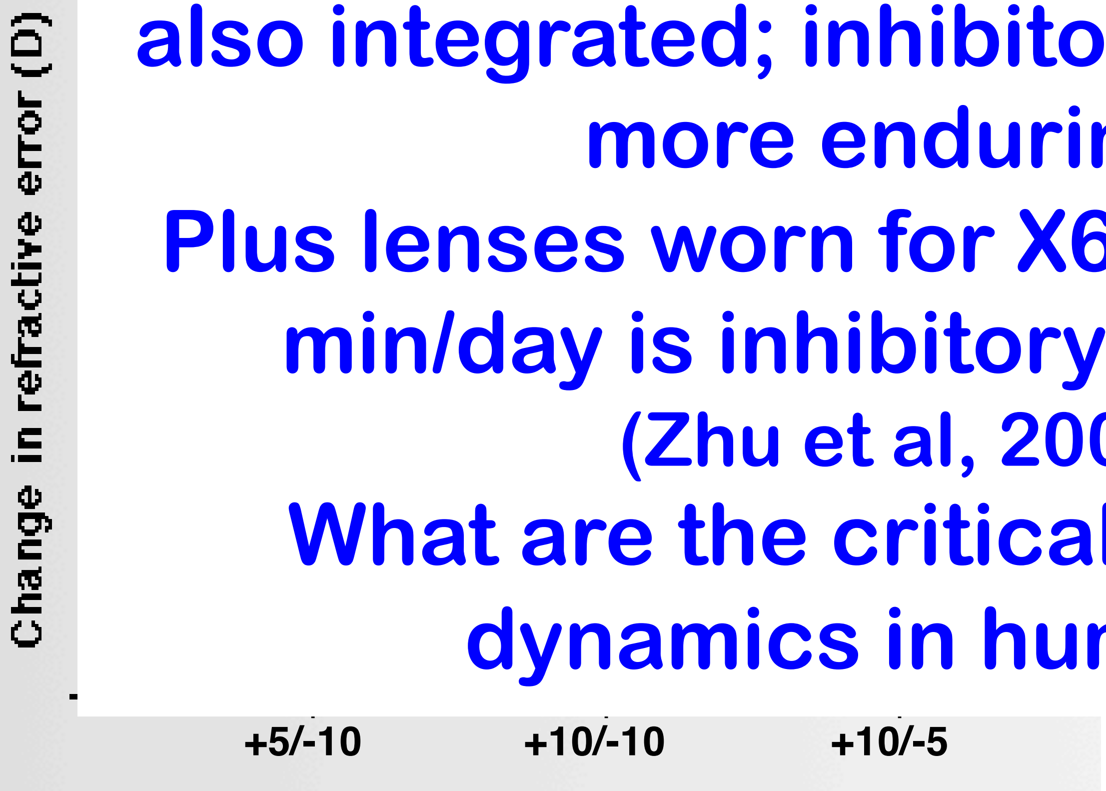
Defocus-derived growth signals are also integrated; inhibitory signals are more enduring.

Plus lenses worn for X6 periods of 2 min/day is inhibitory in chicks!

(Zhu et al, 2003)

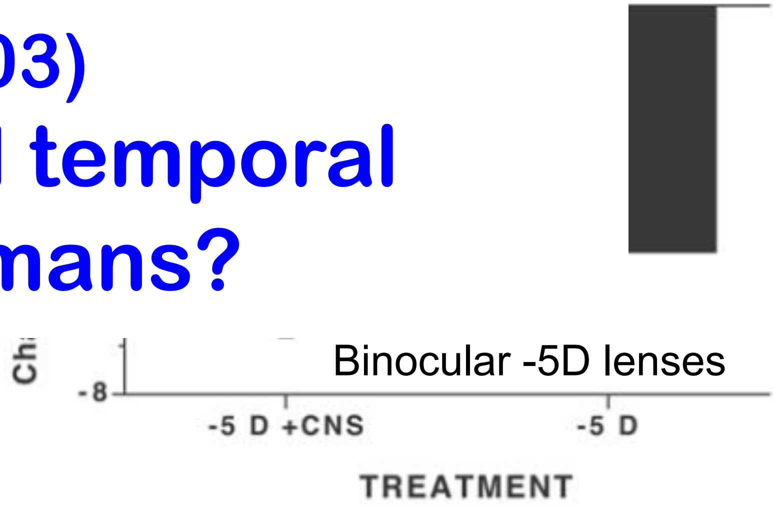
What are the critical temporal dynamics in humans?

even
ed to
ar



LENS TREATMENT

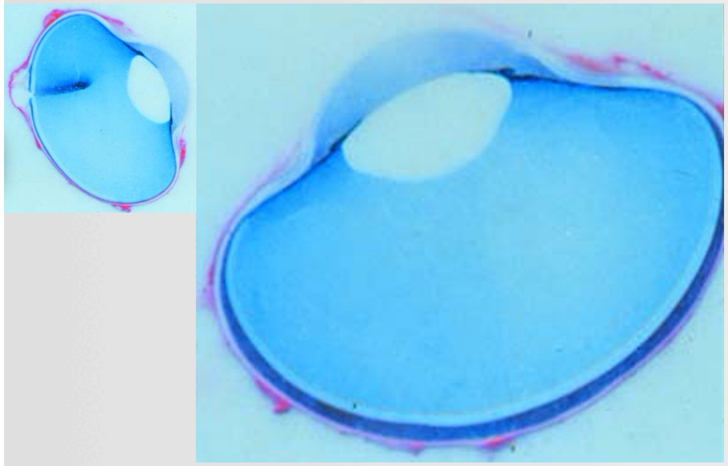
(Collaboration with Mike Collins,1998)



Binocular -5D lenses

The role of choroid in eye growth regulation & myopia control?

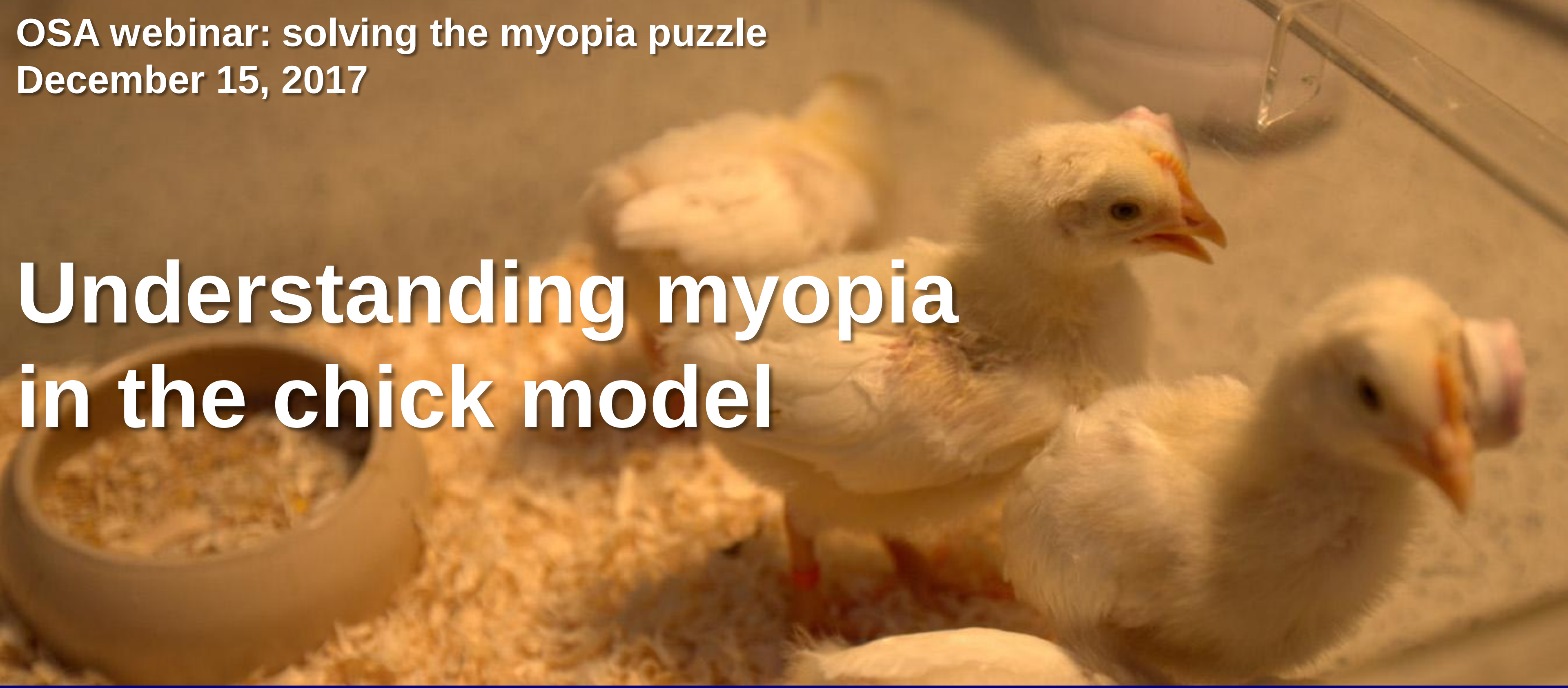
Beginning with the avian eye story, evidence of thickening in response to myopic defocus in animals & humans, & with some myopia control treatments; also differences related to myopia susceptibility



From Gordon L Walls (1942) on the choroid of bird eyes:…connective tissue cords and columns which often contain (or consist largely of) muscle cells..may be smooth or striated, and **their contraction would obviously thin the choroid temporarily and draw the retinal backward**."

(Van Alphen, 1986)

OSA webinar: solving the myopia puzzle
December 15, 2017



Understanding myopia in the chick model

UKT

Forschungsinstitut für Augenheilkunde

Sektion für
Neurobiologie des Auges

Frank Schaeffel

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http://www.eye-tuebingen.de/schaeffellab/

UNIVERSITÄTS
KLINIKUM
TÜBINGEN

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

a poor image on the retina makes the eye long

- first discovered in rhesus monkeys in 1977

TORSTEN N. WIESEL
ELIO RAVIOLA
Departments of Neurobiology and Anatomy,
Harvard Medical School,
Boston, Massachusetts 02115

Nature Vol. 266 3 March 1977

Fig. 1 Eyes of a rhesus monkey in which the lids on the right (*b*) were fused at the age of 2 weeks and opened 18 months later (experiment 5 in Table 1). Suture threads mark the insertions of the extrinsic ocular muscles. The left eye (*a*) was normal.

Myopia and eye enlargement after neonatal lid fusion in monkeys

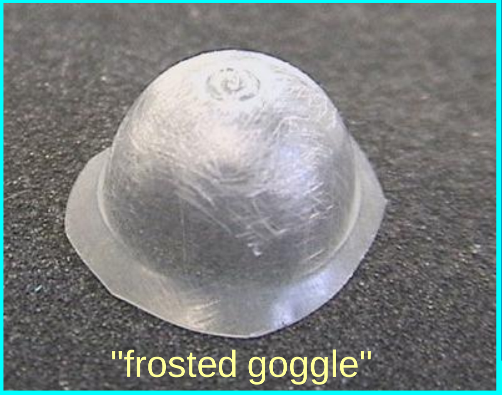
THE aetiology of myopia has been studied mainly by investigating the distribution of refractive errors in human populations[1]. No clear conclusion has emerged, however, so the prevailing clinical attitude is that myopia can neither be prevented nor cured, but only corrected with appropriate

of a 1% solution of homatropine and the refraction of both eyes determined by using a streak retinoscope and hand-held trial case lenses. The corneal curvature was measured with a keratometer and the fundus was examined. At various times after lid opening, animals were refracted again, used for electrophysiological studies on the visual pathways and finally perfused through the heart with 10%

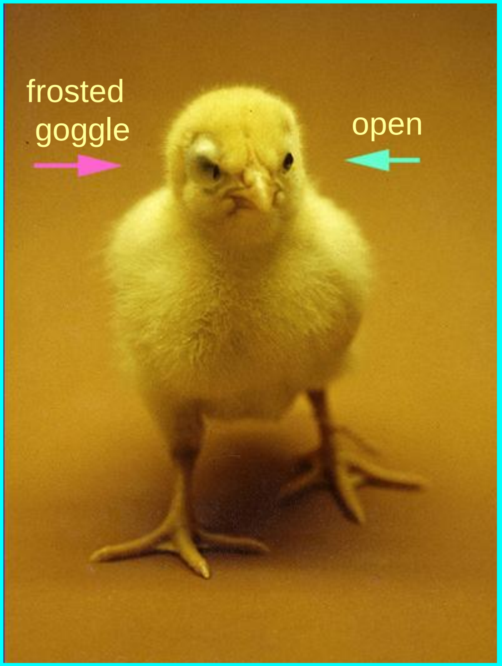
a poor image on the retina generates high amounts of myopia in chickens
- eyes up to 2 mm longer after 10 days and more than 20 D myopic
- independently on both sides

(first shown by Josh Wallman and colleagues, Science 1978)

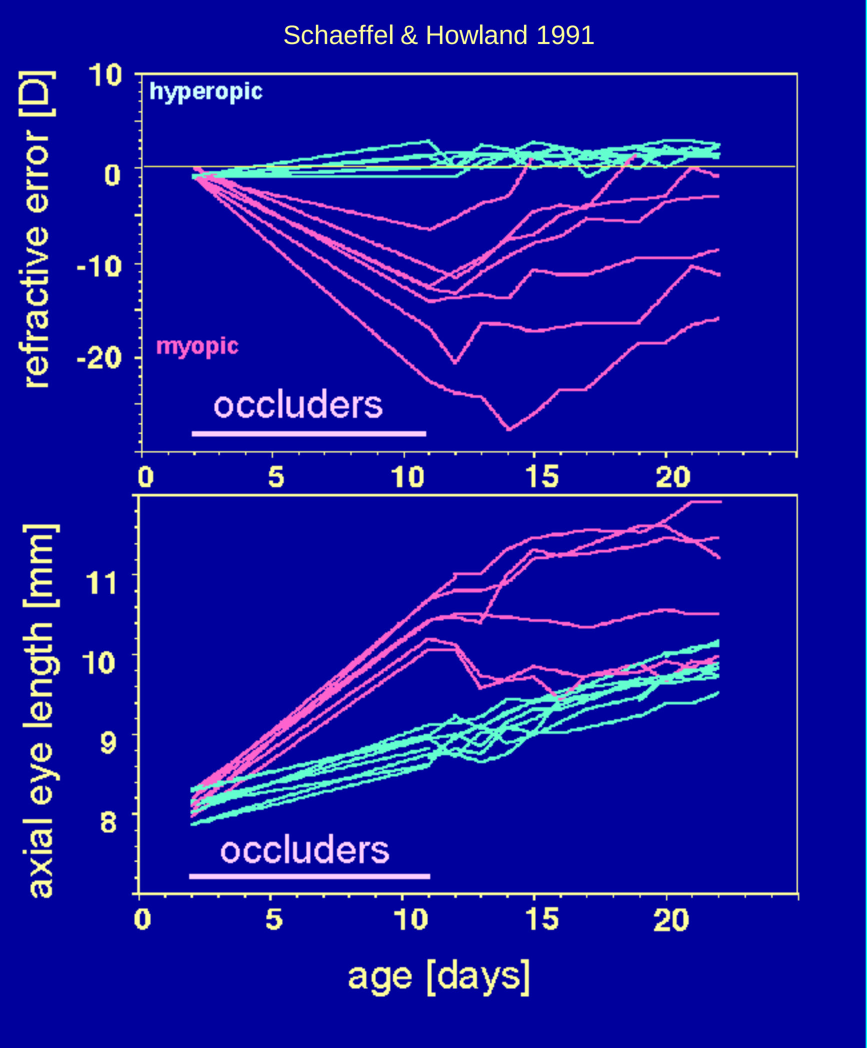
Josh Wallman, 1985



"frosted goggle"



data from Tübingen 1991



…the biological sense of

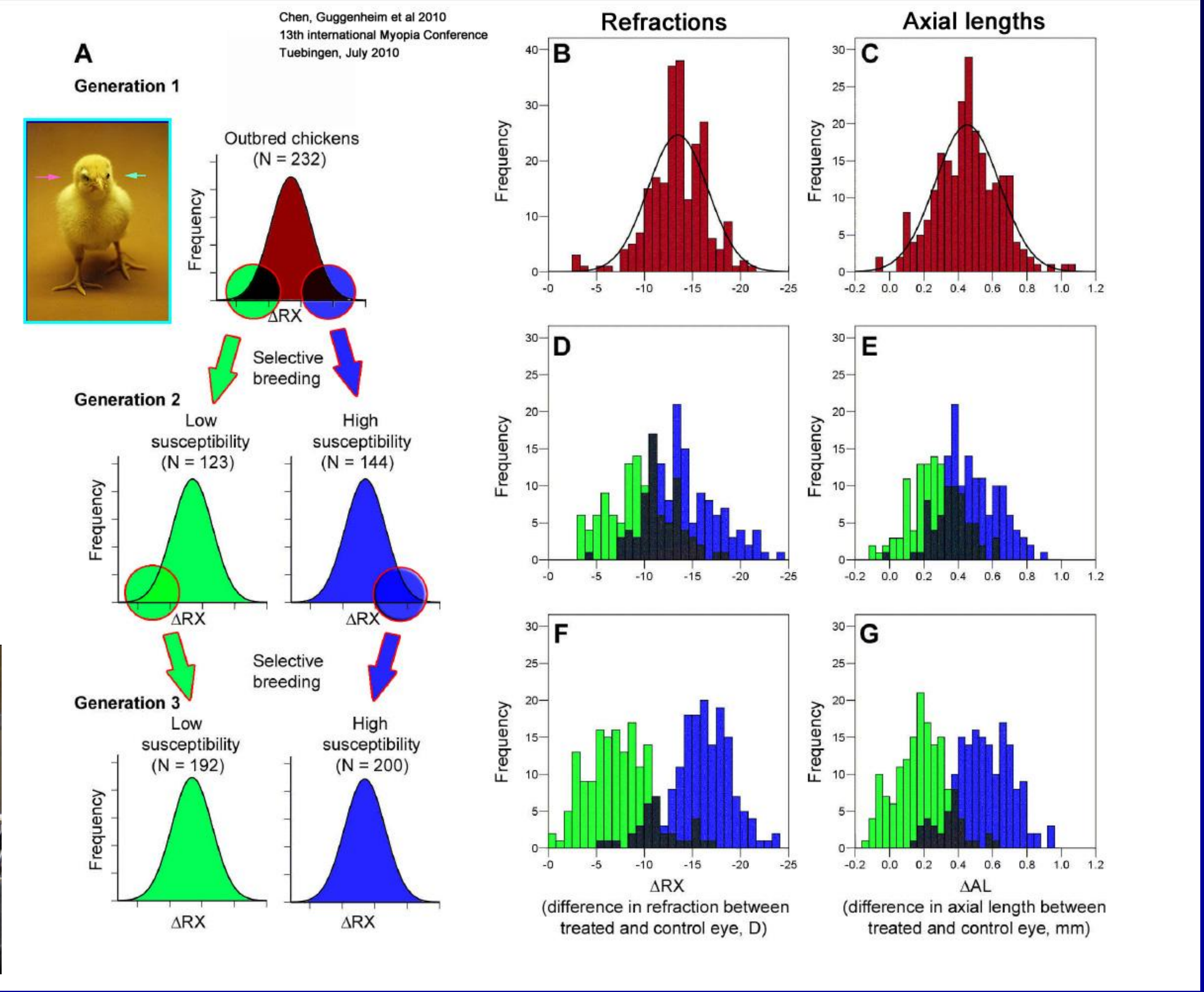
"deprivation myopia"

is not really clear

(but present in all models)

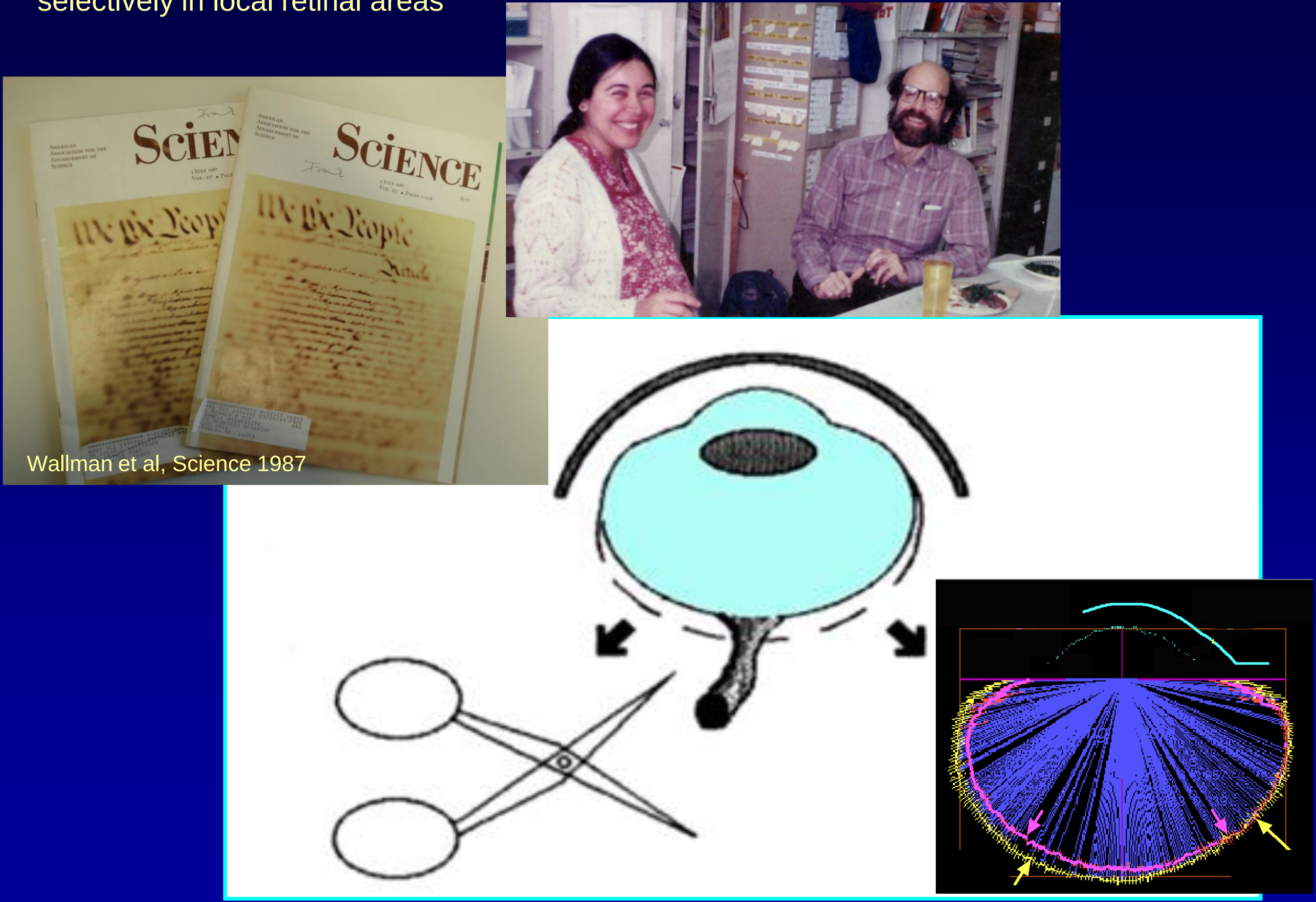
Variability in deprivation myopia is genetically determined:

results of selective breeding



Chen, Guggenheim et al 2010
13th international Myopia Conference
Tuebingen, July 2010

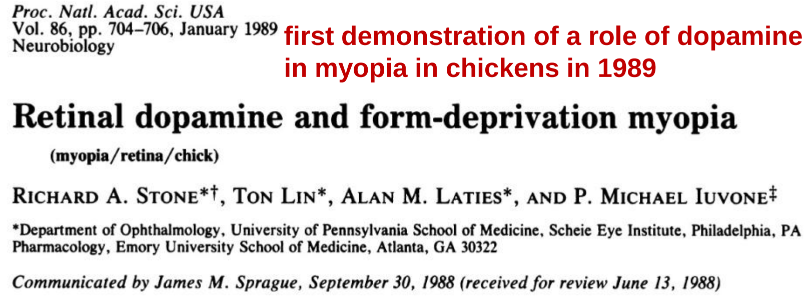
unexpected: an intact optic nerve is not necessary, and deprivation myopia can be induced selectively in local retinal areas



Wallman et al, Science 1987

dopamine release from the retina is controlled retinal image brightness and image contrast

(Sibylle Ohngemach, Marita Feldkaemper et al 1997)



Proc. Natl. Acad. Sci. USA
Vol. 86, pp. 704–706, January 1989
Neurobiology

Retinal dopamine and form-deprivation myopia

(myopia/retina/chick)

RICHARD A. STONE*†, TON LIN*, ALAN M. LATIES*, AND P. MICHAEL IUVONE‡

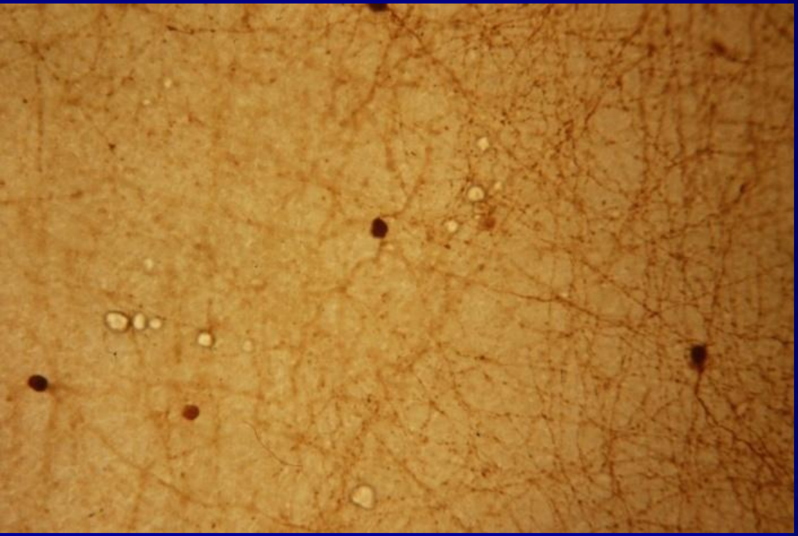
*Department of Ophthalmology, University of Pennsylvania School of Medicine, Scheie Eye Institute, Philadelphia, PA
Pharmacology, Emory University School of Medicine, Atlanta, GA 30322

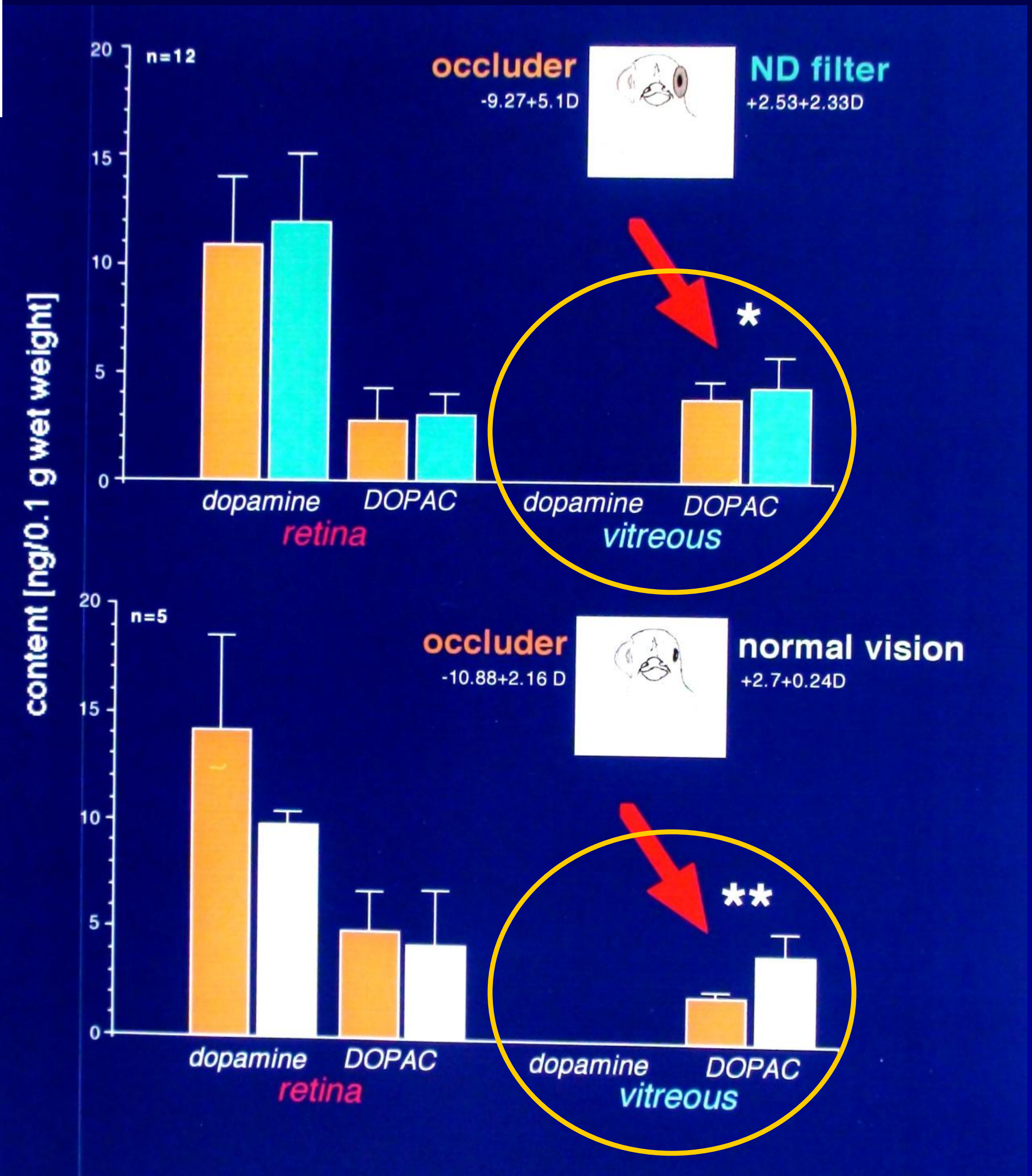
Communicated by James M. Sprague, September 30, 1988 (received for review June 13, 1988)

first demonstration of a role of dopamine in myopia in chickens in 1989

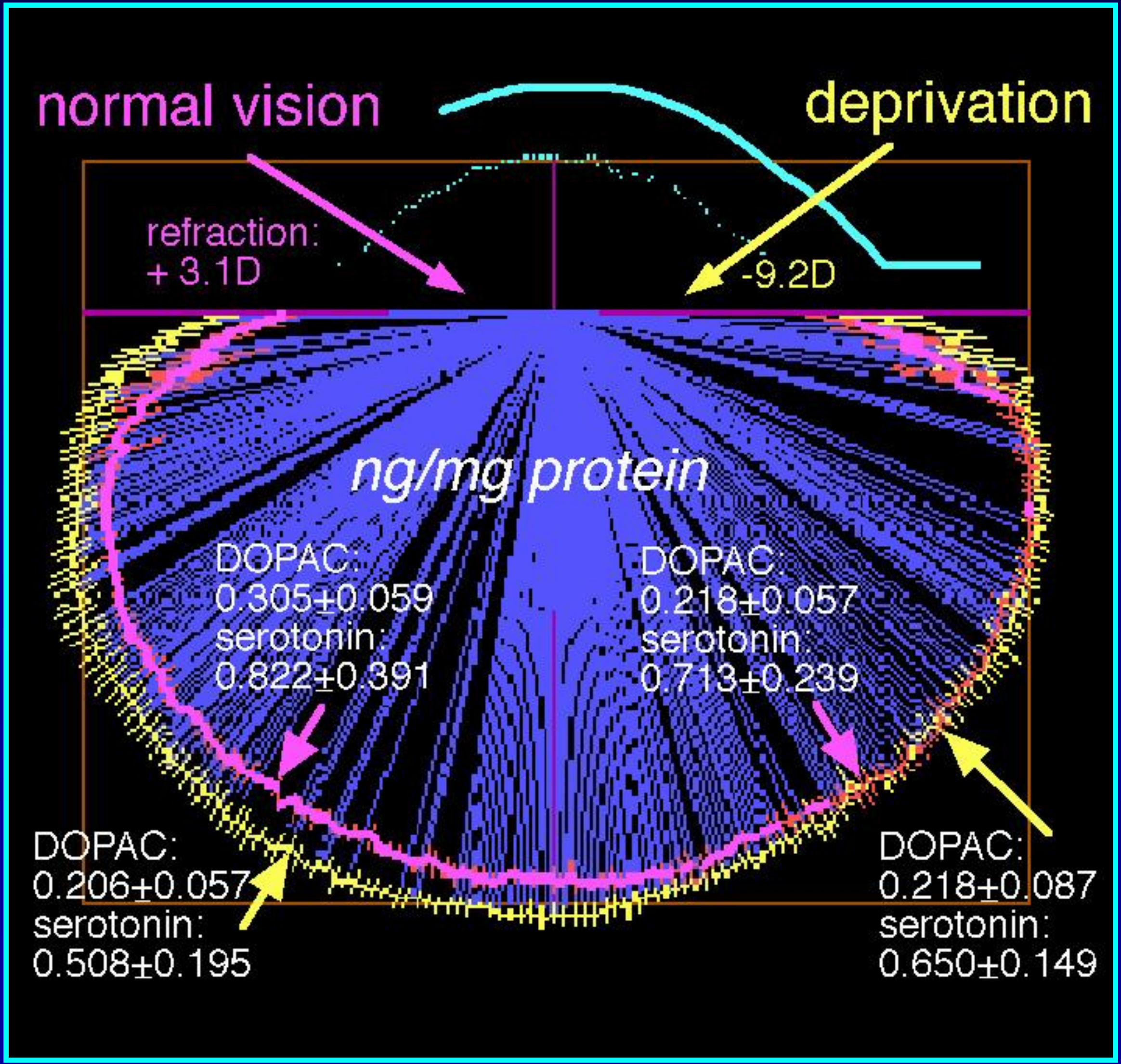
Richard Stone

Mike Iuvone





dopamine content and release from the retina are locally controlled



DOPAC:
0.305±0.059
serotonin:
0.822±0.391

DOPAC:
0.218±0.057
serotonin:
0.713±0.239

DOPAC:
0.206±0.057
serotonin:
0.508±0.195

DOPAC:
0.218±0.087
serotonin:
0.650±0.149

dopamine controls the coupling of both horizontal and amacrine cells in the retina in a light dependent way

<u>consequence</u>:
dopamine controls receptive field sizes and thereby the spatial filters in the retina

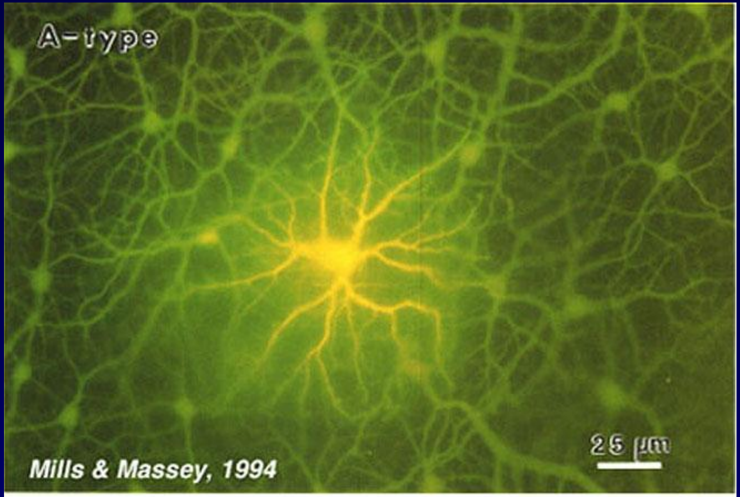
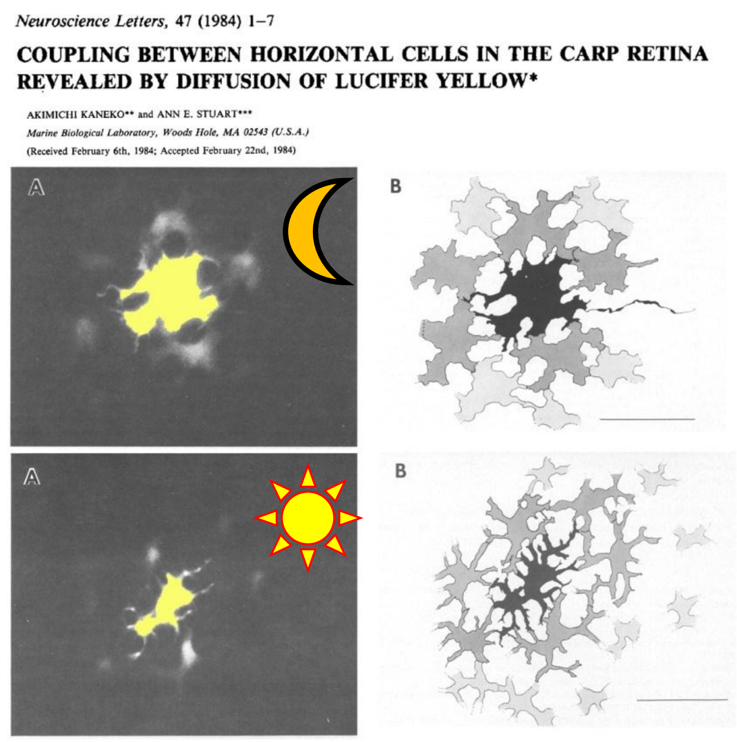


Fig. 13a. Rabbit horizontal cell network revealed by dye injections. The dye spreads via the gap junctions linking the A-Type horizontal cells to reveal the centrally injected cell and hundreds of neighbouring cells.



Neuroscience Letters, 47 (1984) 1–7

COUPLING BETWEEN HORIZONTAL CELLS IN THE CARP RETINA REVEALED BY DIFFUSION OF LUCIFER YELLOW*

AKIMICHI KANEKO** and ANN E. STUART***
Marine Biological Laboratory, Woods Hole, MA 02543 (U.S.A.)
(Received February 6th, 1984; Accepted February 22nd, 1984)

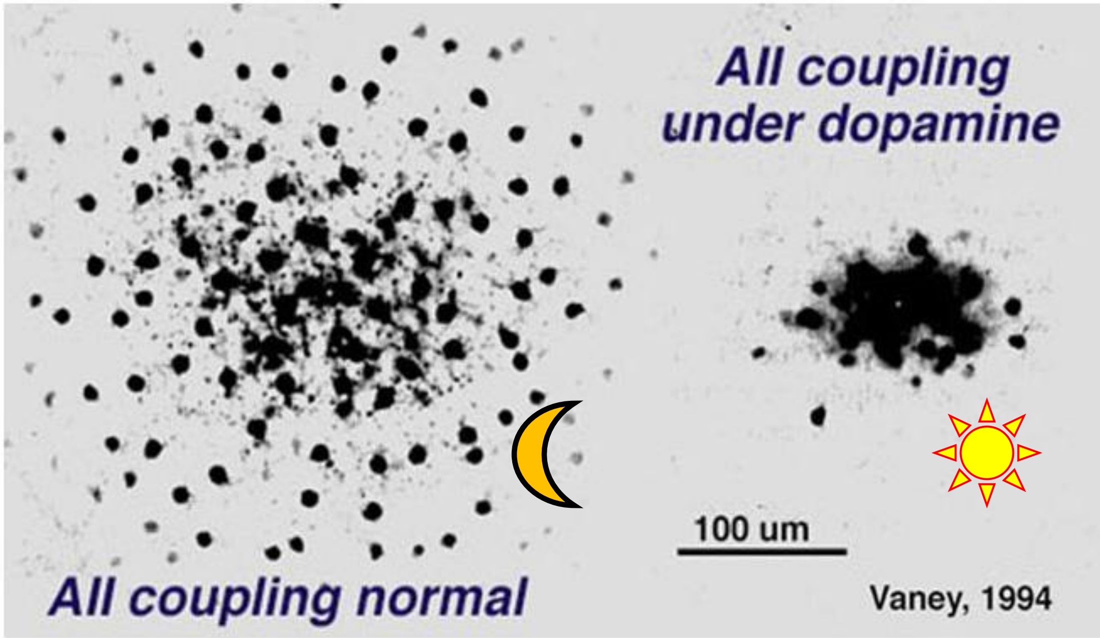
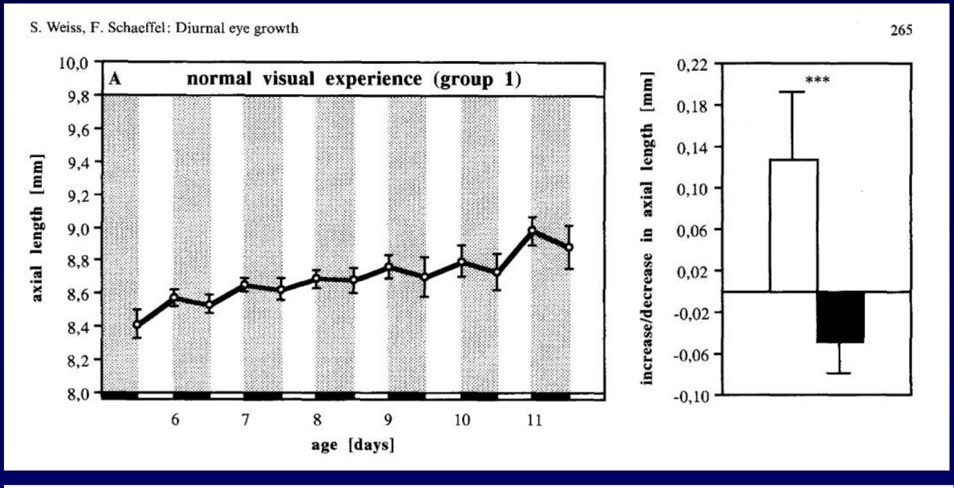


Fig. 34. Effects of dopamine on AII amacrine cell coupling. AII cells are normally coupled extensively, but under the influence of dopamine release, AII cells uncouple.

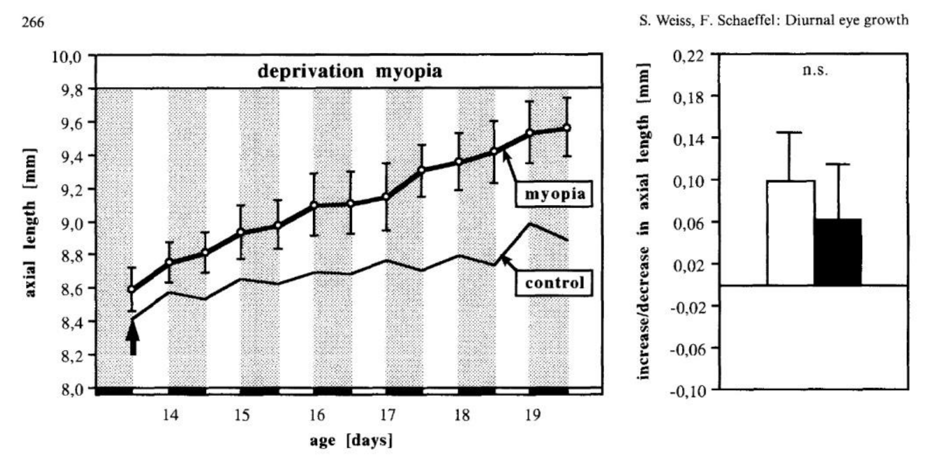
deprivation myopia and diurnal growth rhythms in the chick eye

normal vision



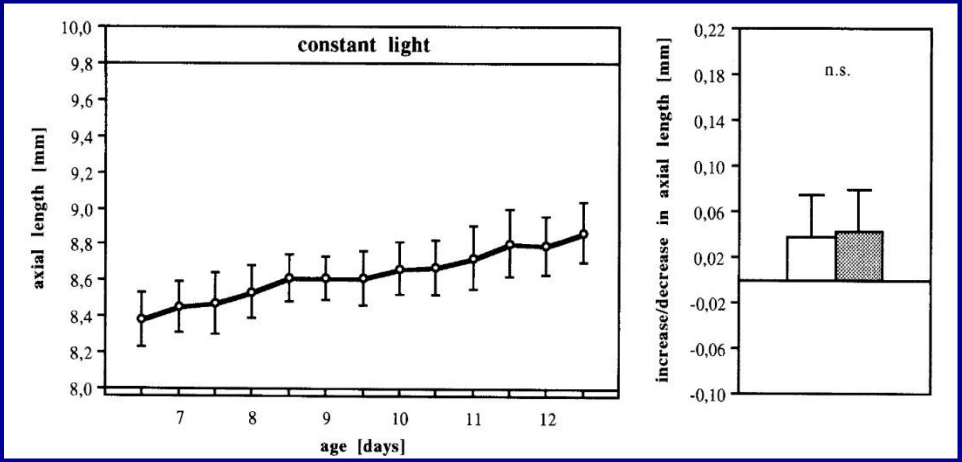
S. Weiss, F. Schaeffel: Diurnal eye growth 265

deprivation myopia

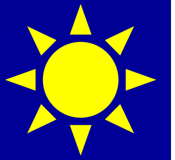


266 S. Weiss, F. Schaeffel: Diurnal eye growth

continuous light

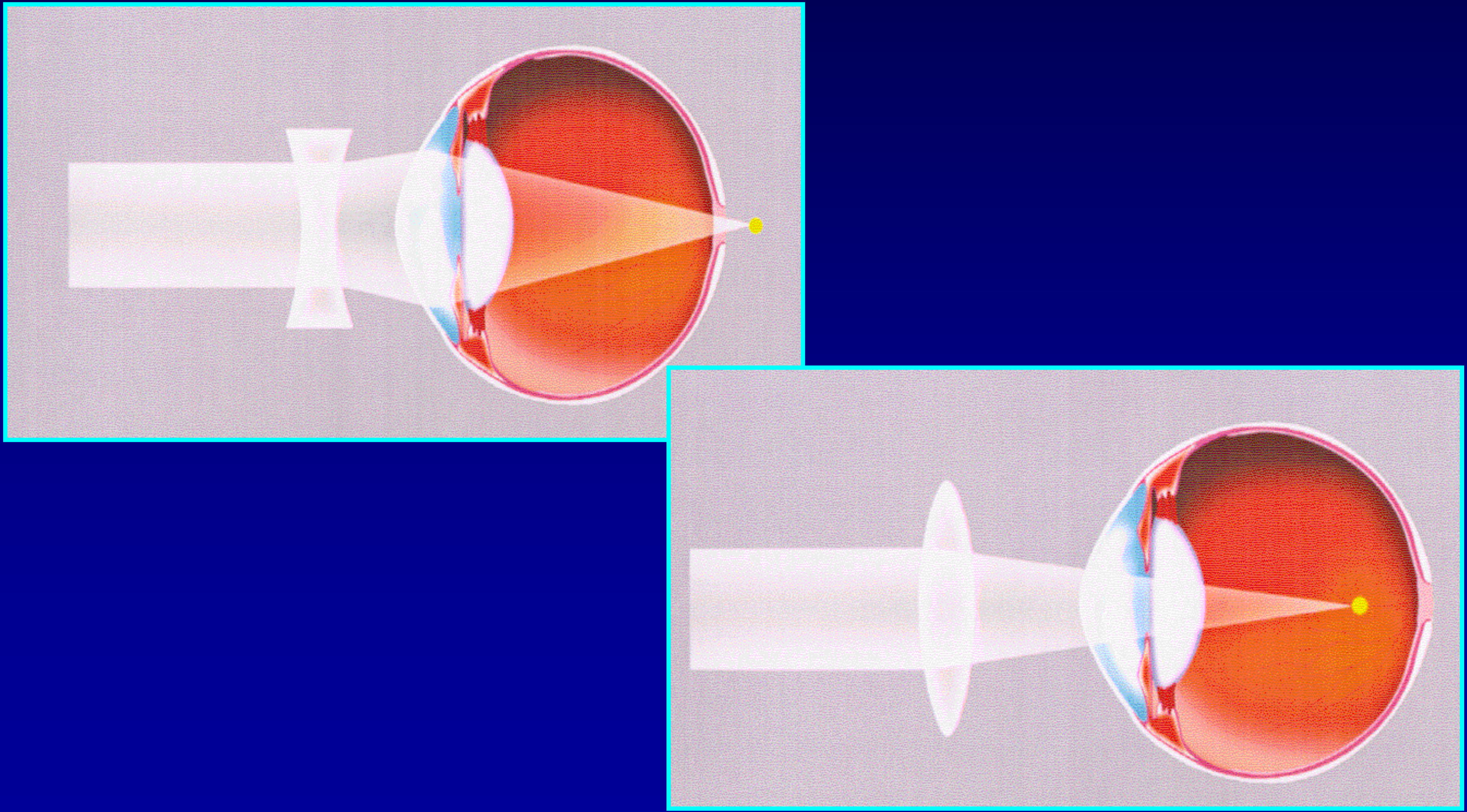


Stefan Weiss, 1999

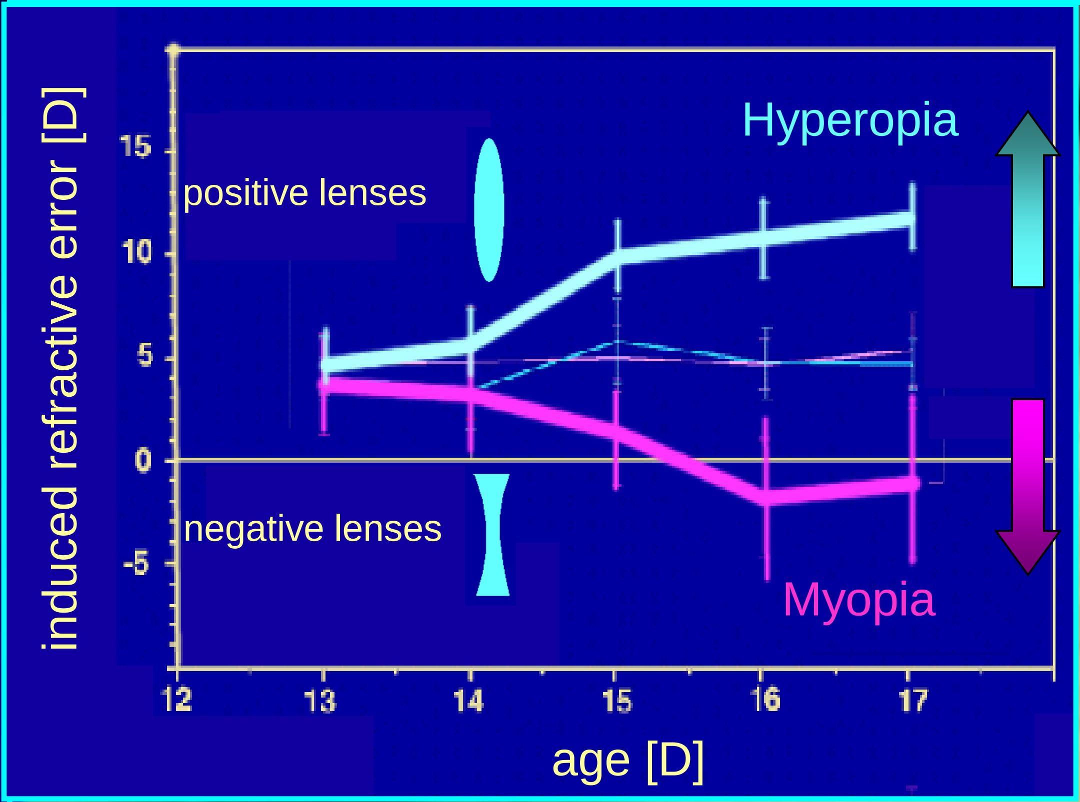


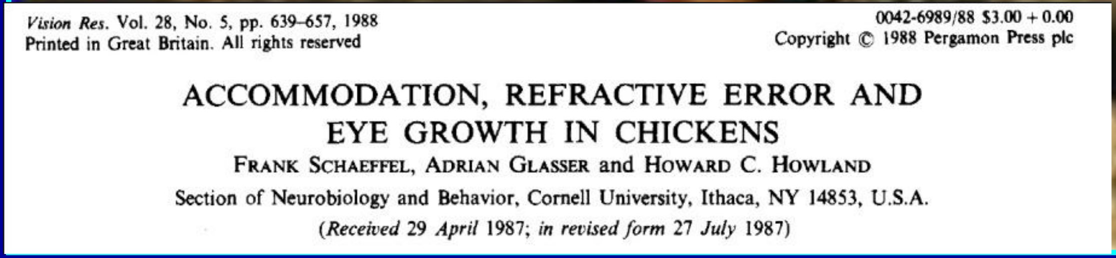
Does the mechanisms of deprivation myopia account for emmetropization?

Or does the retina detect the position of the focal plane to adjust axial eye growth rates?



(pictures by Earl Smith III, Houston)



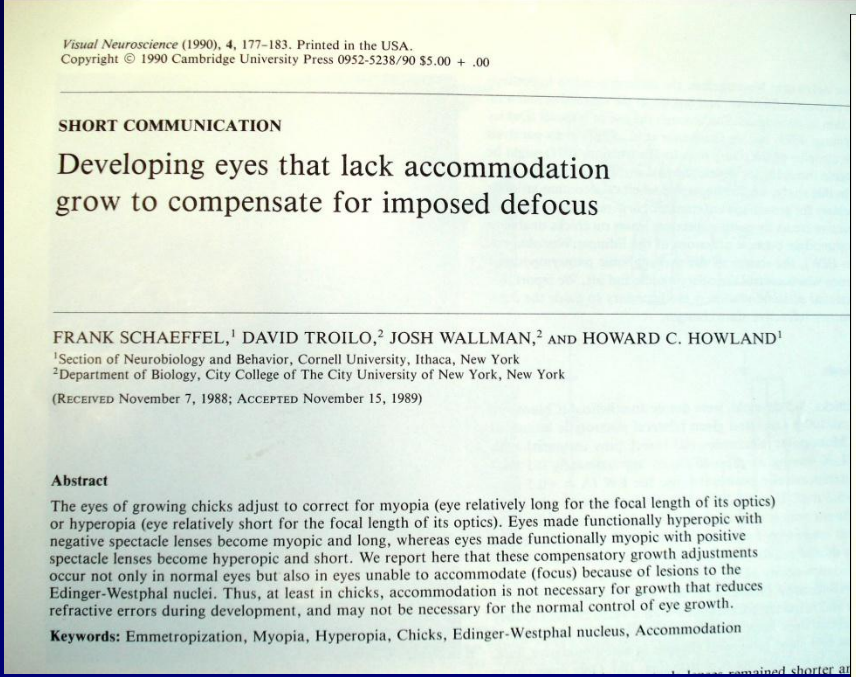

Vision Res. Vol. 28, No. 5, pp. 639–657, 1988
Printed in Great Britain. All rights reserved

0042-6989/88 $3.00 + 0.00

ACCOMMODATION, REFRACTIVE ERROR AND EYE GROWTH IN CHICKENS

FRANK SCHAEFFEL, ADRIAN GLASSER and HOWARD C. HOWLAND
Section of Neurobiology and Behavior, Cornell University, Ithaca, NY 14853, U.S.A.

(*Received* 29 *April* 1987; *in revised form* 27 *July* 1987)



Visual Neuroscience (1990), **4**, 177–183. Printed in the USA.
Copyright © 1990 Cambridge University Press 0952-5238/90 $5.00 + .00

SHORT COMMUNICATION

Developing eyes that lack accommodation grow to compensate for imposed defocus

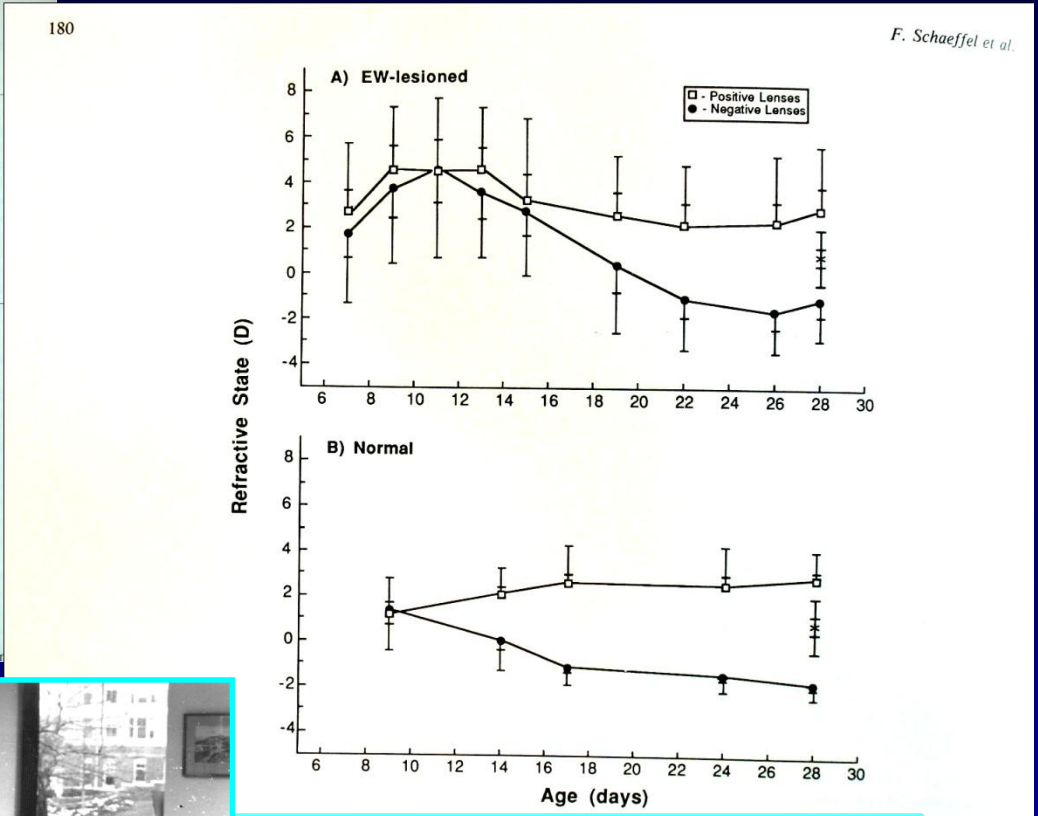
FRANK SCHAEFFEL,[1] DAVID TROILO,[2] JOSH WALLMAN,[2] AND HOWARD C. HOWLAND[1]
[1]Section of Neurobiology and Behavior, Cornell University, Ithaca, New York
[2]Department of Biology, City College of The City University of New York, New York

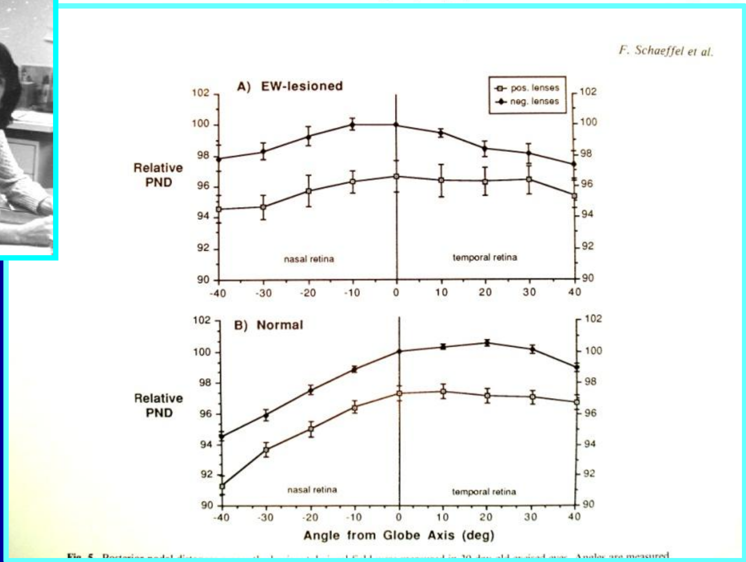
(RECEIVED November 7, 1988; ACCEPTED November 15, 1989)

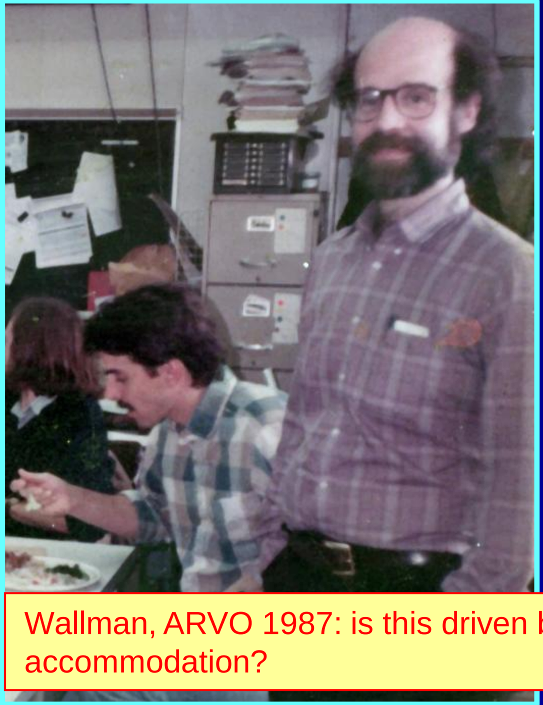
Abstract

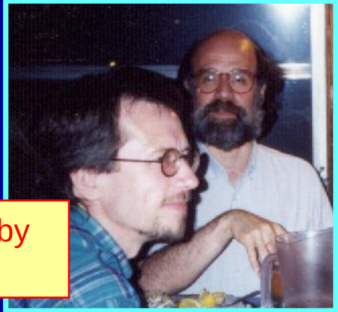
The eyes of growing chicks adjust to correct for myopia (eye relatively long for the focal length of its optics) or hyperopia (eye relatively short for the focal length of its optics). Eyes made functionally hyperopic with negative spectacle lenses become myopic and long, whereas eyes made functionally myopic with positive spectacle lenses become hyperopic and short. We report here that these compensatory growth adjustments occur not only in normal eyes but also in eyes unable to accommodate (focus) because of lesions to the Edinger-Westphal nuclei. Thus, at least in chicks, accommodation is not necessary for growth that reduces refractive errors during development, and may not be necessary for the normal control of eye growth.

Keywords: Emmetropization, Myopia, Hyperopia, Chicks, Edinger-Westphal nucleus, Accommodation





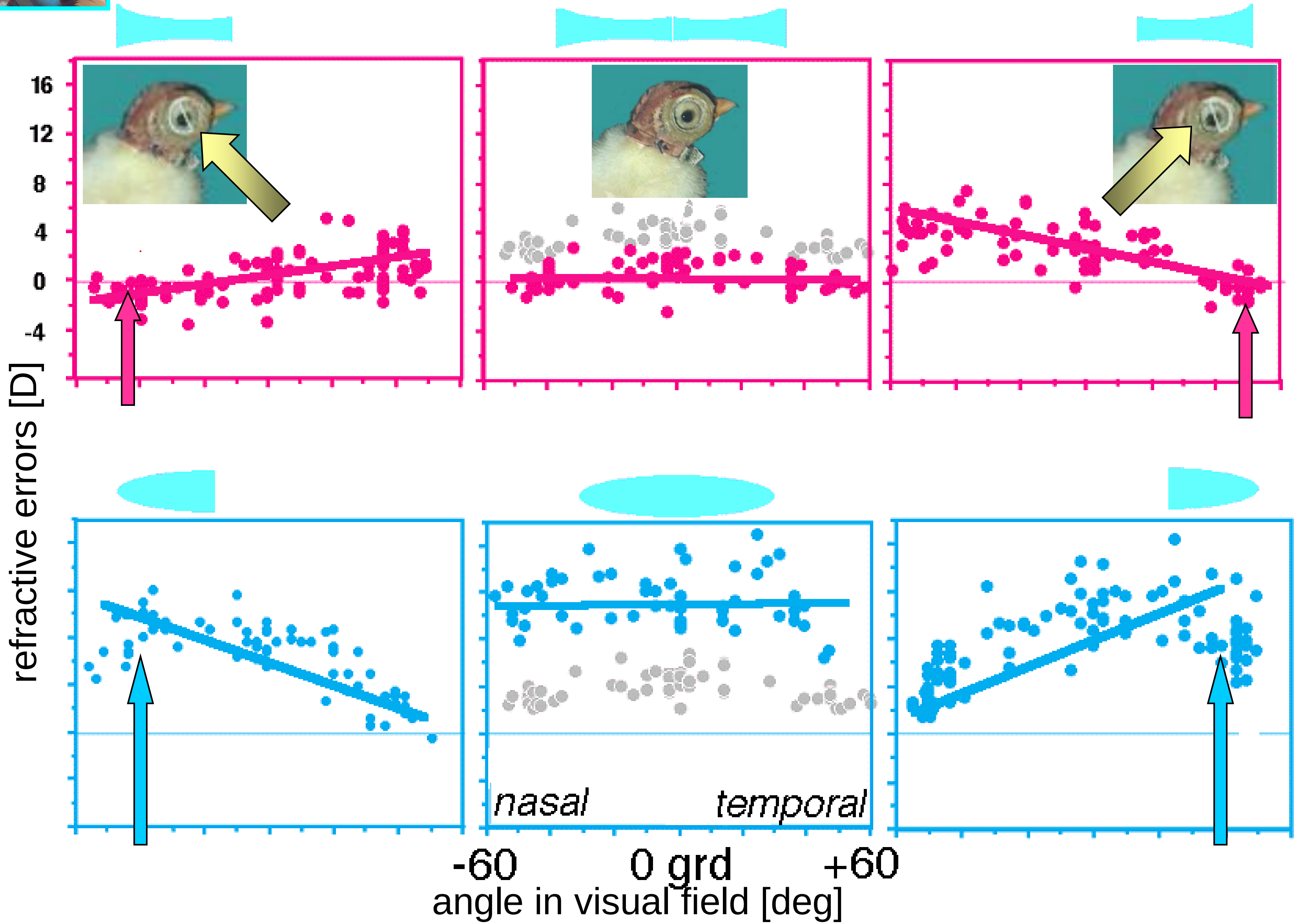




Wallman, ARVO 1987: is this driven by accommodation?

local changes in eye growth with "hemifield lenses" - even though accommodation is NOT local

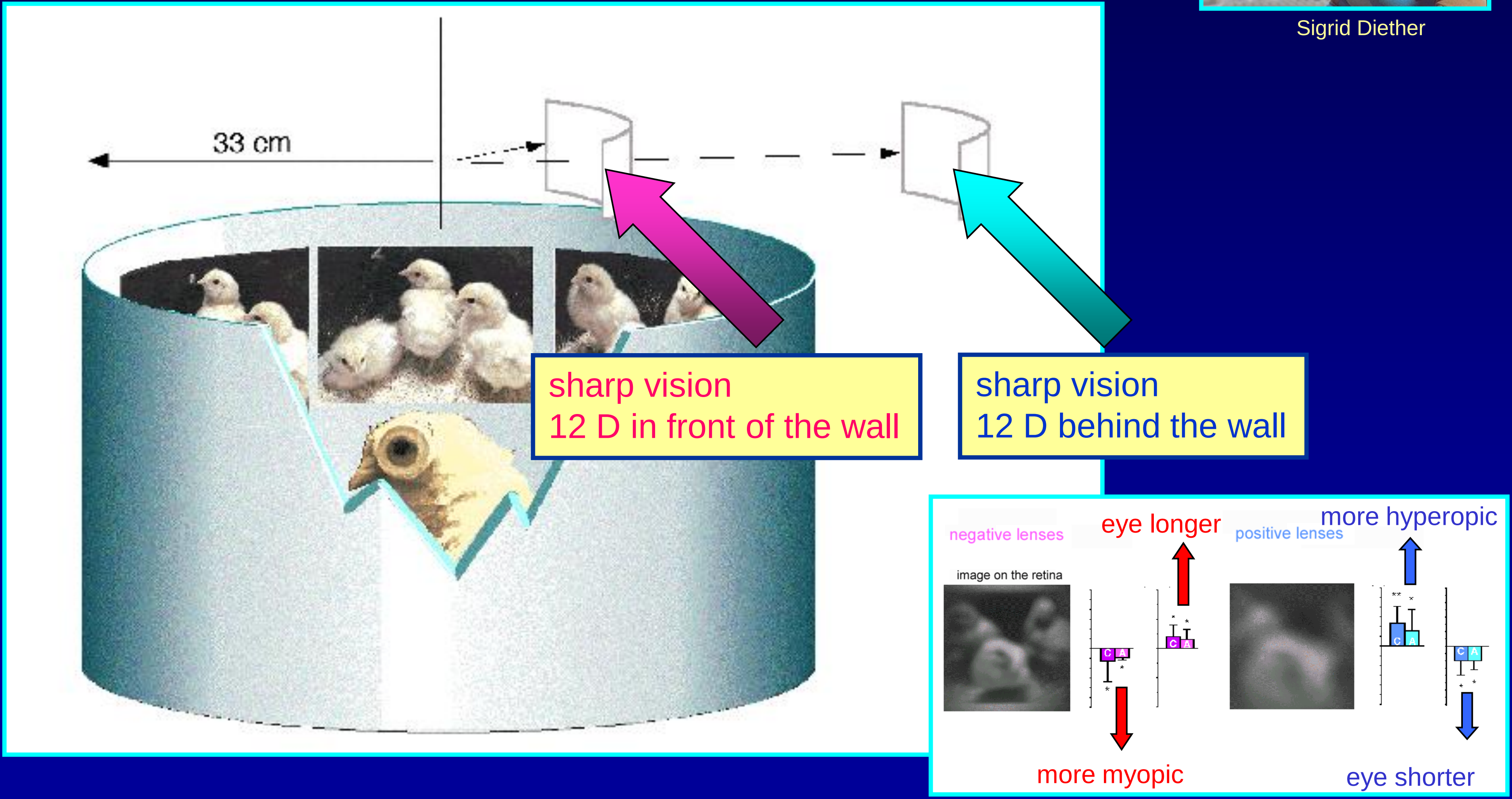
(Diether and Schaeffel, Vision Research 1997)



The retina can distinguish the sign of defocus

- chick in center of drum - only one viewing distance
- lenses move the plane of sharp vision either 12 D in front or behind the wall

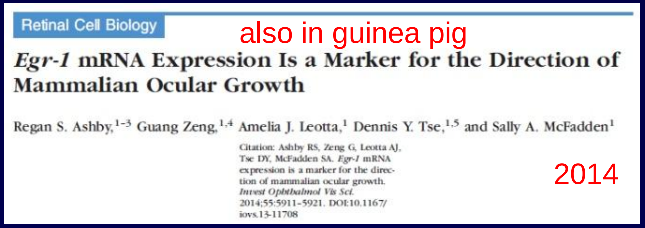
Sigrid Diether



sharp vision
12 D in front of the wall

sharp vision
12 D behind the wall

retinal glucagon amacrine cells "know" in a few minutes the sign of defocus: expression of the ZENK protein (2002, 1999)



Retinal Cell Biology

also in guinea pig

Egr-1 mRNA Expression Is a Marker for the Direction of Mammalian Ocular Growth

Regan S. Ashby,[1-3] Guang Zeng,[1,4] Amelia J. Leotta,[1] Dennis Y. Tse,[1,5] and Sally A. McFadden[1]

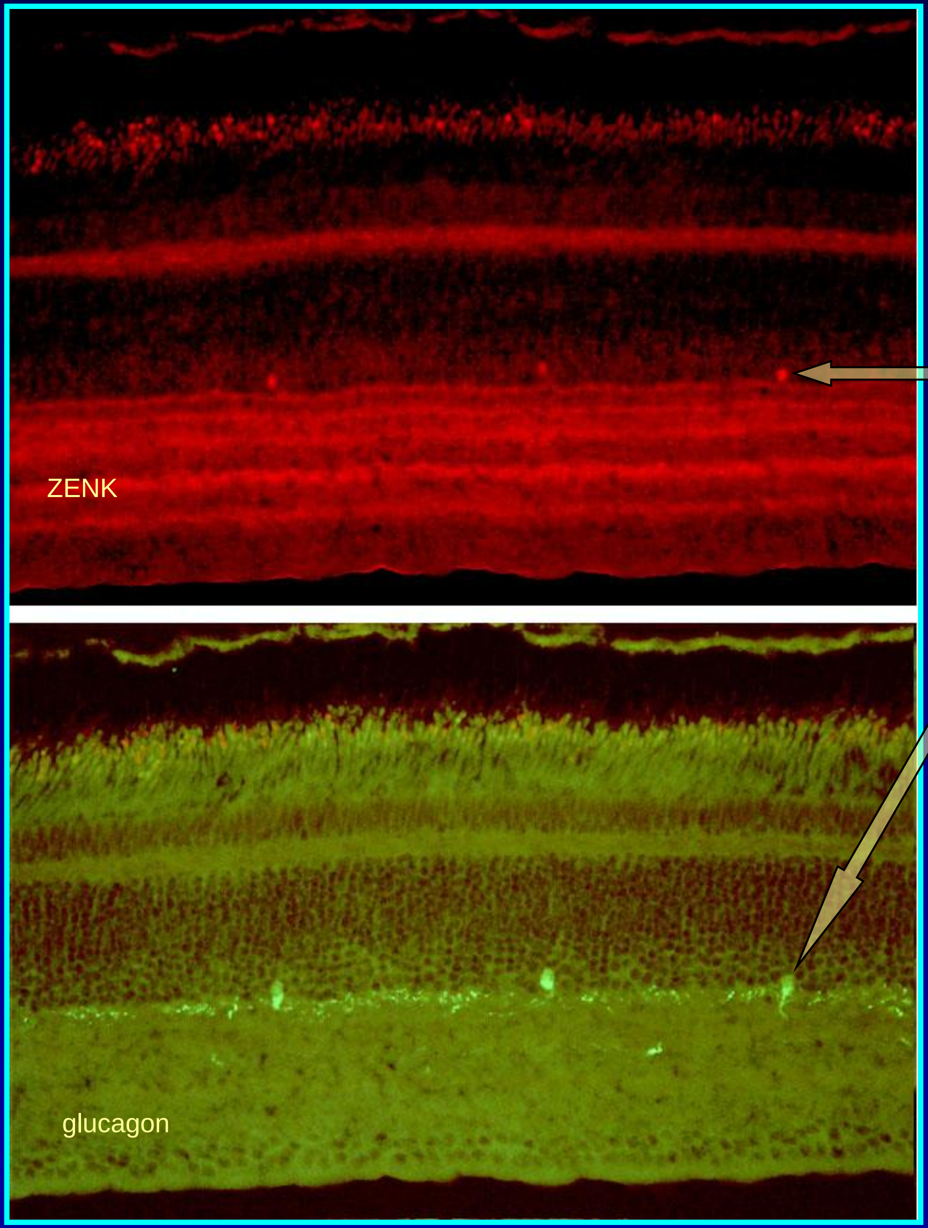
Citation: Ashby RS, Zeng G, Leotta AJ, Tse DY, McFadden SA. *Egr-1* mRNA expression is a marker for the direction of mammalian ocular growth. *Invest Ophthalmol Vis Sci.* 2014;55:5911–5921. DOI:10.1167/iovs.13-11708

2014

Michaela Bitzer

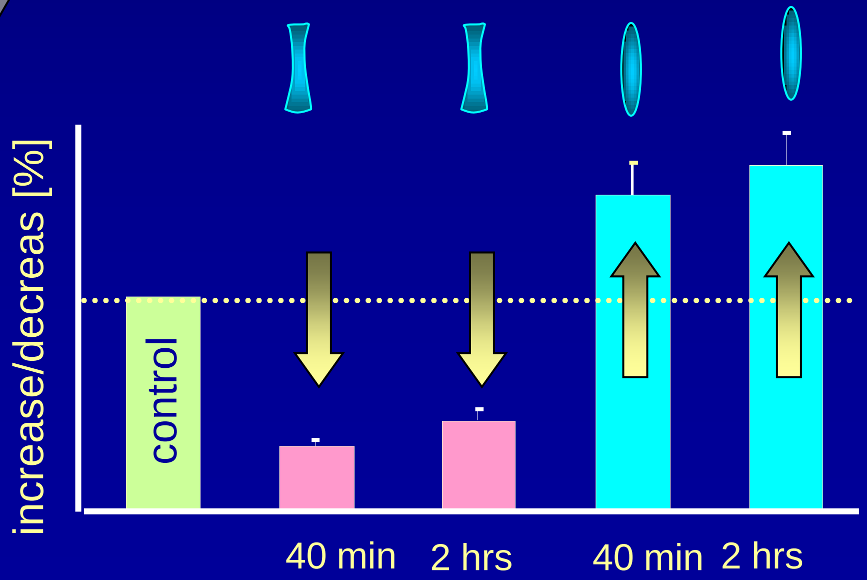
outer retina:
diurnal and light-triggered expression of ZENK

inner retina:
independent of diurnal and light

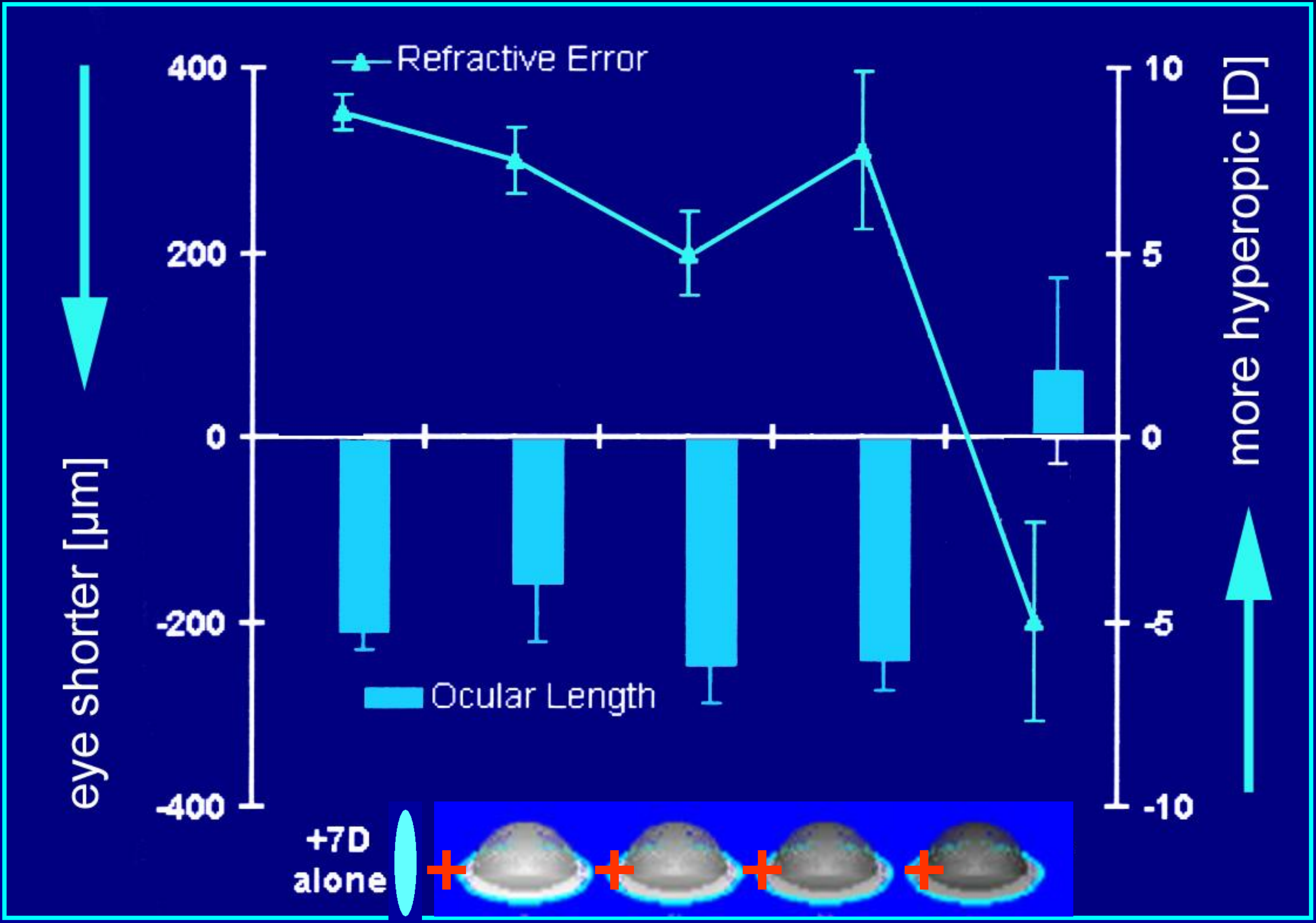


controlled by **defocus**

proportion of ZENK positive glucagon amacrine cells

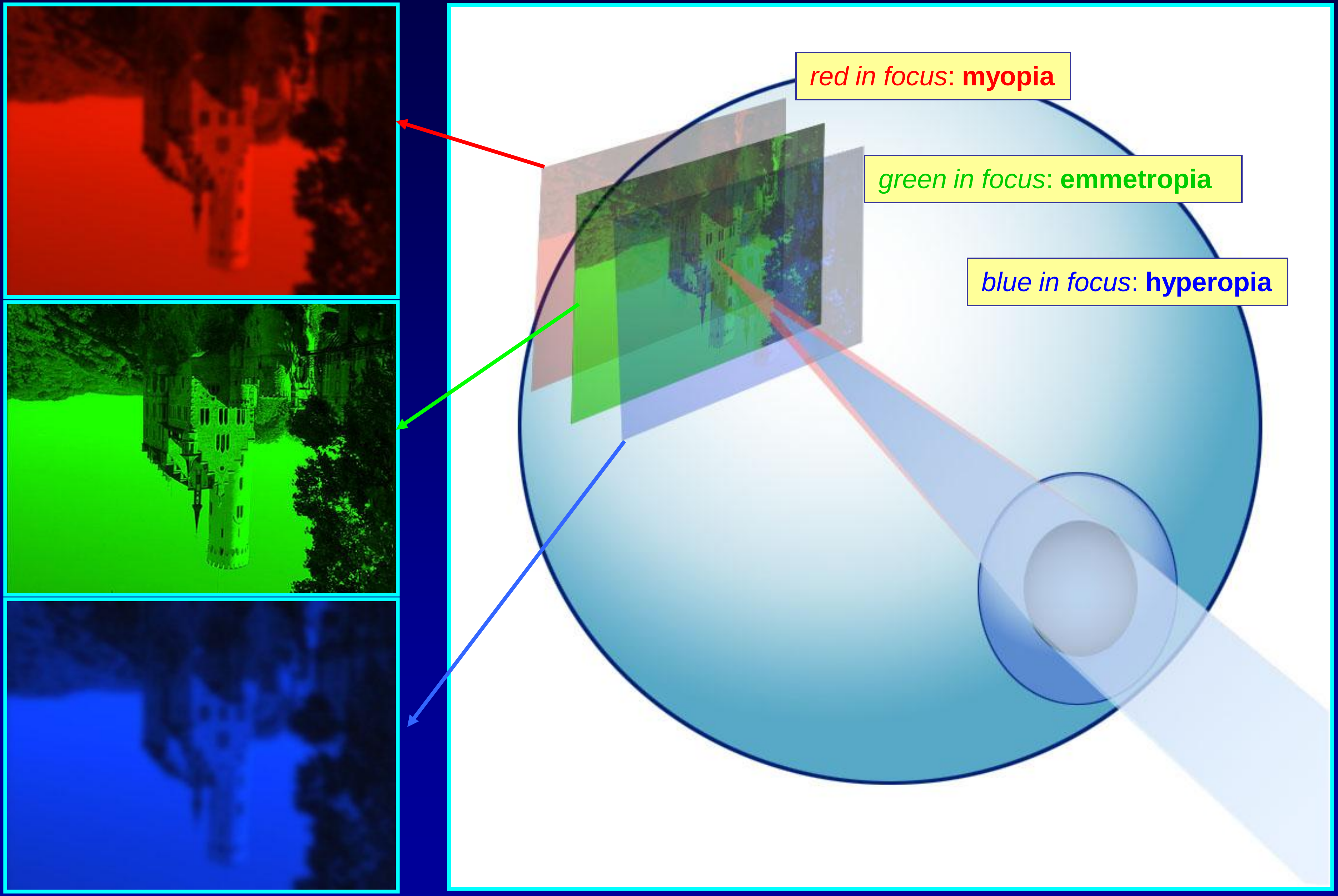


The sign of defocus detection very robust: positive lenses induce hyperopia even with diffusers (Park, Winawer, Wallman 2003)



AND short periods of defocus with positive lenses block myopia induced by negative lenses in chicks (Winawer et al 2005) and monkeys (Kee et al 2007)

How is the sign of defocus detected ?
perhaps longitudinal chromatic aberration

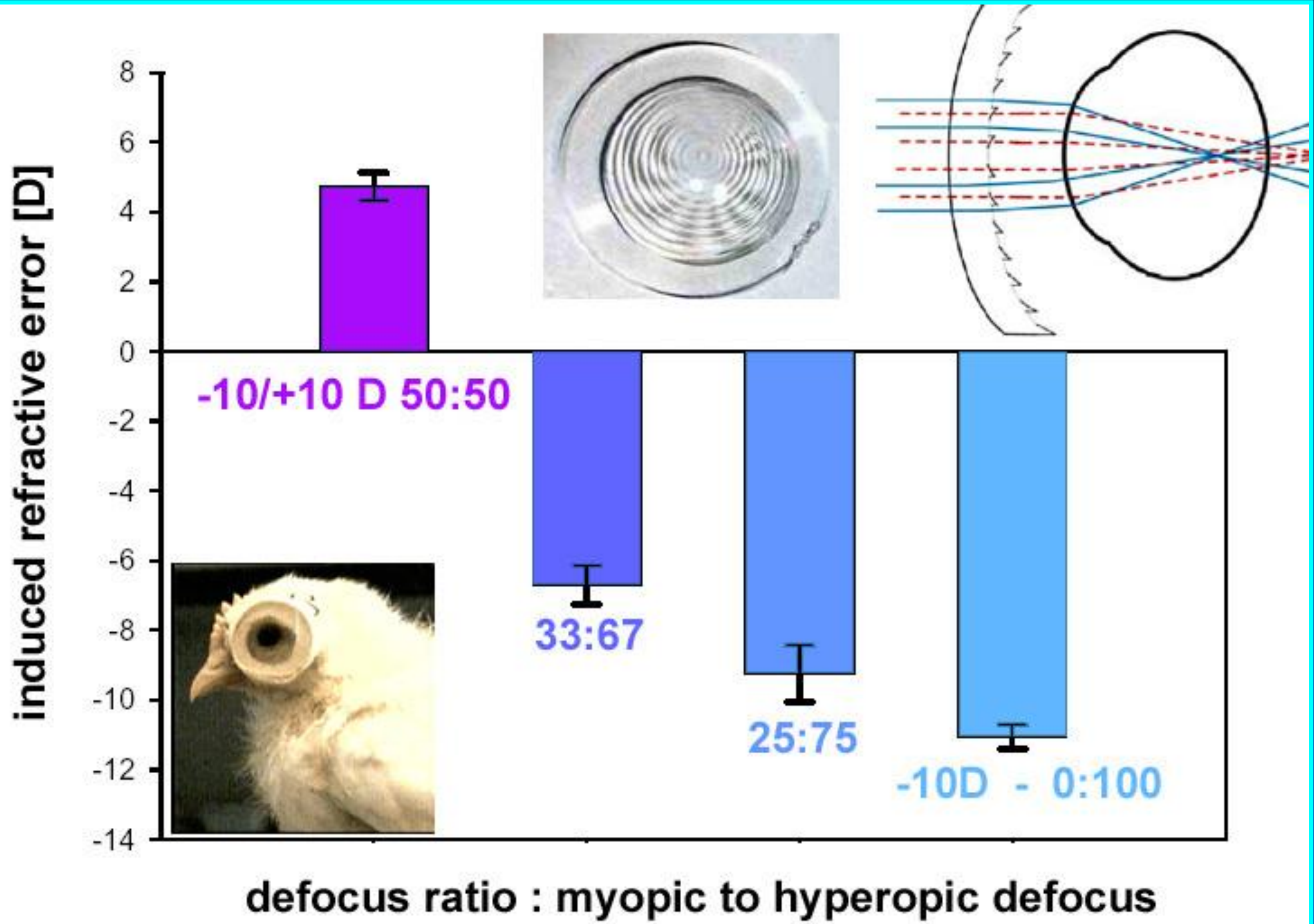


red in focus: **myopia**

green in focus: **emmetropia**

blue in focus: **hyperopia**

The retina can average over several focal planes (2006)



Tse & To, OPO 2006, p13 (2006)

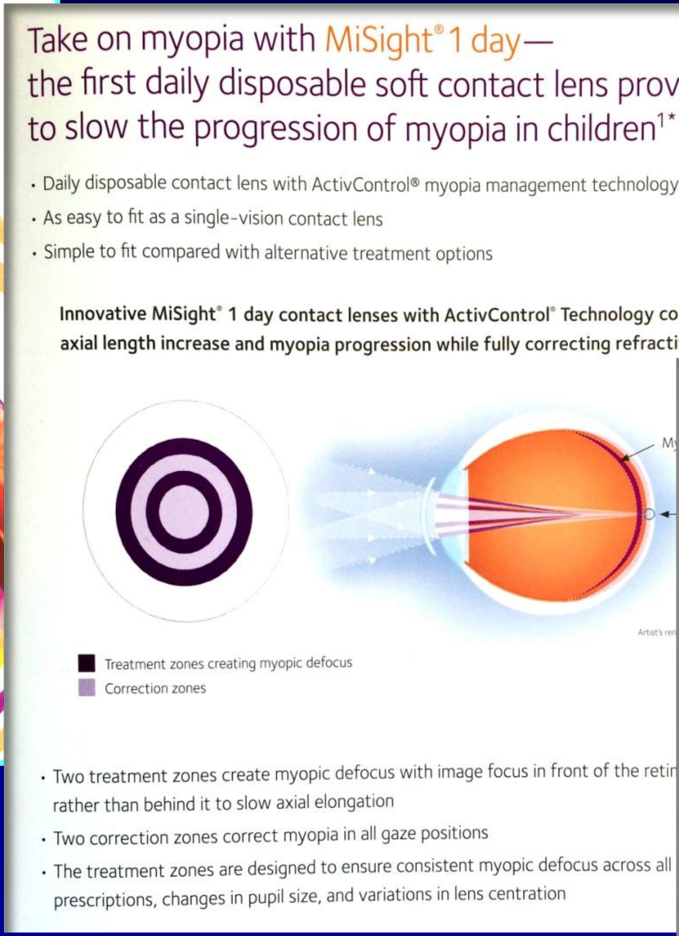
new multifocal contact lenses to superimpose myopic defocus for myopia inhibition
- Cooper Vision 2017

Frank

CooperVision®
Live Brightly.

Ready to take on myopia

MiSight® 1 day contact lenses are proven to significantly slow the progression of myopia[1*]



Take on myopia with MiSight® 1 day— the first daily disposable soft contact lens proven to slow the progression of myopia in children[1*]

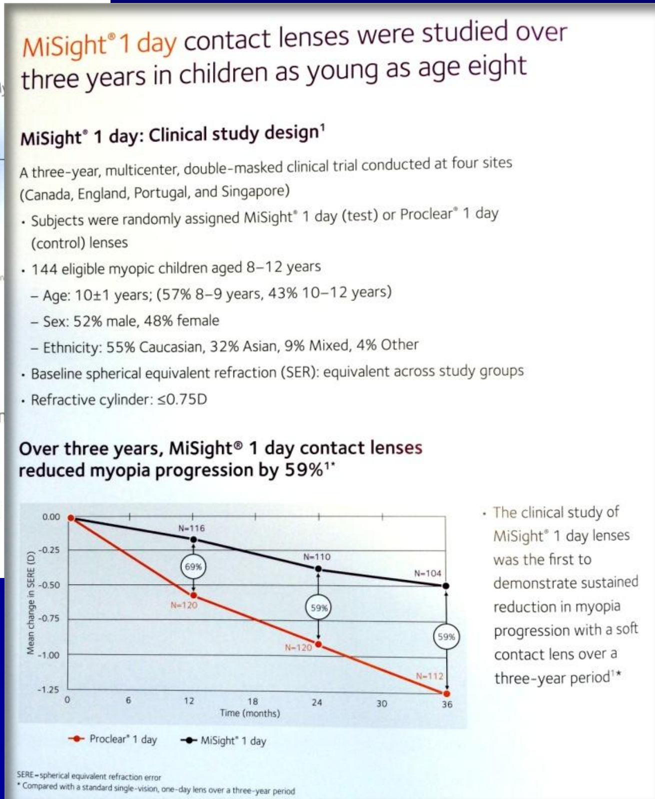
- Daily disposable contact lens with ActivControl® myopia management technology
- As easy to fit as a single-vision contact lens
- Simple to fit compared with alternative treatment options

Innovative MiSight® 1 day contact lenses with ActivControl® Technology control both axial length increase and myopia progression while fully correcting refractive error[1,4]

▇ Treatment zones creating myopic defocus
▨ Correction zones

- Two treatment zones create myopic defocus with image focus in front of the retin rather than behind it to slow axial elongation
- Two correction zones correct myopia in all gaze positions
- The treatment zones are designed to ensure consistent myopic defocus across all prescriptions, changes in pupil size, and variations in lens centration

also: Aller, Liu und Wildsoet find 50% inhibition of myopia with bifocal contact lenses (*Vistakon Acuvue Bifocal*) (Optom Vis Sci 2016 Apr;93(4):344-52)



MiSight® 1 day contact lenses were studied over three years in children as young as age eight

MiSight® 1 day: Clinical study design[1]

A three-year, multicenter, double-masked clinical trial conducted at four sites (Canada, England, Portugal, and Singapore)

- Subjects were randomly assigned MiSight® 1 day (test) or Proclear® 1 day (control) lenses
- 144 eligible myopic children aged 8–12 years
  - Age: 10±1 years; (57% 8–9 years, 43% 10–12 years)
  - Sex: 52% male, 48% female
  - Ethnicity: 55% Caucasian, 32% Asian, 9% Mixed, 4% Other
- Baseline spherical equivalent refraction (SER): equivalent across study groups
- Refractive cylinder: ≤0.75D

Over three years, MiSight® 1 day contact lenses reduced myopia progression by 59%[1*]

- The clinical study of MiSight® 1 day lenses was the first to demonstrate sustained reduction in myopia progression with a soft contact lens over a three-year period[1*]

SERE=spherical equivalent refraction error
* Compared with a standard single-vision, one-day lens over a three-year period

n = 104 children in treated group, 112 in control group, 36 months

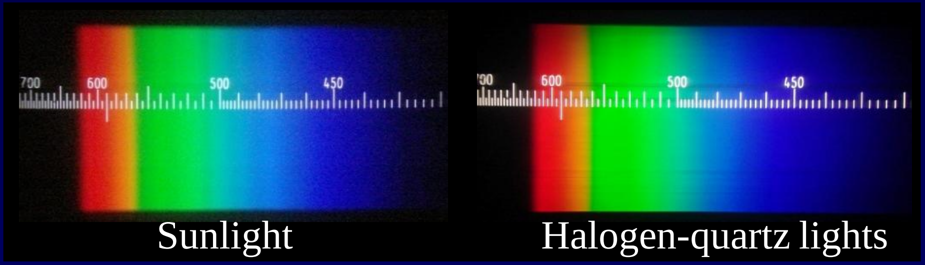
59% reduced myopia progression
52% reduced axial eye growth

inhibition of myopia by bright light

Firefox hat das Ausführen von "Adobe Flash" auf www.daserste.de verhindert.

Video: Durchblick am Display: Mit Tageslicht Sehschwäche vorbeugen

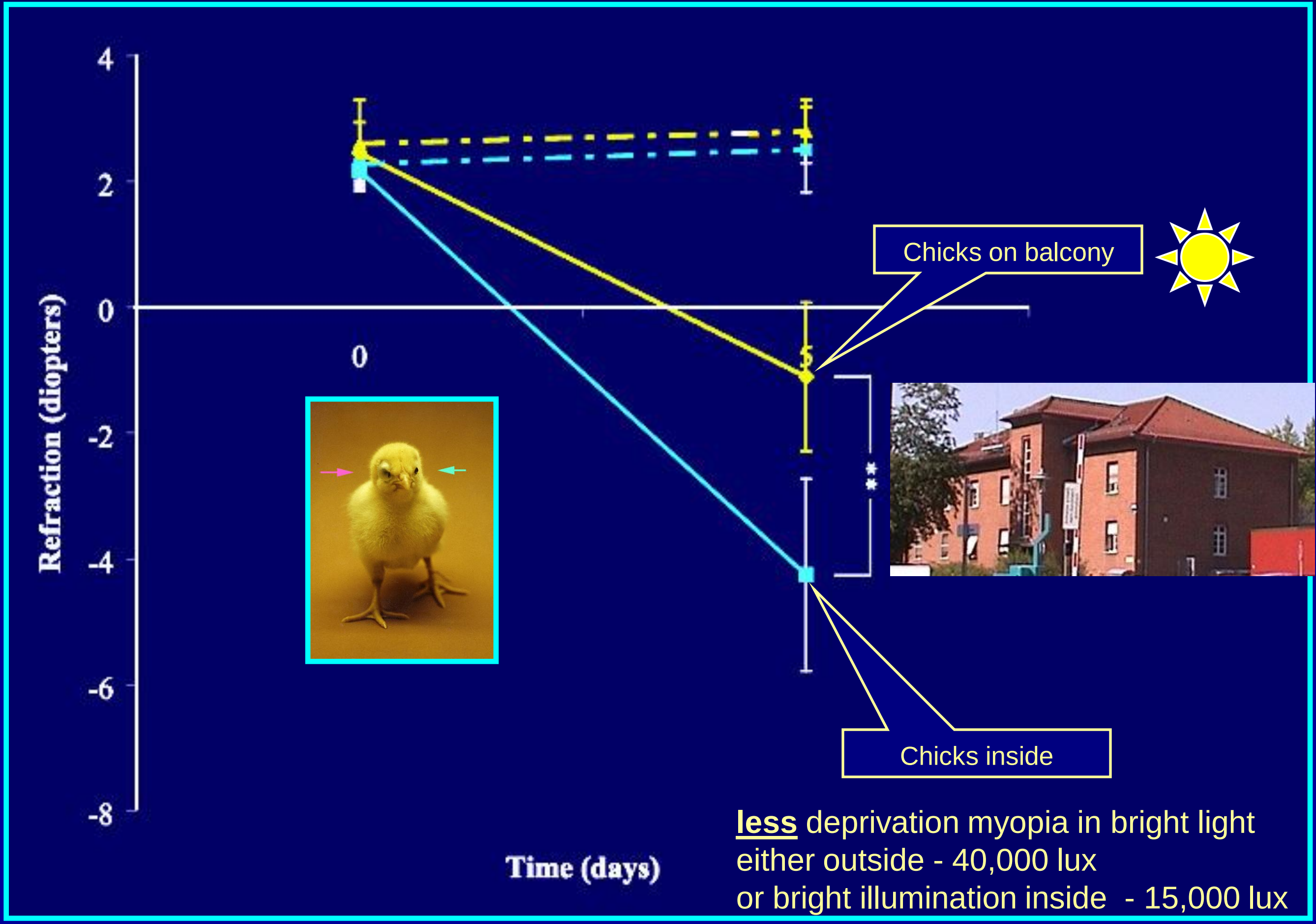
also chicks become less myopic in bright light



Sunlight

Halogen-quartz lights

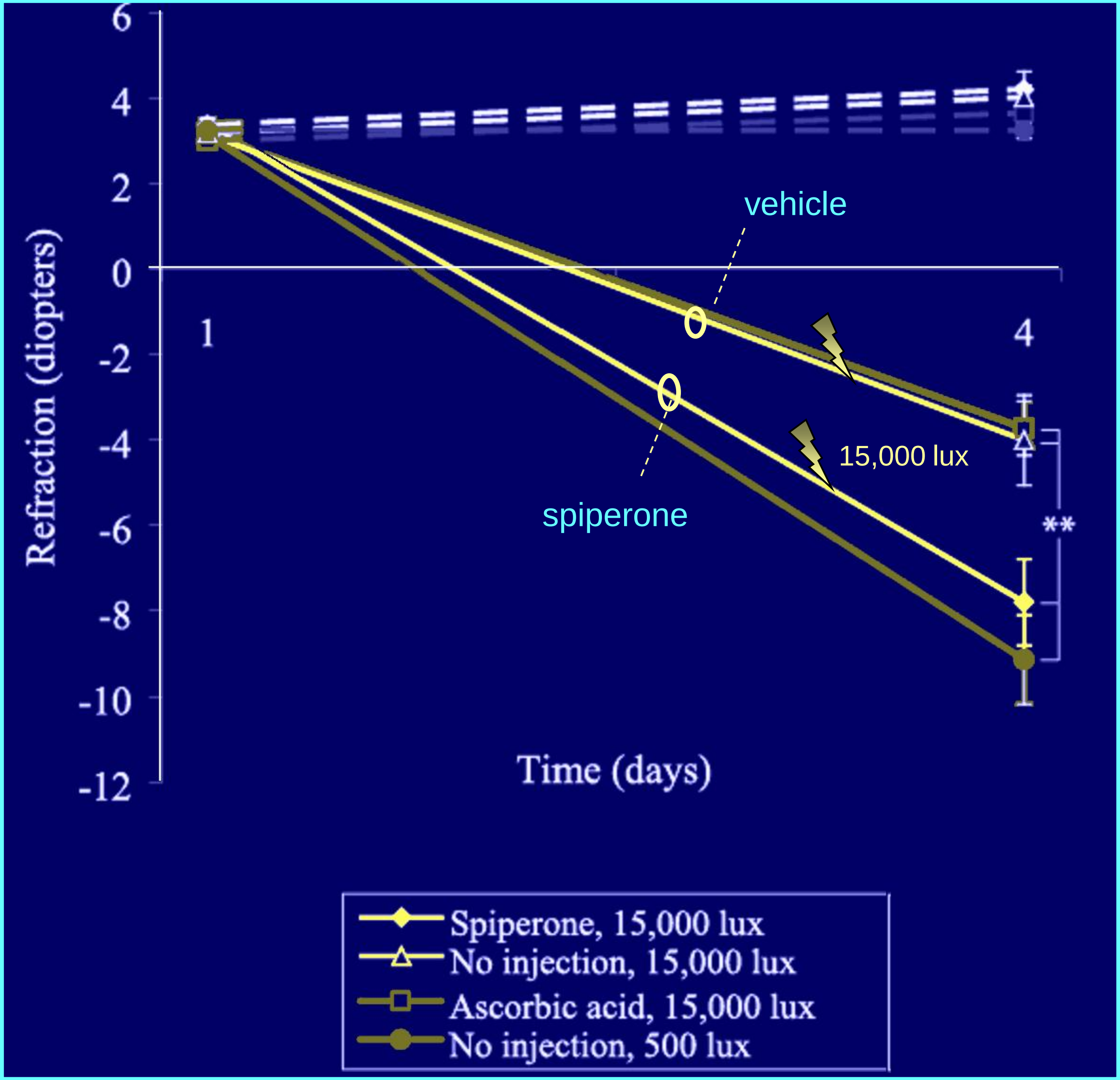
15,000 lux



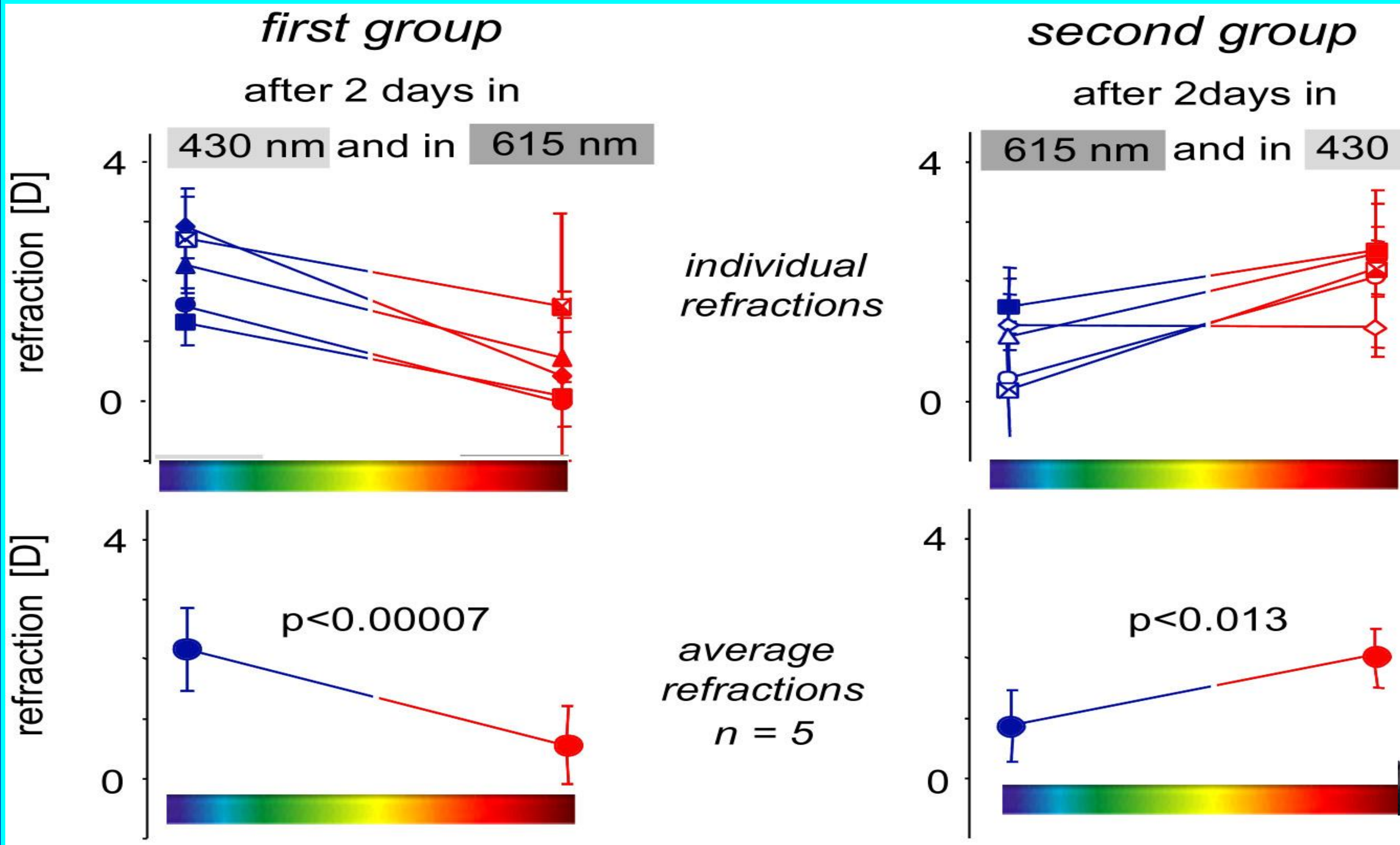
less deprivation myopia in bright light
either outside - 40,000 lux
or bright illumination inside - 15,000 lux

probably mediated by dopamine: a dopamine antagonist blocks the effect of bright light on myopia

(Regan Ashby 2010)

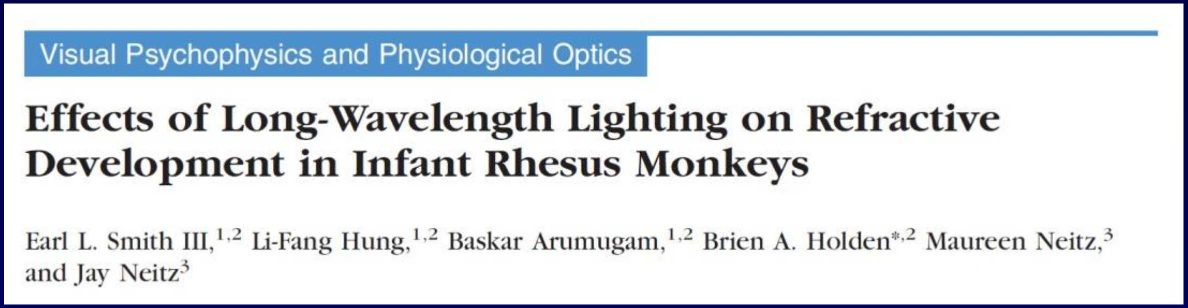


raising chicks in monochromatic light for 2 days causes a permanent shift in refractive state that persists in the dark or under cycloplegia



Anne Seidemann

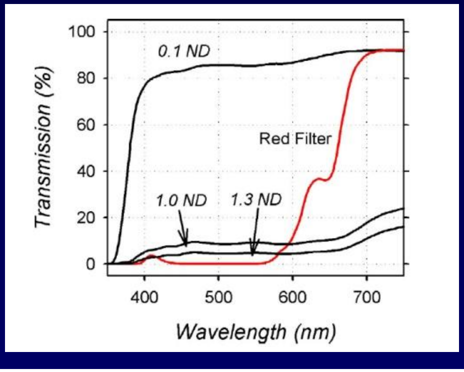
most striking: red light induces hyperopia in rhesus monkeys

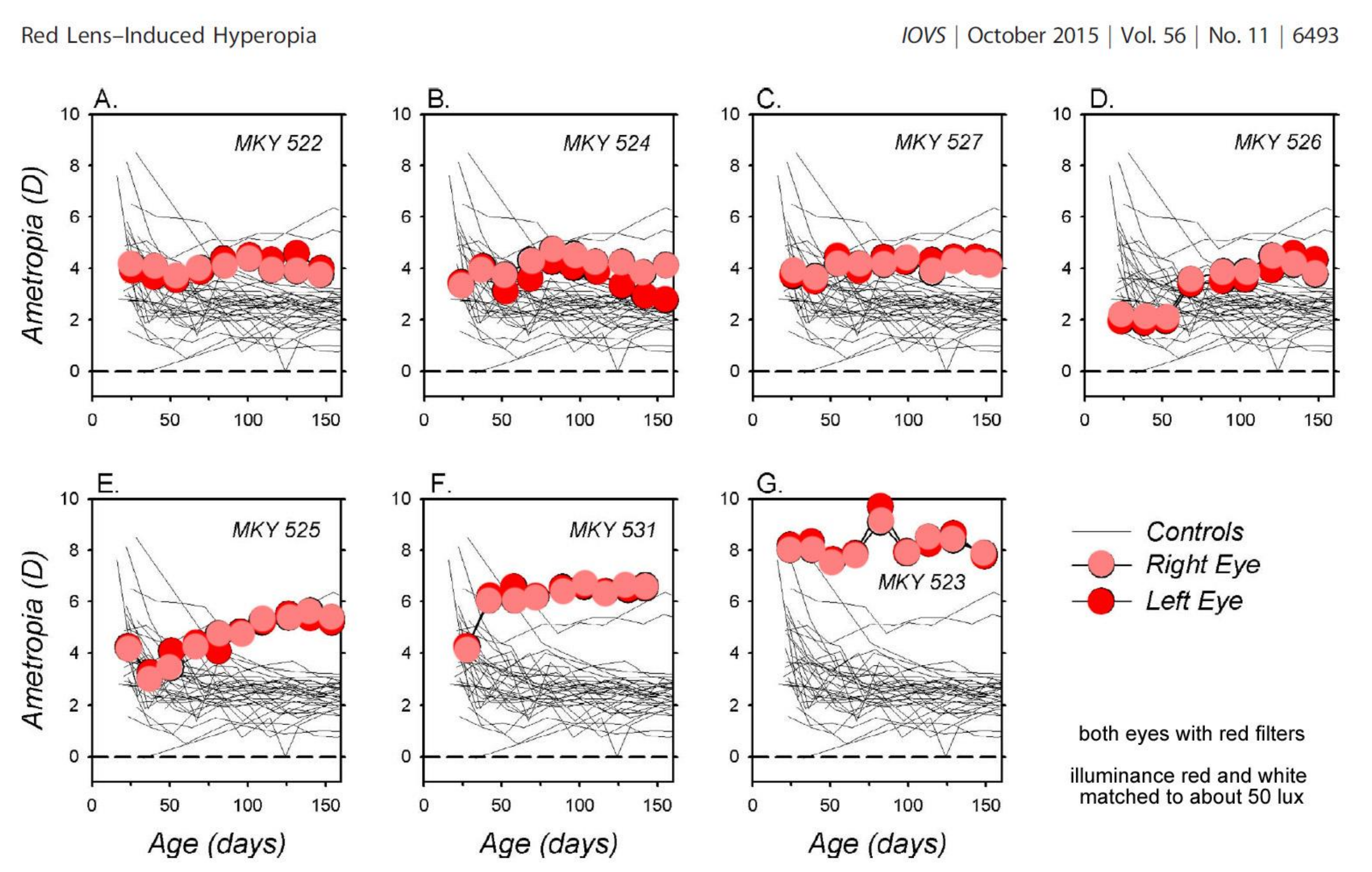


Visual Psychophysics and Physiological Optics

Effects of Long-Wavelength Lighting on Refractive Development in Infant Rhesus Monkeys

Earl L. Smith III,[1,2] Li-Fang Hung,[1,2] Baskar Arumugam,[1,2] Brien A. Holden*,[2] Maureen Neitz,[3] and Jay Neitz[3]





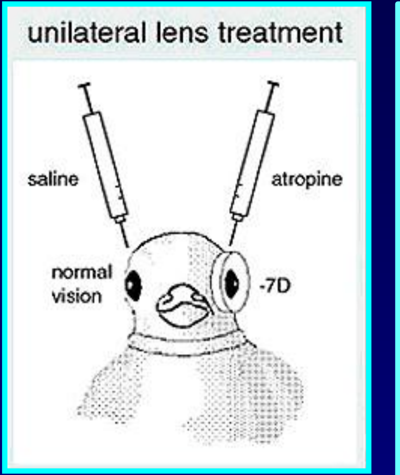
both eyes with red filters

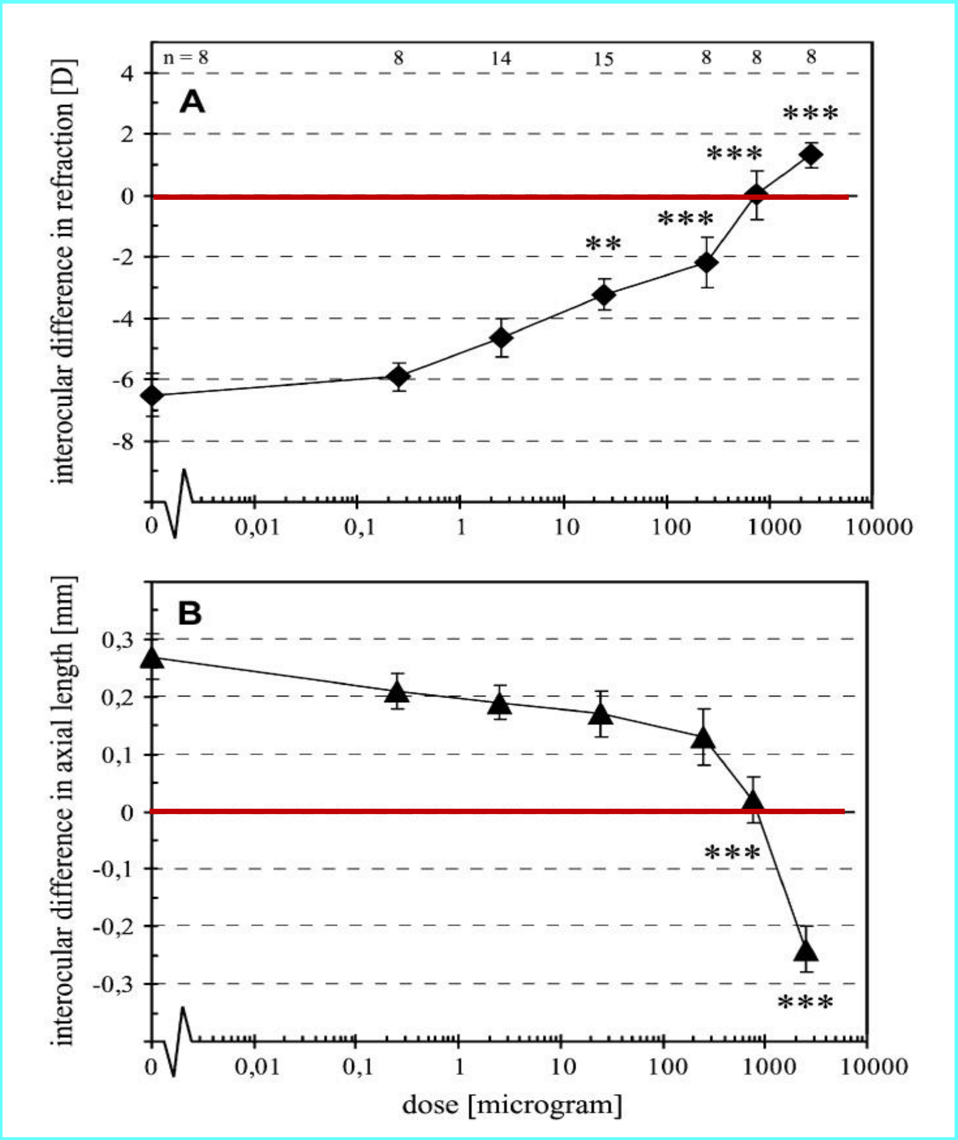
illuminance red and white
matched to about 50 lux

Inhibition of myopia by atropine

Inhibition of lens-induced myopia by atropine

uni-lateral intravitreal injection

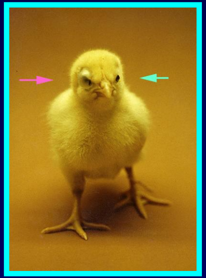


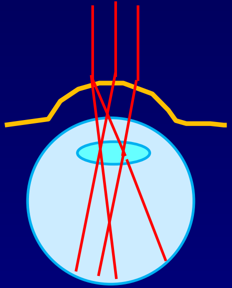


Sigrid Diether

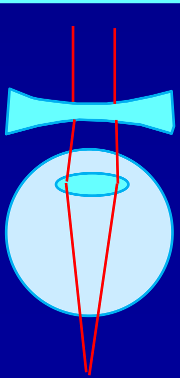
Muscarinic drug screening in collaboration with Novartis, Basel, ARVO 2004 and 2005

Similar effects of atropine on deprivation myopia and lens-induced myopia

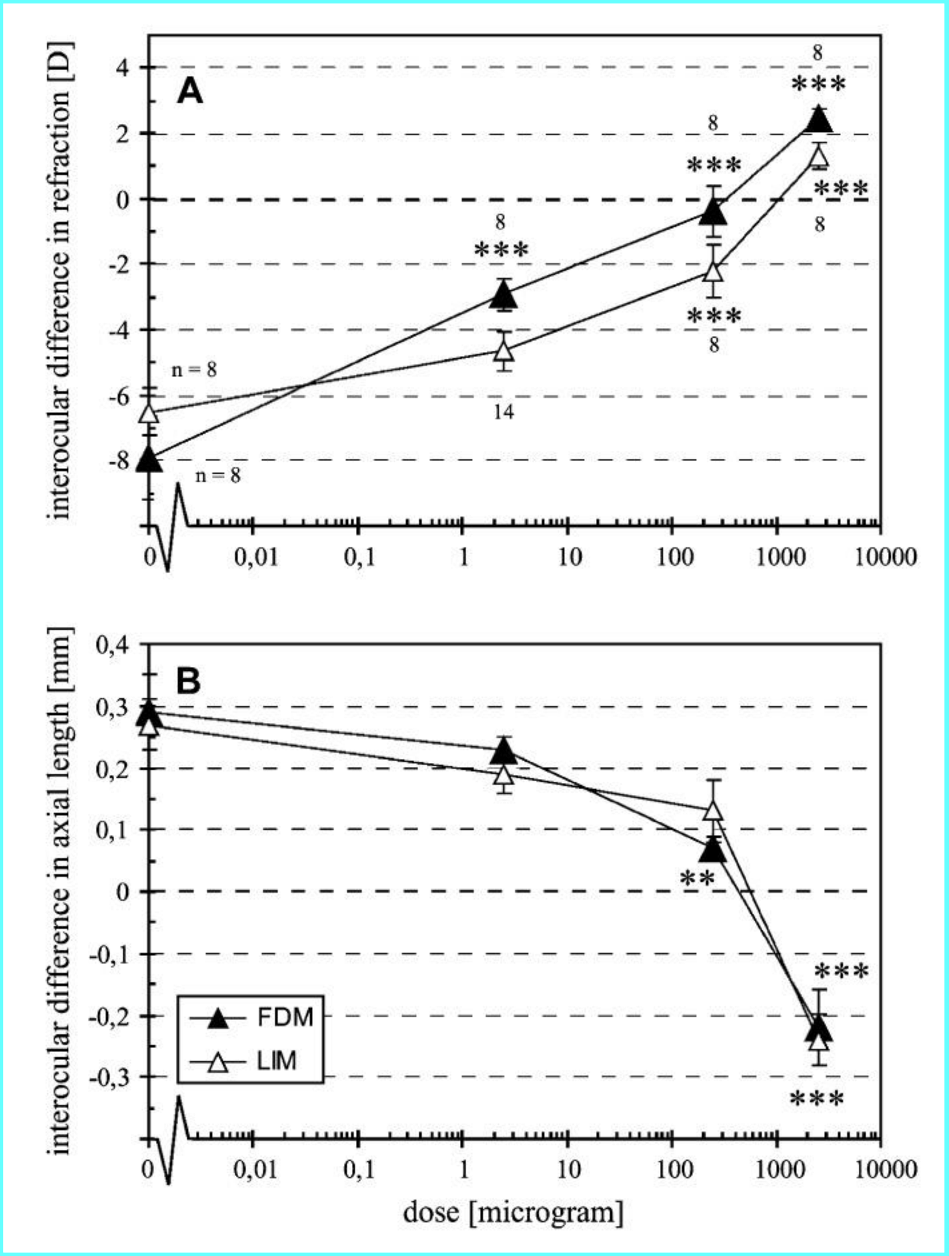




deprivation myopia



lens-induced myopia



Sigrid Diether

since image processing to detect negative defocus should be different than for detecting just poor image quality,
the effect of atropine must be unspecific with respect to the type of retinal image processing

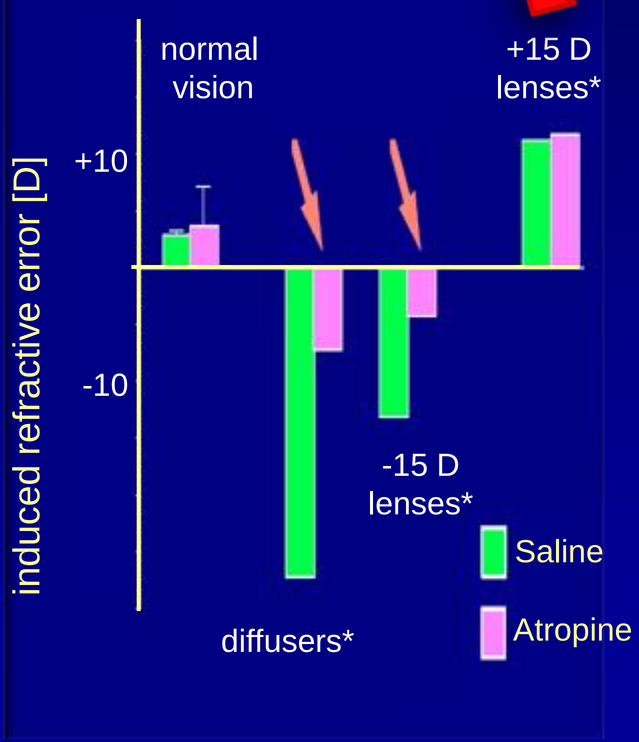
(or not in the retina at all?)

atropine only inhibits myopia, not hyperopia

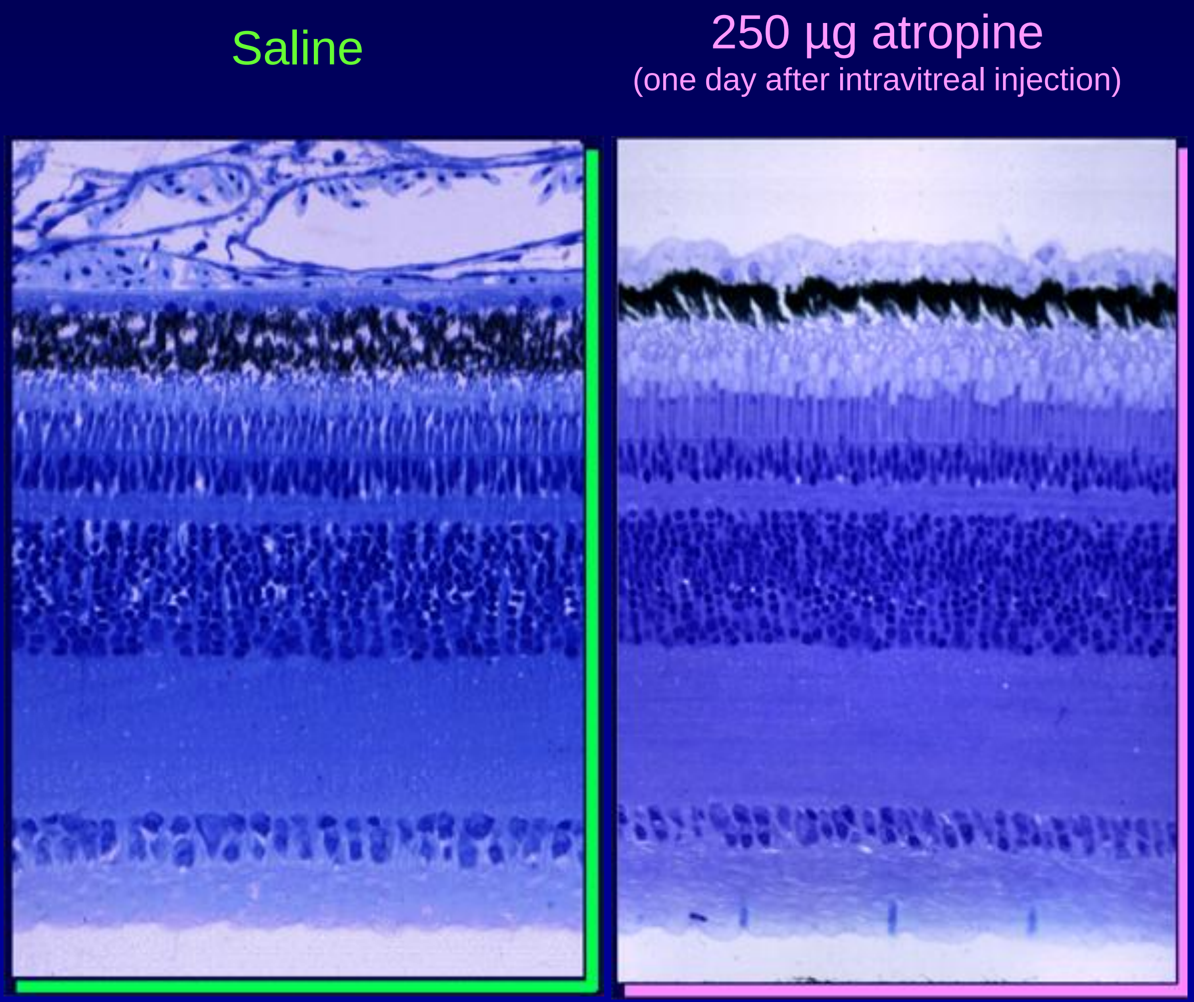
and no toxicity observed

refractive development

* data by Christine F. Wildsoet
ARVO 1994

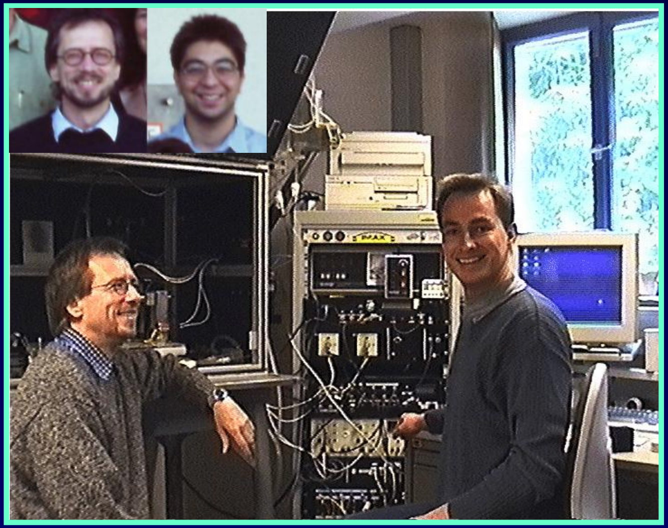


no toxic effects seen in retina, even at the highest doses (chick)

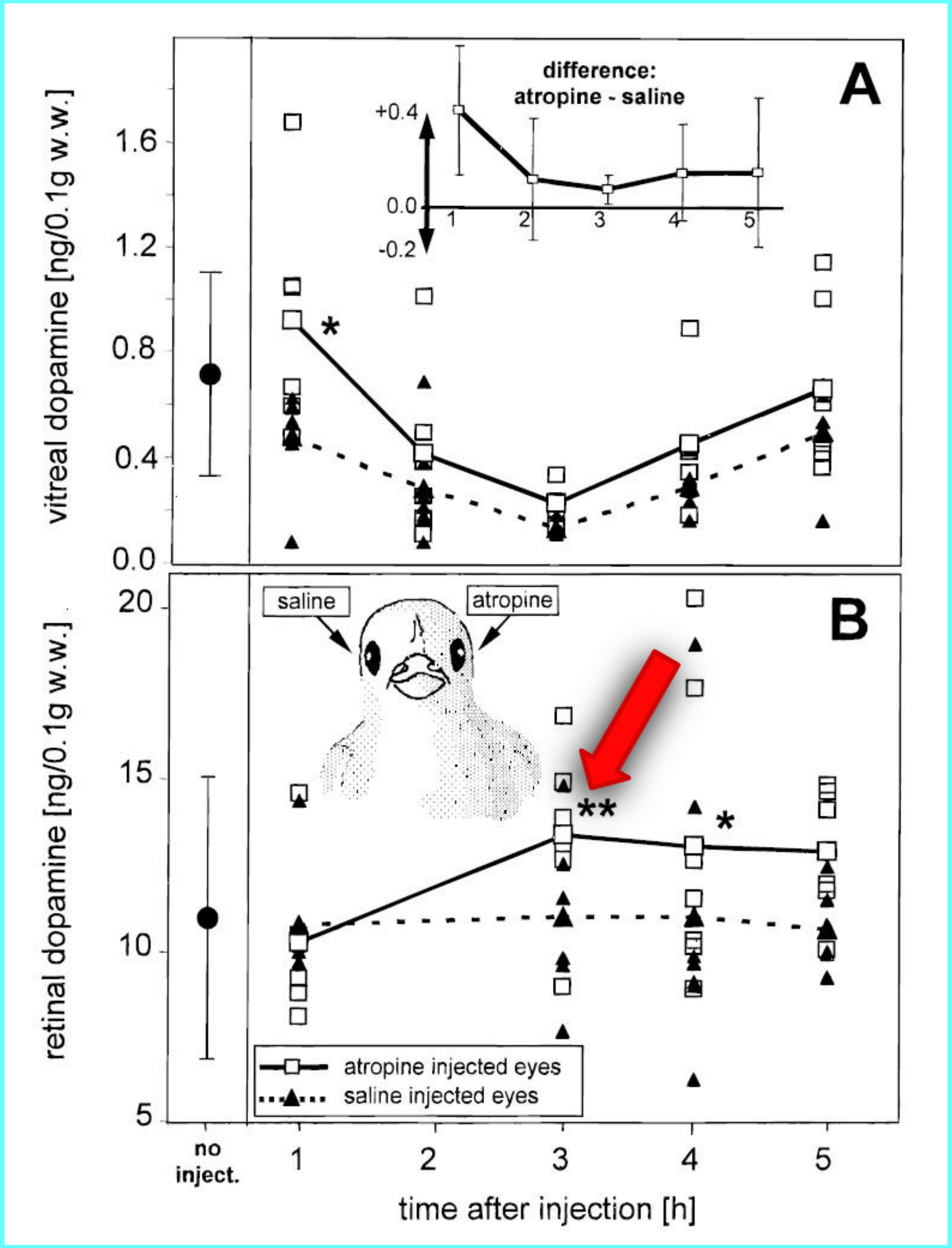


Saline

250 µg atropine
(one day after intravitreal injection)

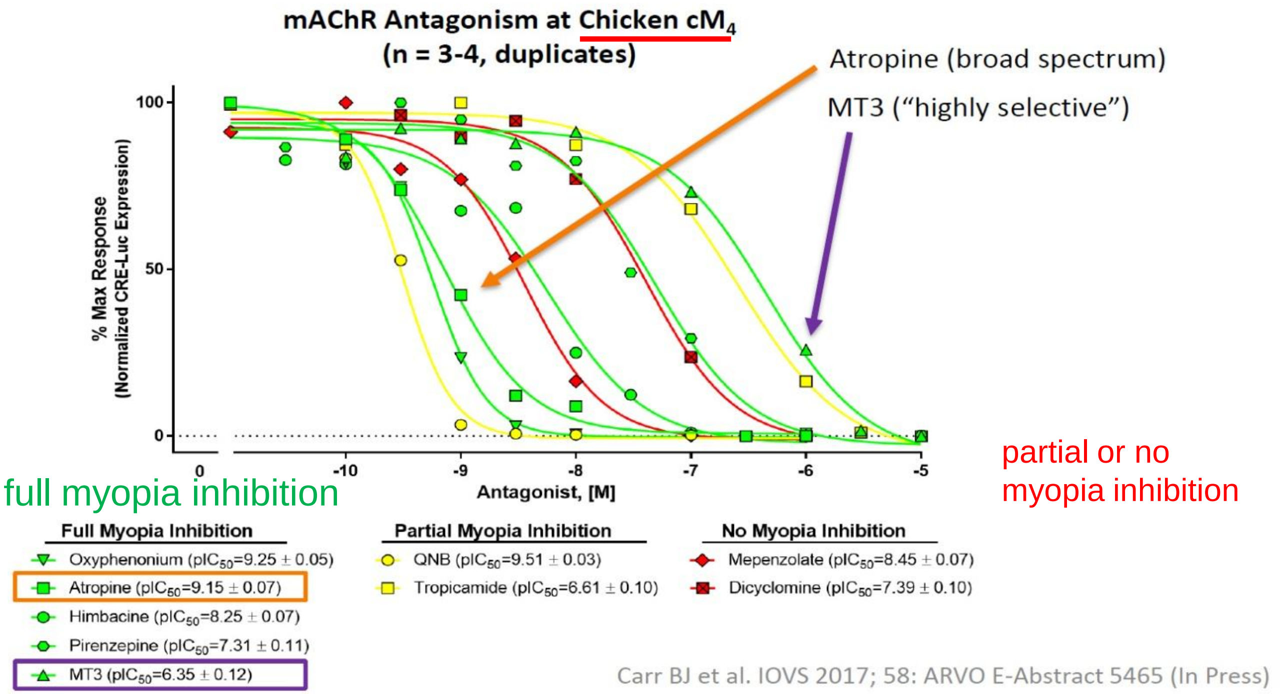


atropine increases
dopamine release
from the retina *in vivo*



Schwahn, Kaymak, Schaeffel (2000)
Visual Neuroscience17(2):165-76

<u>chicken muscarinic receptor M4</u> binding correlates poorly with myopia inhibition in chicks



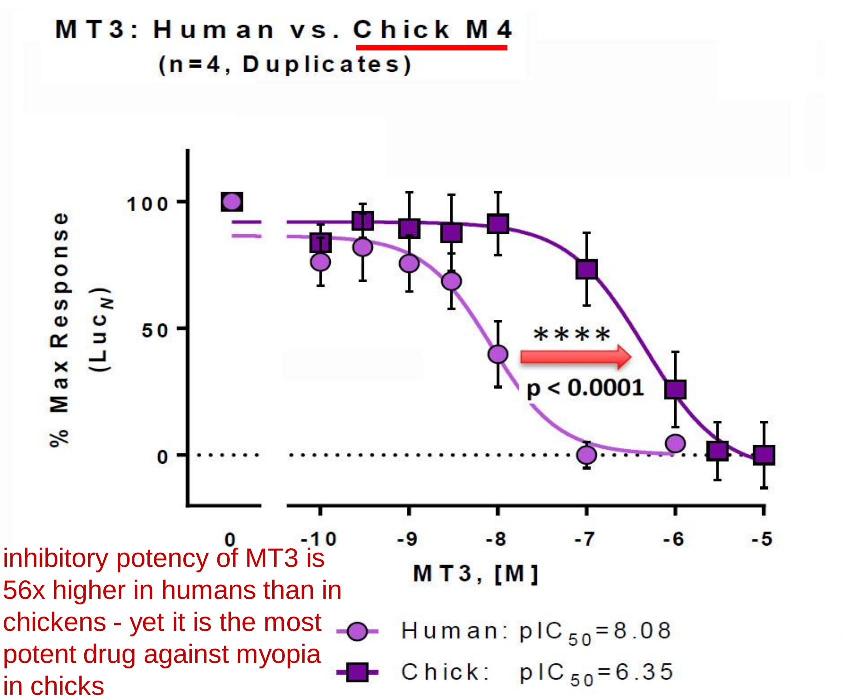
full myopia inhibition

partial or no myopia inhibition

Carr BJ et al. IOVS 2017; 58: ARVO E-Abstract 5465 (In Press)

except for MT3 ("mamba toxin3", a M4 antagonist), there were <u>no differences in inhibitory potency in human and chick muscarinic receptors</u> (means that the data are comparable)

http://forums.cgsociety.org



inhibitory potency of MT3 is 56x higher in humans than in chickens - yet it is the most potent drug against myopia in chicks

UNIVERSITY OF CALGARY

Bill Stell

Brittany Carr

THE OHIO STATE UNIVERSITY

COLLEGE OF OPTOMETRY

Delaying Myopia Onset as an Approach in Myopia Control

Donald O. Mutti, OD, PhD

Background

- Control of myopia progression
  - Many have tried, few have succeeded
    - conventional rigid lenses
    - under-correction
    - bifocal spectacles
    - bifocal spectacles in esophores
    - PALs
    - PALs in esophores with a high accommodative lag

RGPs (conventional fit)

Study	Difference
CLAMP (Walline, 2004)	0.40 (0.19, 0.61)
Katz (2003)	–0.02 (–0.14, 0.10)

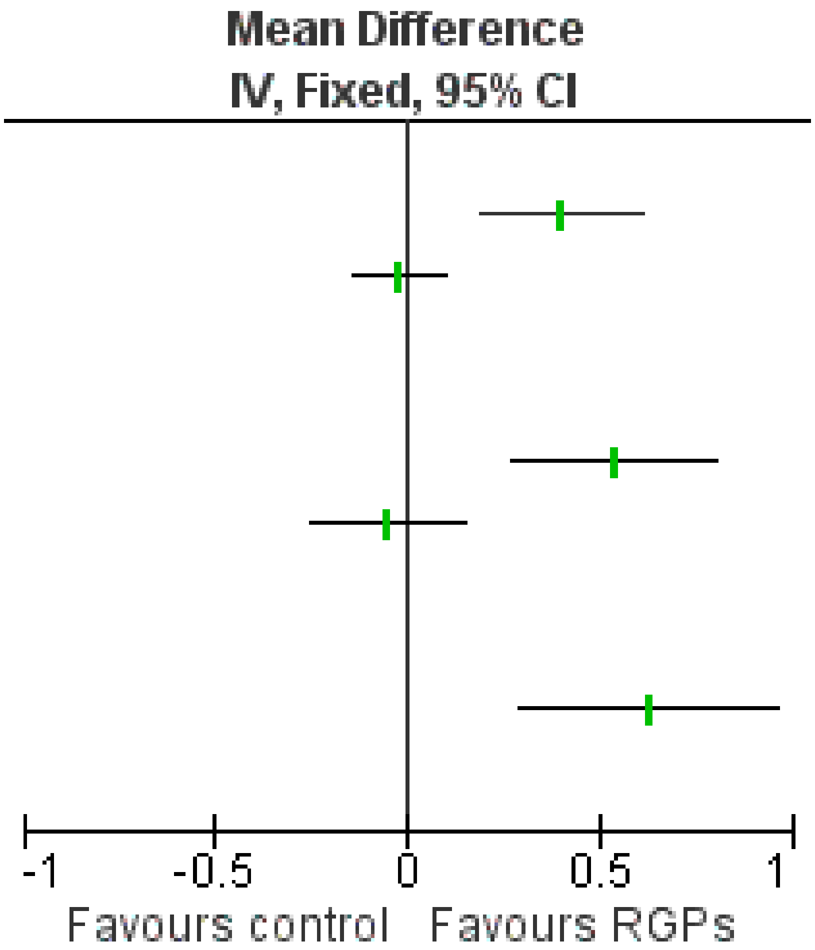
One year

CLAMP (Walline, 2004)	0.54 (0.27, 0.81)
Katz (2003)	–0.05 (–0.21, 0.15)

Two years

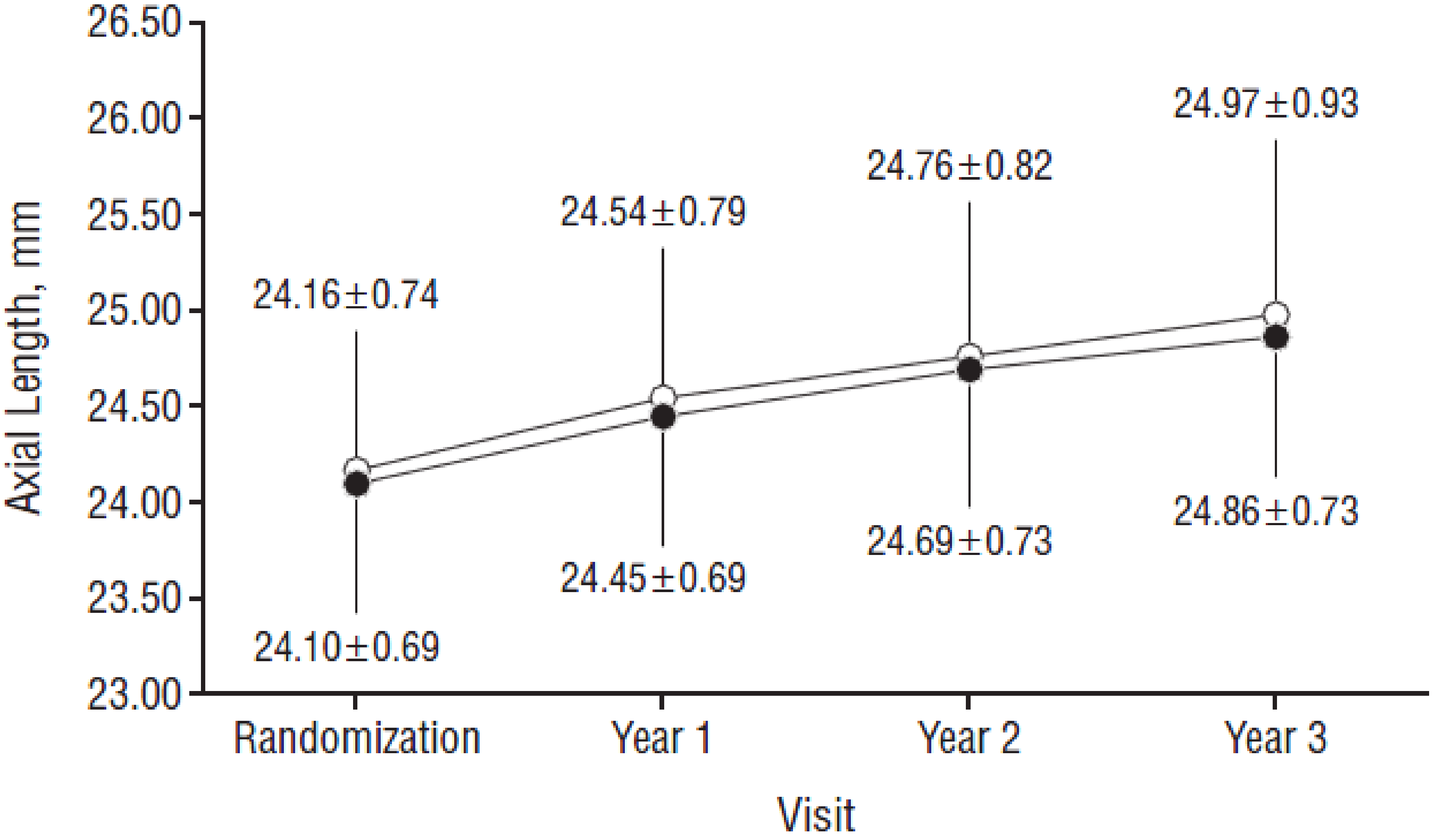
CLAMP (Walline, 2004)	0.63 (0.30, 0.96)

Three years



CLAMP (conventional RGP) Axial Length

Walline et al. (2004)



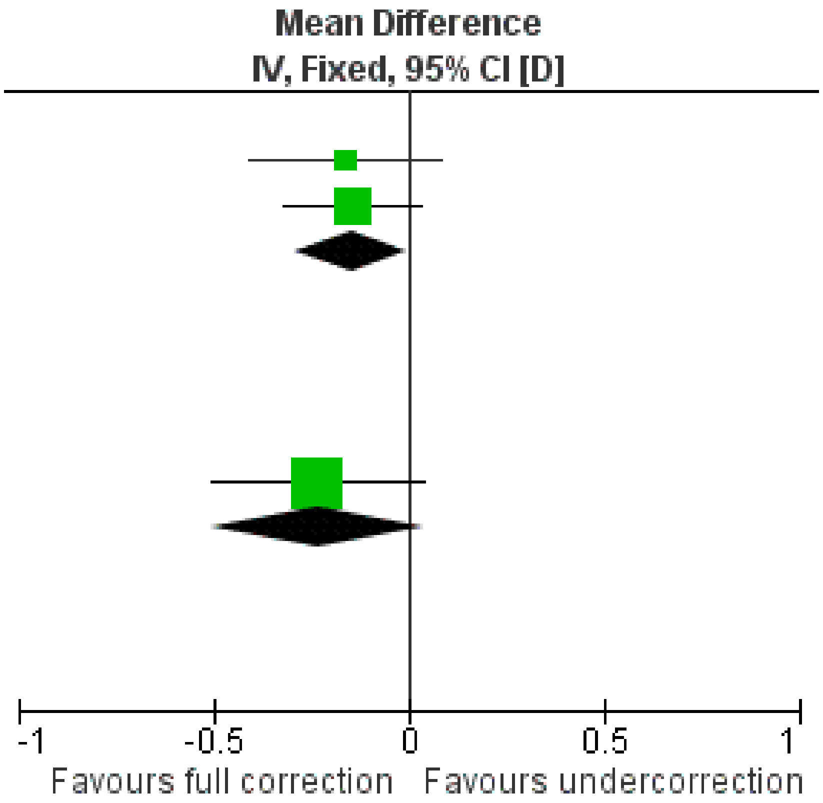
Under-Correction

Study	Difference
Adler (2006)	–0.16 (–0.41, 0.09)
Chung (2002)	–0.14 (–0.32, 0.04)
Total	**–0.15 (–0.29, 0.00)**

One year

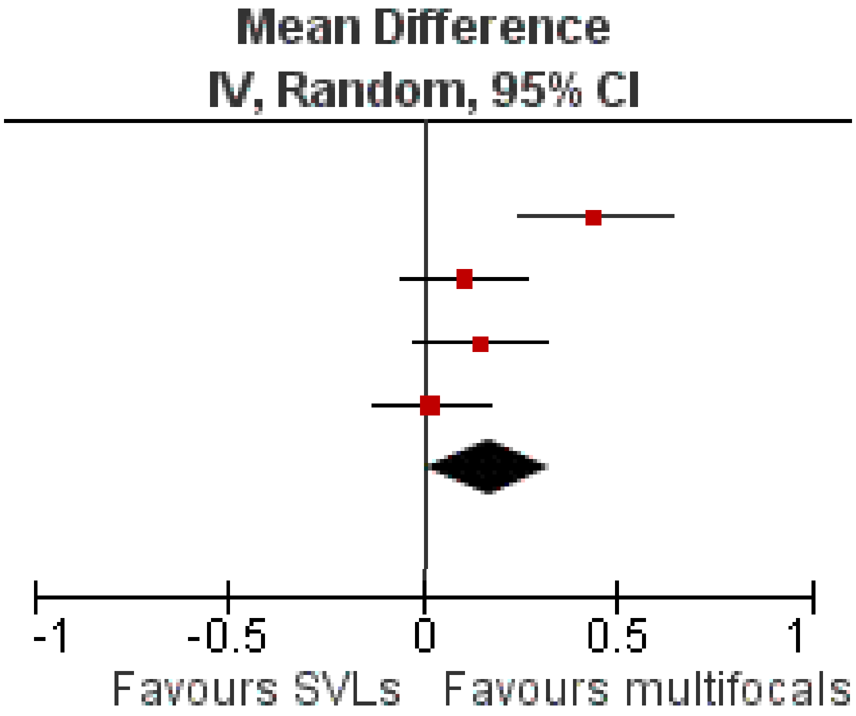
Study	Difference
Chung (2002)	–0.23 (–0.50, 0.04)

Two years



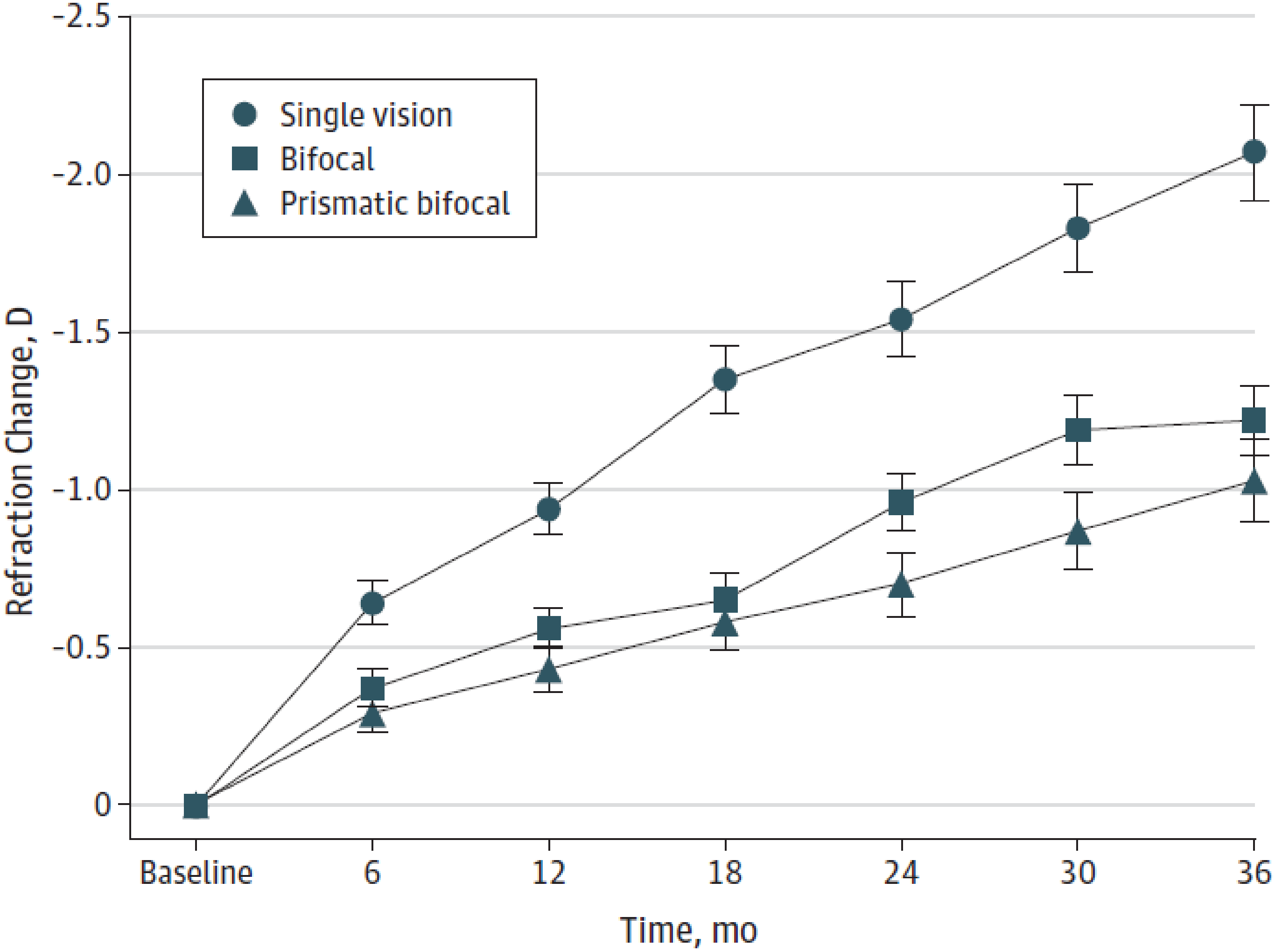
Multi-focal Spectacles

Study	Difference
Cheng (2010)	0.42 (0.23, 0.61)
Fulk (2002)	0.10 (–0.05, 0.25)
Jensen (1991)	0.14 (–0.02, 0.30)
Pärssinen (1989)	0.02 (–0.12, 0.16)
Total	**0.16 (0.01, 0.32)**



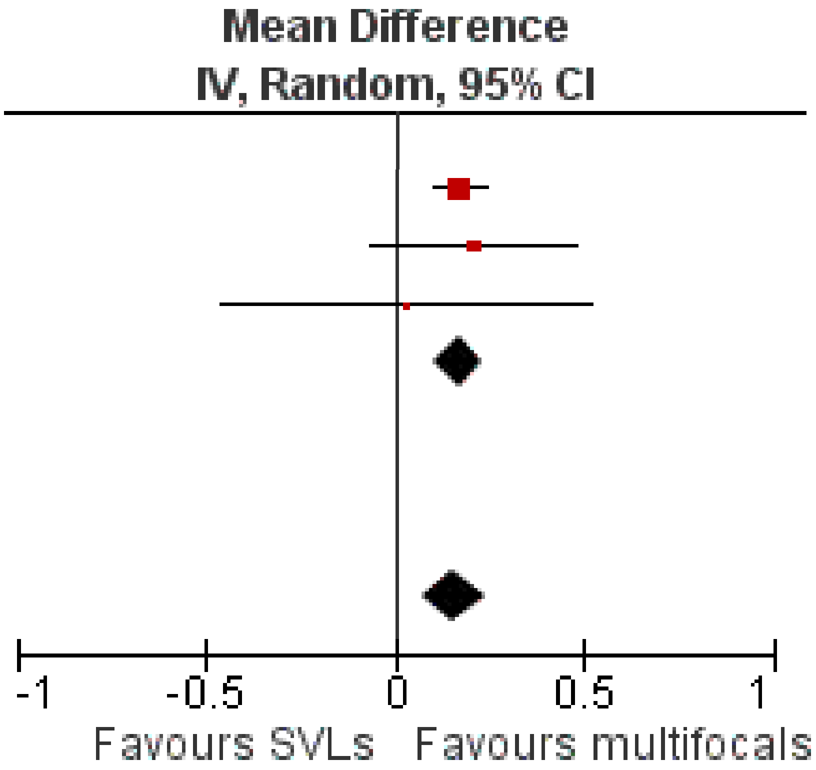
Executive bifocals (+1.50D add) with and without 6∆ BI Essilor Myopilux Max

Cheng et al. (2014)



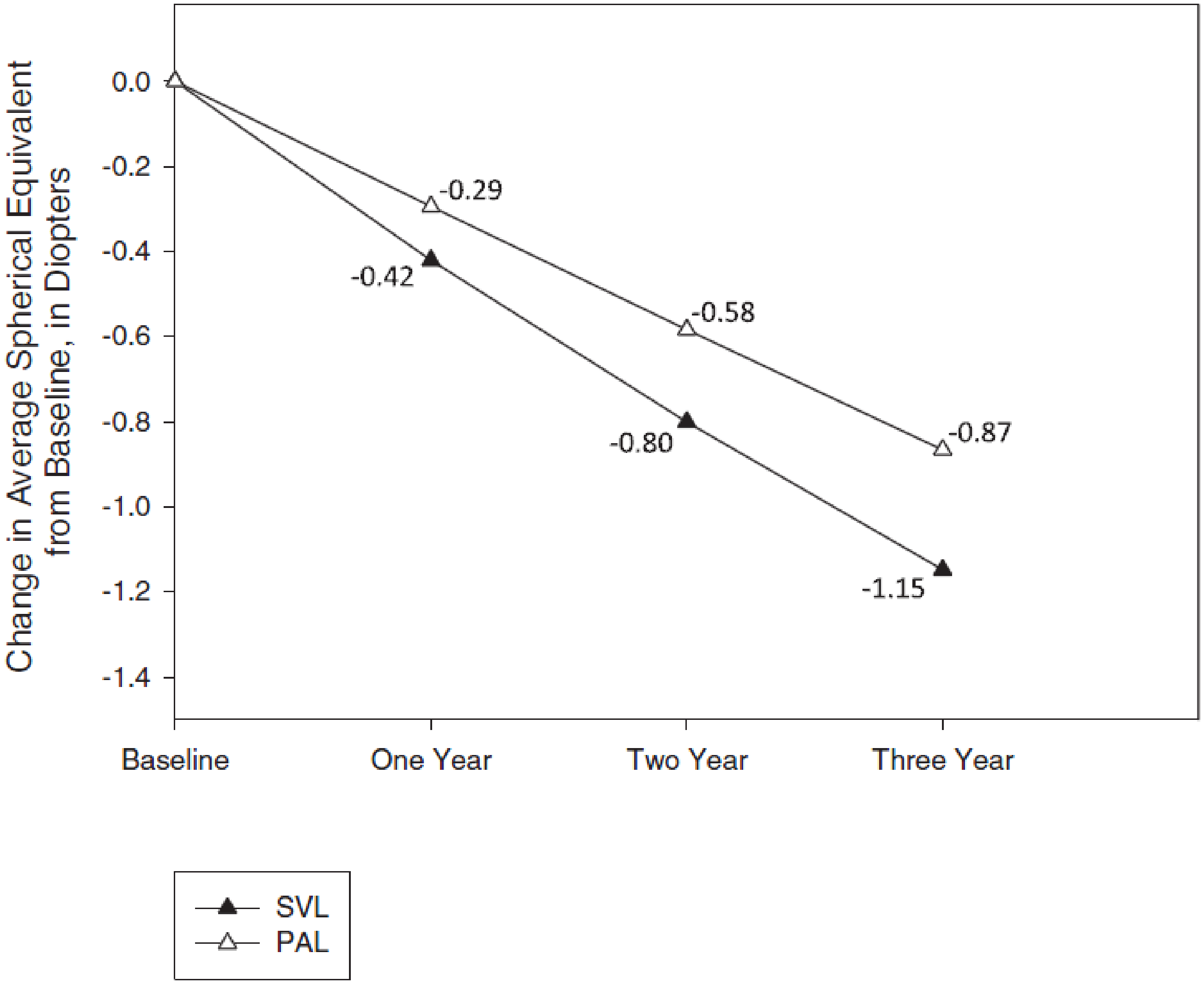
Progressive Addition Lenses

Study	Difference
COMET (Gwiazda, 2003)	0.17 (0.10, 0.24)
Edwards (2002)	0.21 (–0.06, 0.48)
MIT (Shih, 2001)	0.03 (–0.46, 0.52)
Total	**0.17 (0.10, 0.24)**

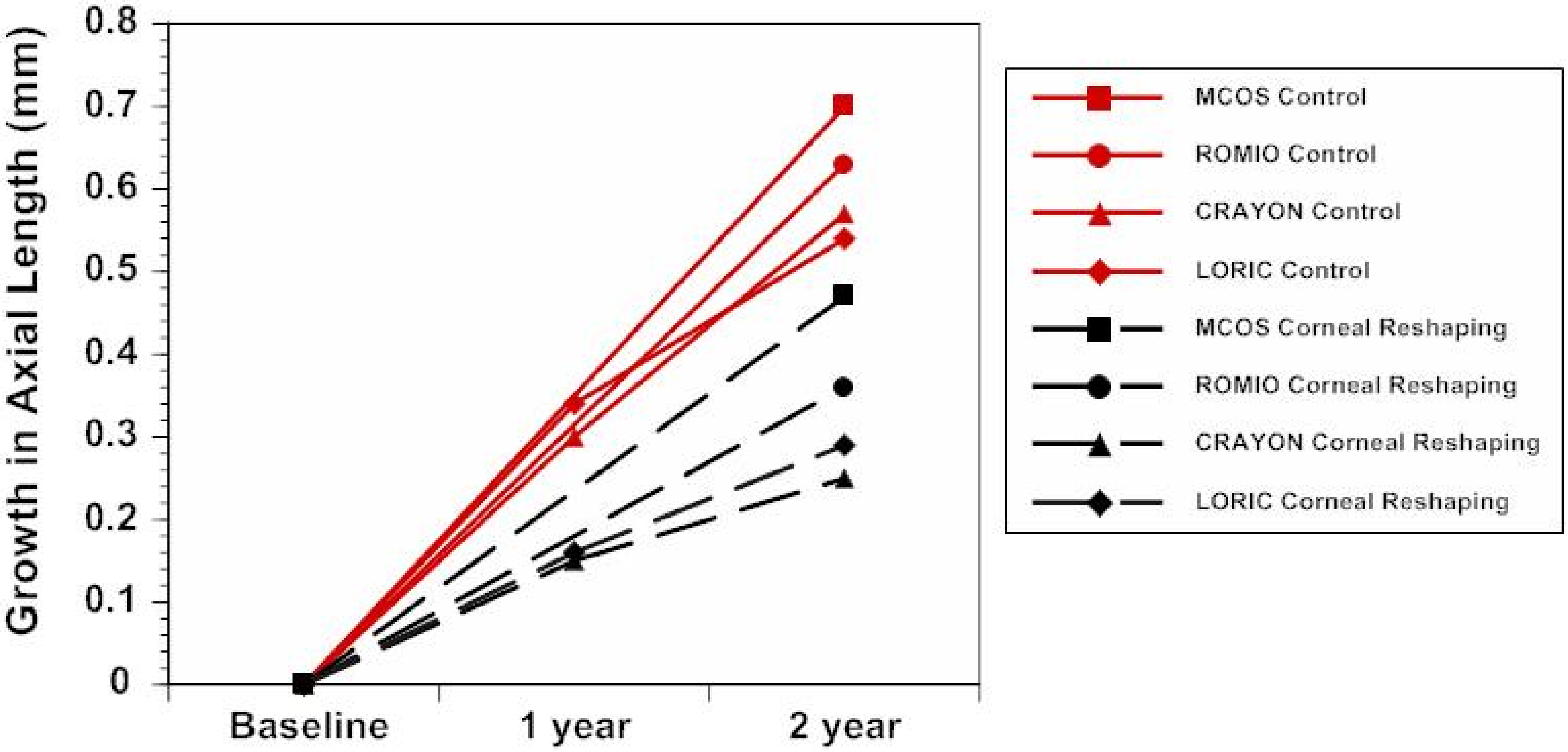


High lagging esophore treatment effect predicted ≈ 0.60 D

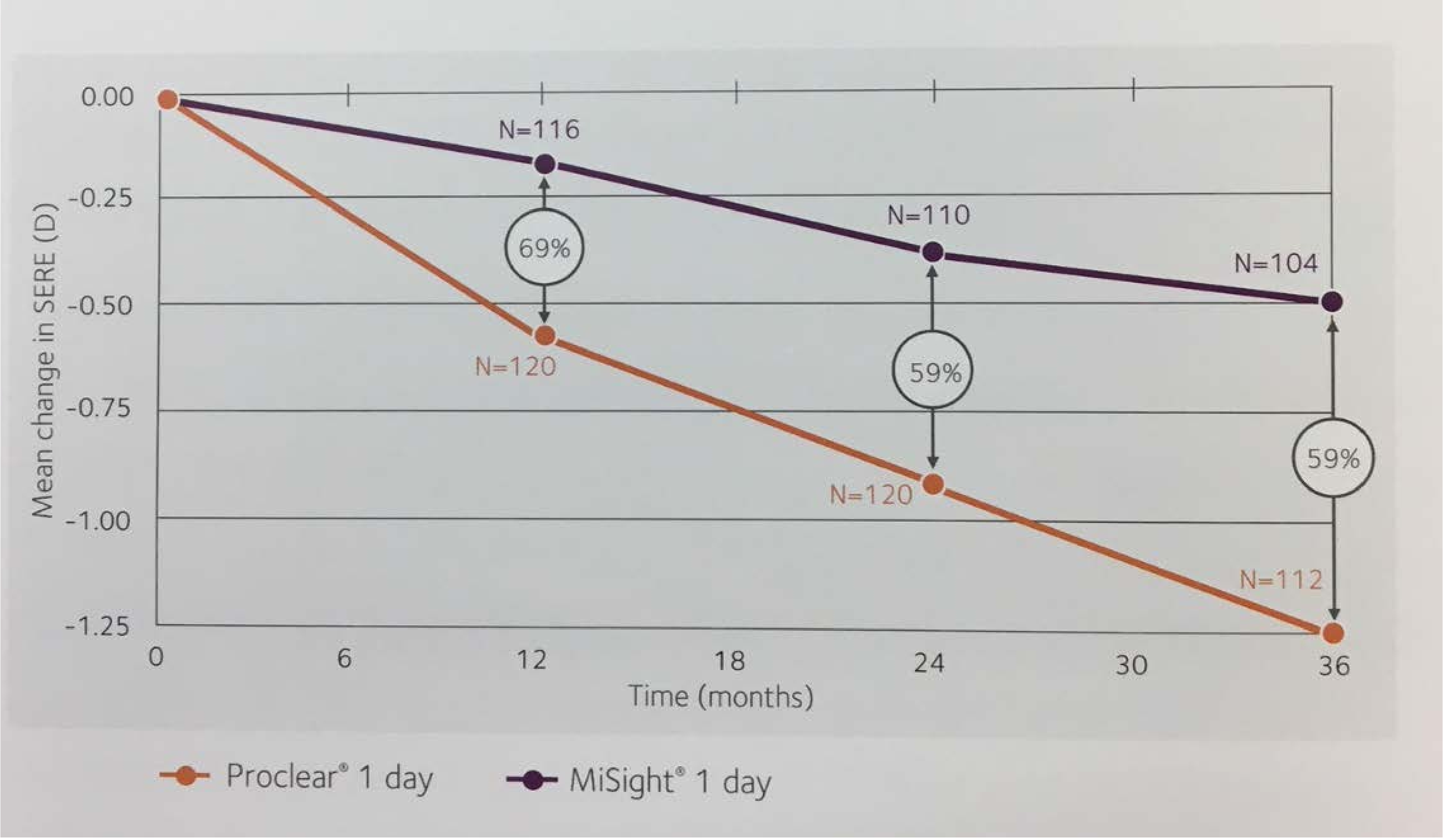
COMET 2 (2011)



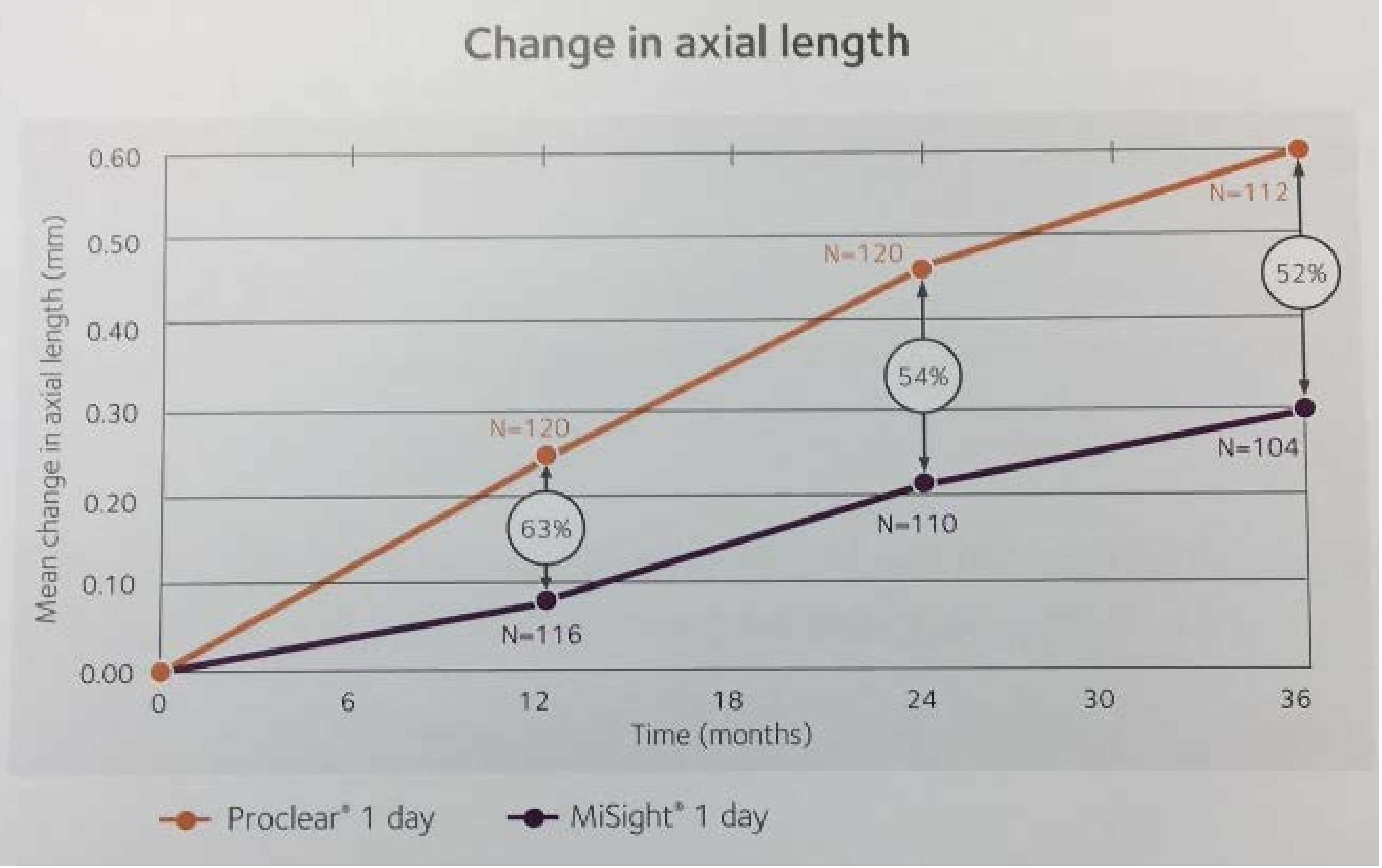
Corneal Reshaping Contact Lenses



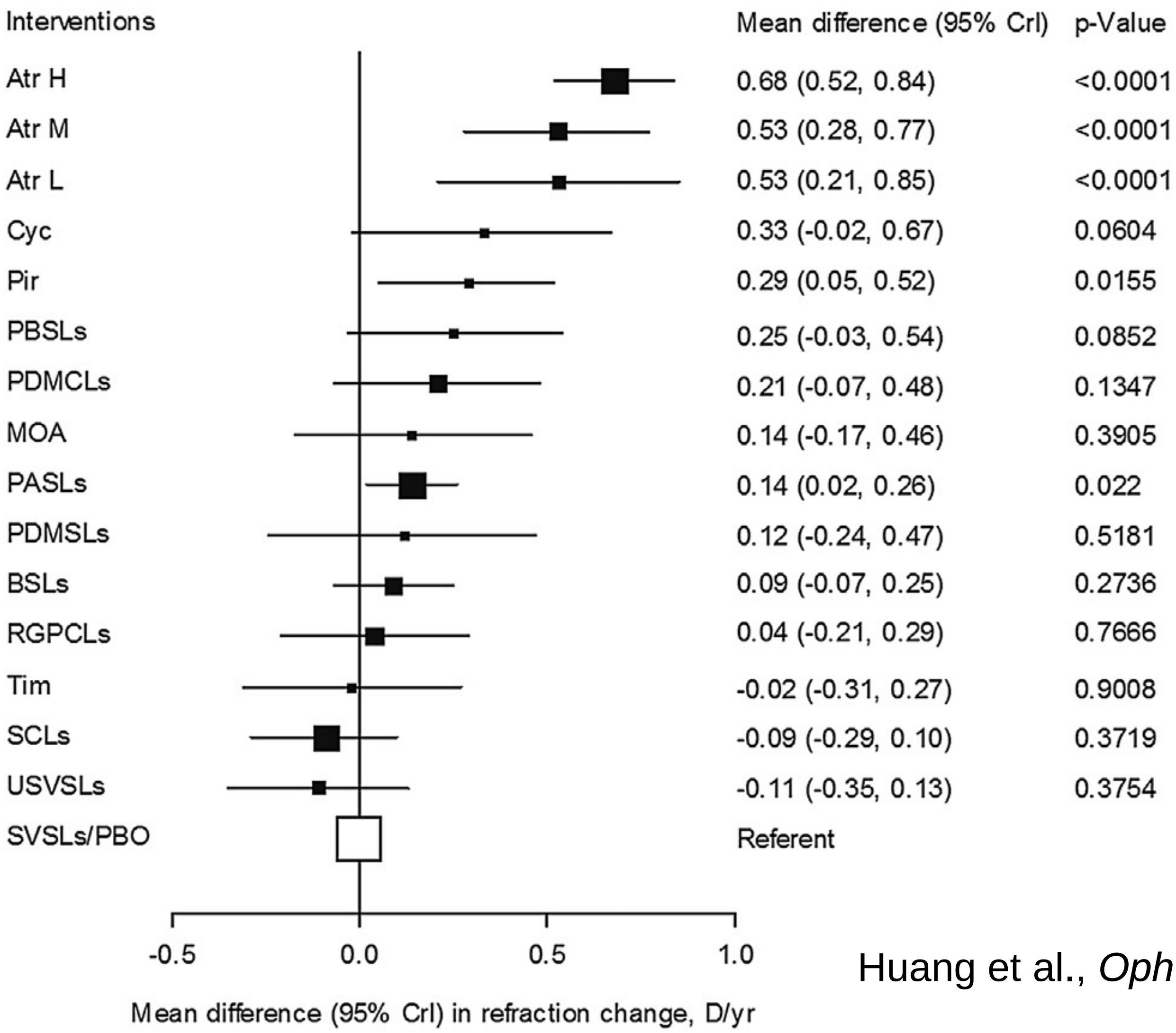
MiSight 3-year Results (Chamberlain, AAO 2017)



MiSight 3-year Results (Chamberlain, AAO 2017)



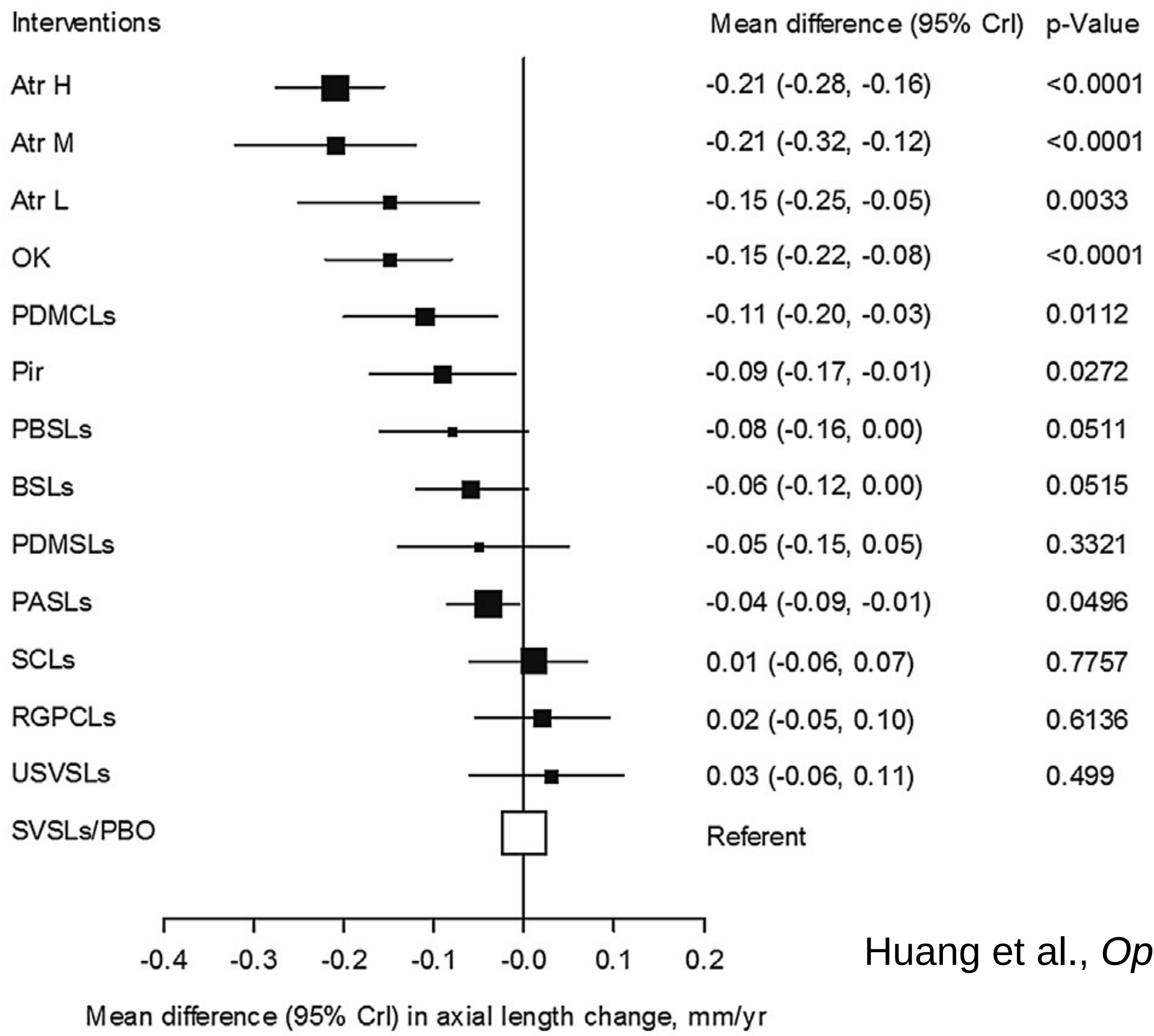
Refractive Error Forest Plot for Myopia Treatments



Interventions	Mean difference (95% Crl)	p-Value
Atr H	0.68 (0.52, 0.84)	<0.0001
Atr M	0.53 (0.28, 0.77)	<0.0001
Atr L	0.53 (0.21, 0.85)	<0.0001
Cyc	0.33 (-0.02, 0.67)	0.0604
Pir	0.29 (0.05, 0.52)	0.0155
PBSLs	0.25 (-0.03, 0.54)	0.0852
PDMCLs	0.21 (-0.07, 0.48)	0.1347
MOA	0.14 (-0.17, 0.46)	0.3905
PASLs	0.14 (0.02, 0.26)	0.022
PDMSLs	0.12 (-0.24, 0.47)	0.5181
BSLs	0.09 (-0.07, 0.25)	0.2736
RGPCLs	0.04 (-0.21, 0.29)	0.7666
Tim	-0.02 (-0.31, 0.27)	0.9008
SCLs	-0.09 (-0.29, 0.10)	0.3719
USVSLs	-0.11 (-0.35, 0.13)	0.3754
SVSLs/PBO	Referent	

Huang et al., *Ophthalmology* 2016

Axial Length Forest Plot for Myopia Treatments

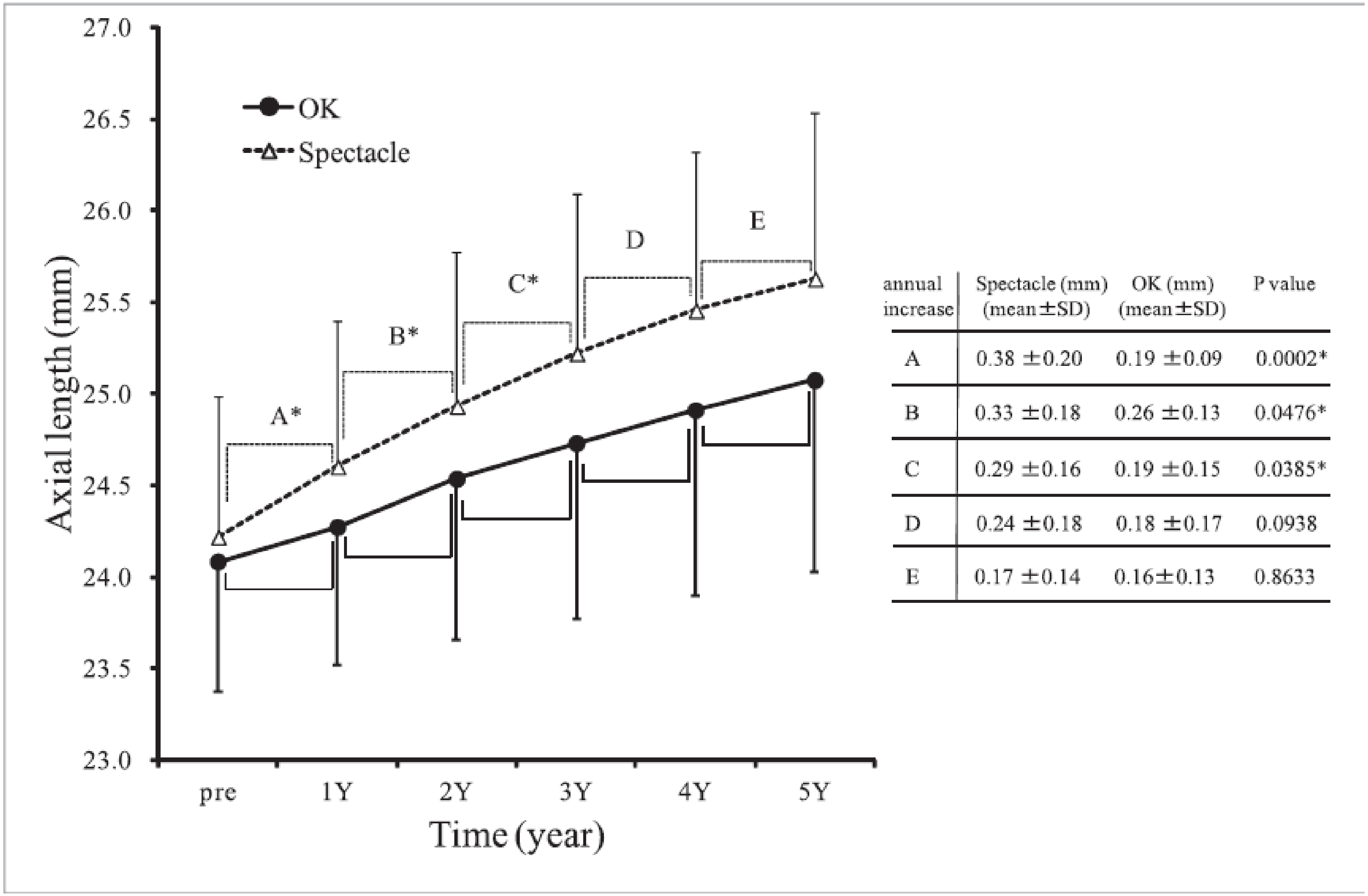


Interventions	Mean difference (95% CrI)	p-Value
Atr H	-0.21 (-0.28, -0.16)	<0.0001
Atr M	-0.21 (-0.32, -0.12)	<0.0001
Atr L	-0.15 (-0.25, -0.05)	0.0033
OK	-0.15 (-0.22, -0.08)	<0.0001
PDMCLs	-0.11 (-0.20, -0.03)	0.0112
Pir	-0.09 (-0.17, -0.01)	0.0272
PBSLs	-0.08 (-0.16, 0.00)	0.0511
BSLs	-0.06 (-0.12, 0.00)	0.0515
PDMSLs	-0.05 (-0.15, 0.05)	0.3321
PASLs	-0.04 (-0.09, -0.01)	0.0496
SCLs	0.01 (-0.06, 0.07)	0.7757
RGPCLs	0.02 (-0.05, 0.10)	0.6136
USVSLs	0.03 (-0.06, 0.11)	0.499
SVSLs/PBO	Referent	

Huang et al., *Ophthalmology* 2016

Overnight ortho-K — Efficacy over time?

Hiraoka et al. (2012)



annual increase	Spectacle (mm) (mean±SD)	OK (mm) (mean±SD)	P value
A	0.38 ±0.20	0.19 ±0.09	0.0002*
B	0.33 ±0.18	0.26 ±0.13	0.0476*
C	0.29 ±0.16	0.19 ±0.15	0.0385*
D	0.24 ±0.18	0.18 ±0.17	0.0938
E	0.17 ±0.14	0.16±0.13	0.8633

Brien Holden Vision Institute Myopia Calculator

Myopia Management Option:

Multifocal soft contact lenses

Percentage reduction in progression of myopia compared to standard correction e.g. single vision spectacles.

49%

If treated with **Multifocal soft contact lenses** that provides **49%** control, then the level of myopia at **17** may be:

-3.97D

If myopia control treatment is not commenced immediately, the final level of your child's myopia at **17** may be:

-7.31D

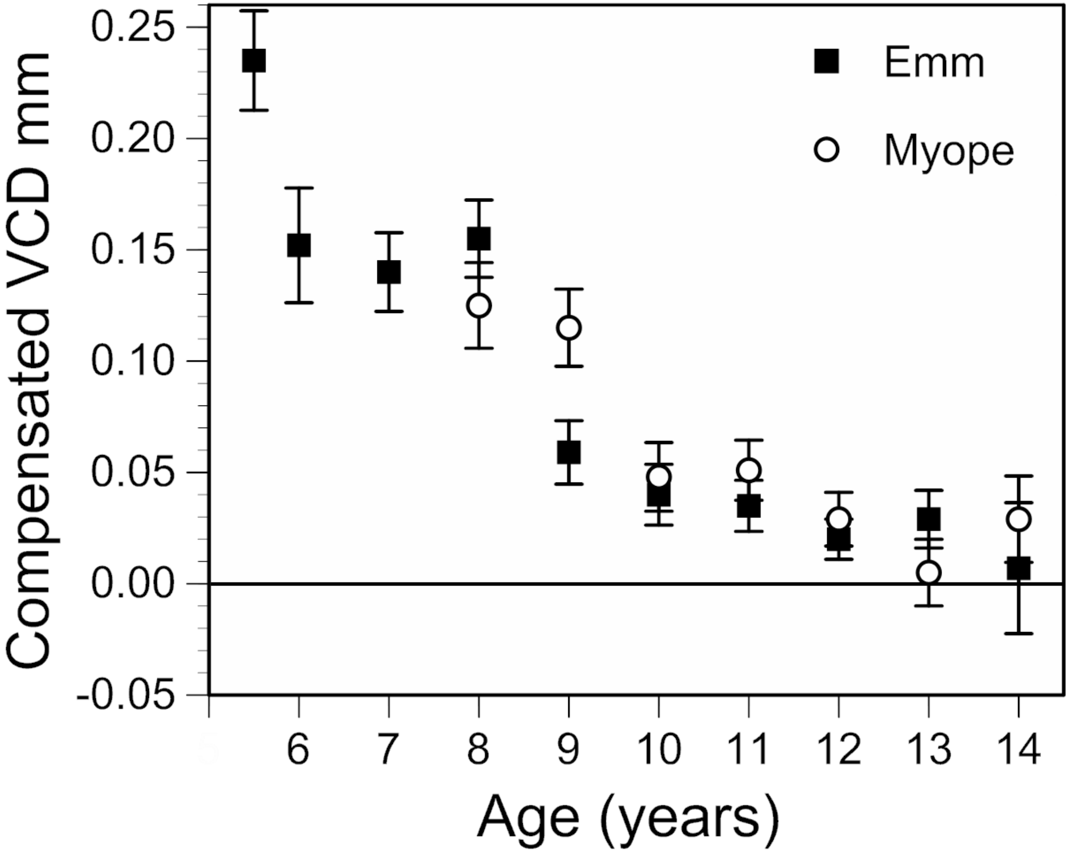
Percentage, or offset?

https://calculator.brienholdenvision.org/

- Instead of imperfect, incomplete myopia control after onset, why not try to delay myopia onset?

- Assuming progression remains normal after delayed onset, every year of delayed myopia onset is 100% myopia control.

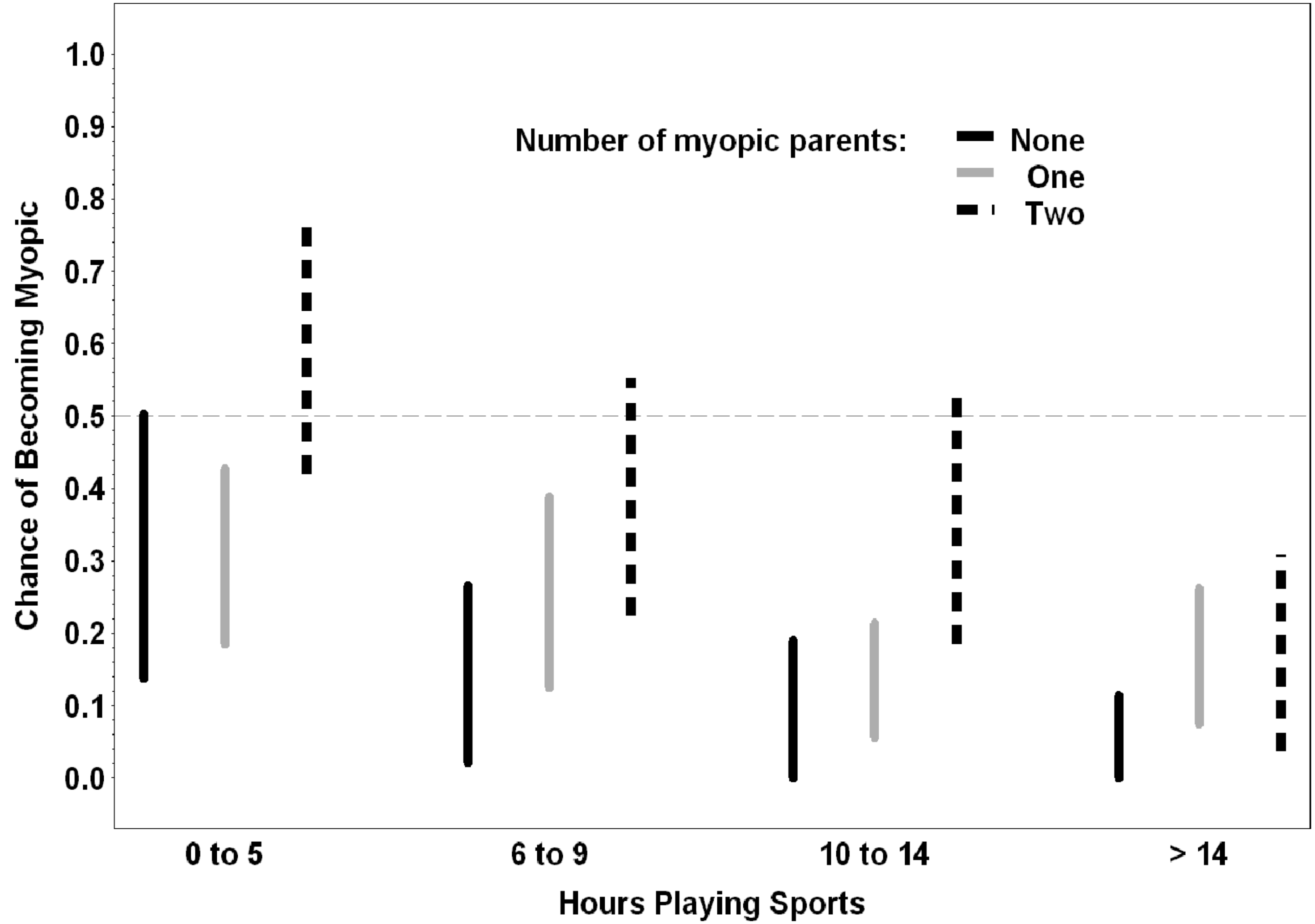
Make the Future Myope have an Emmetrope’s Growth Rate



Age Group P<0.0001; Ref. Error Group P = 0.35; Interaction P = 0.16

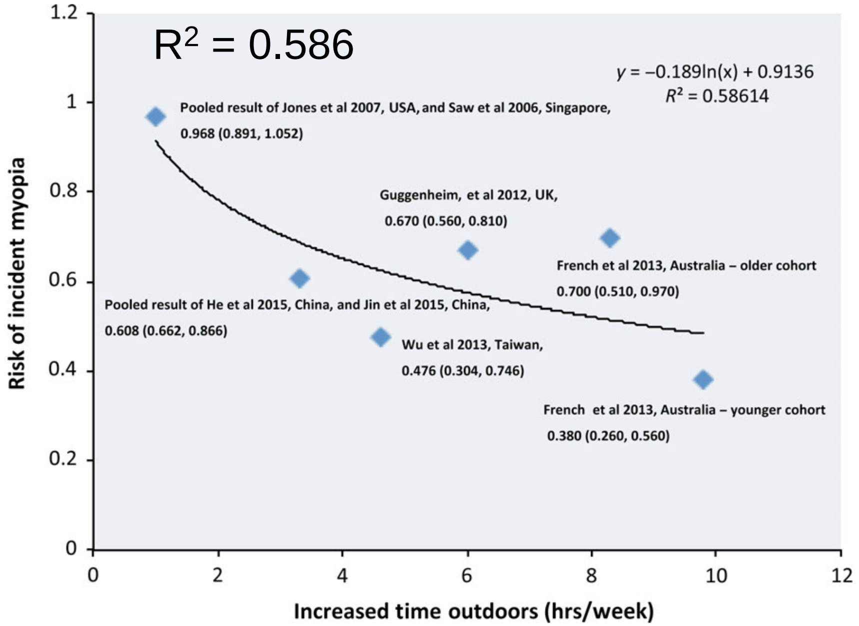
Time Outdoors Reduces Risk of Onset

Jones et al., *Invest Ophthalmol Vis Sci, 2007*

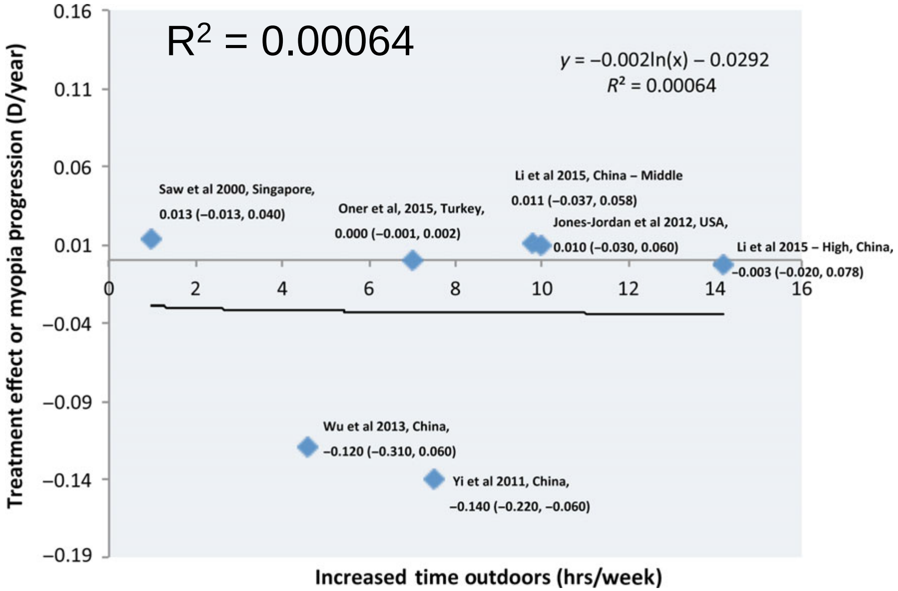


Time outdoors affects risk of onset but not rate of progression

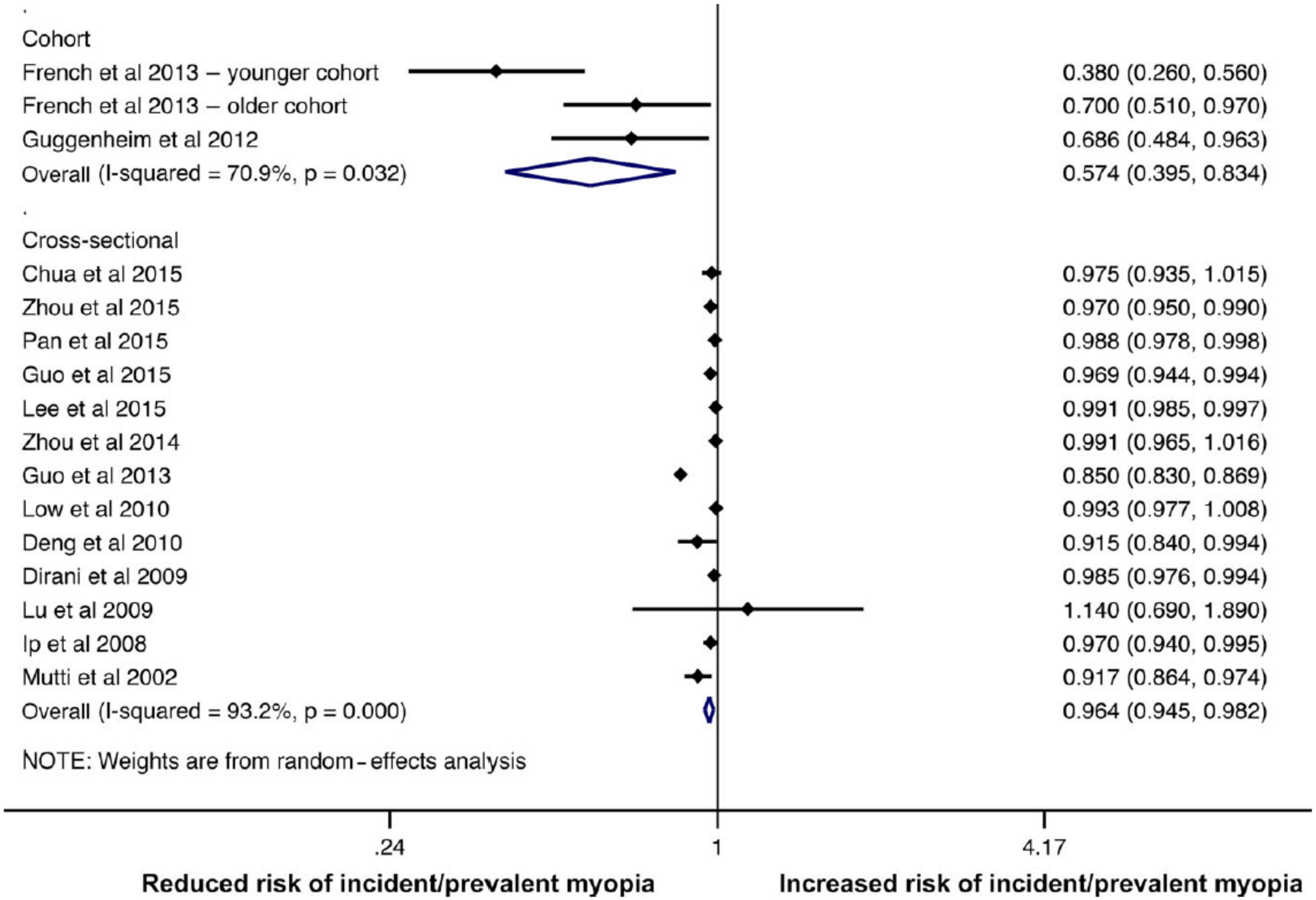
Risk of Onset



Rate of Progression



Xiong et al., *Acta Ophthalmologica* 2017



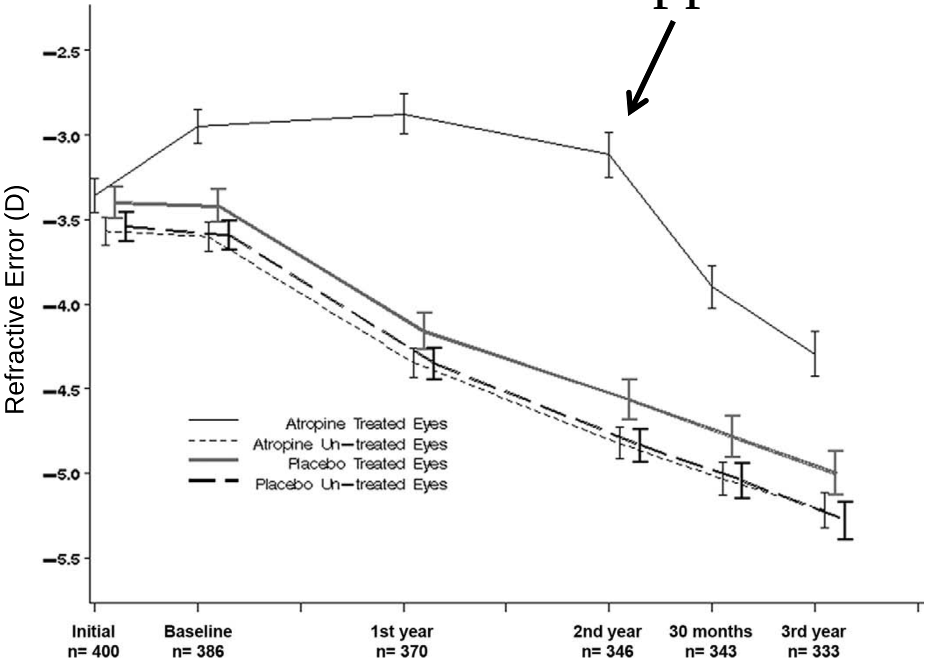
Cohort	
French et al 2013 – younger cohort	0.380 (0.260, 0.560)
French et al 2013 – older cohort	0.700 (0.510, 0.970)
Guggenheim et al 2012	0.686 (0.484, 0.963)
Overall (I-squared = 70.9%, p = 0.032)	0.574 (0.395, 0.834)
Cross-sectional	
Chua et al 2015	0.975 (0.935, 1.015)
Zhou et al 2015	0.970 (0.950, 0.990)
Pan et al 2015	0.988 (0.978, 0.998)
Guo et al 2015	0.969 (0.944, 0.994)
Lee et al 2015	0.991 (0.985, 0.997)
Zhou et al 2014	0.991 (0.965, 1.016)
Guo et al 2013	0.850 (0.830, 0.869)
Low et al 2010	0.993 (0.977, 1.008)
Deng et al 2010	0.915 (0.840, 0.994)
Dirani et al 2009	0.985 (0.976, 0.994)
Lu et al 2009	1.140 (0.690, 1.890)
Ip et al 2008	0.970 (0.940, 0.995)
Mutti et al 2002	0.917 (0.864, 0.974)
Overall (I-squared = 93.2%, p = 0.000)	0.964 (0.945, 0.982)

NOTE: Weights are from random-effects analysis

Xiong et al., *Acta Ophthalmologica* 2017

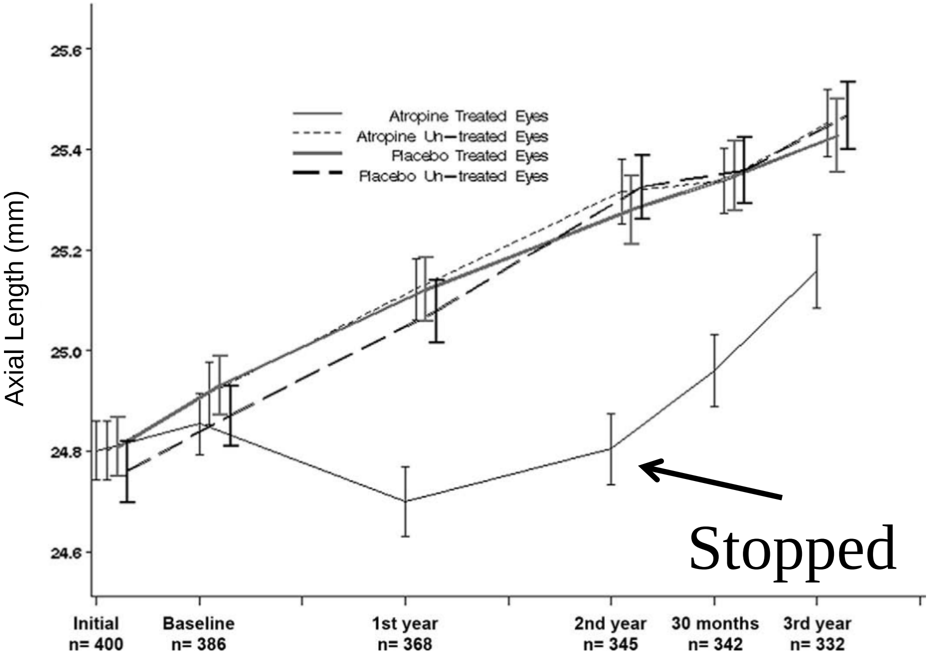
Why not Atropine?
Stopping Atropine — Rebound

Tong et al. (2009)



Stopped

Refractive Error



Stopped

Axial Length

Rebound and Shift in Baseline

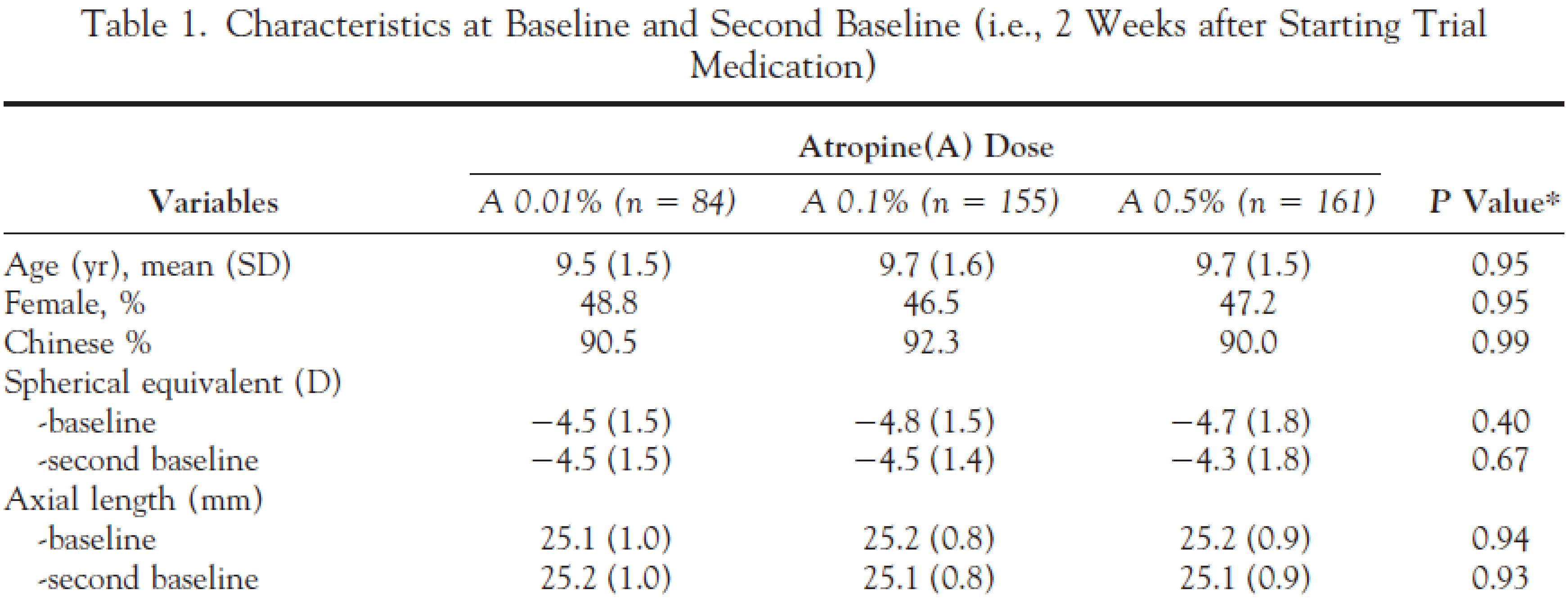


Table 1. Characteristics at Baseline and Second Baseline (i.e., 2 Weeks after Starting Trial Medication)

Variables	Atropine(A) Dose A 0.01% (n = 84)	A 0.1% (n = 155)	A 0.5% (n = 161)	P Value*
Age (yr), mean (SD)	9.5 (1.5)	9.7 (1.6)	9.7 (1.5)	0.95
Female, %	48.8	46.5	47.2	0.95
Chinese %	90.5	92.3	90.0	0.99
Spherical equivalent (D)				
-baseline	−4.5 (1.5)	−4.8 (1.5)	−4.7 (1.8)	0.40
-second baseline	−4.5 (1.5)	−4.5 (1.4)	−4.3 (1.8)	0.67
Axial length (mm)				
-baseline	25.1 (1.0)	25.2 (0.8)	25.2 (0.9)	0.94
-second baseline	25.2 (1.0)	25.1 (0.8)	25.1 (0.9)	0.93

Table 1, Chia et al., *Ophthalmology* 2012

Shift in Baseline Effect on SE and AL Results

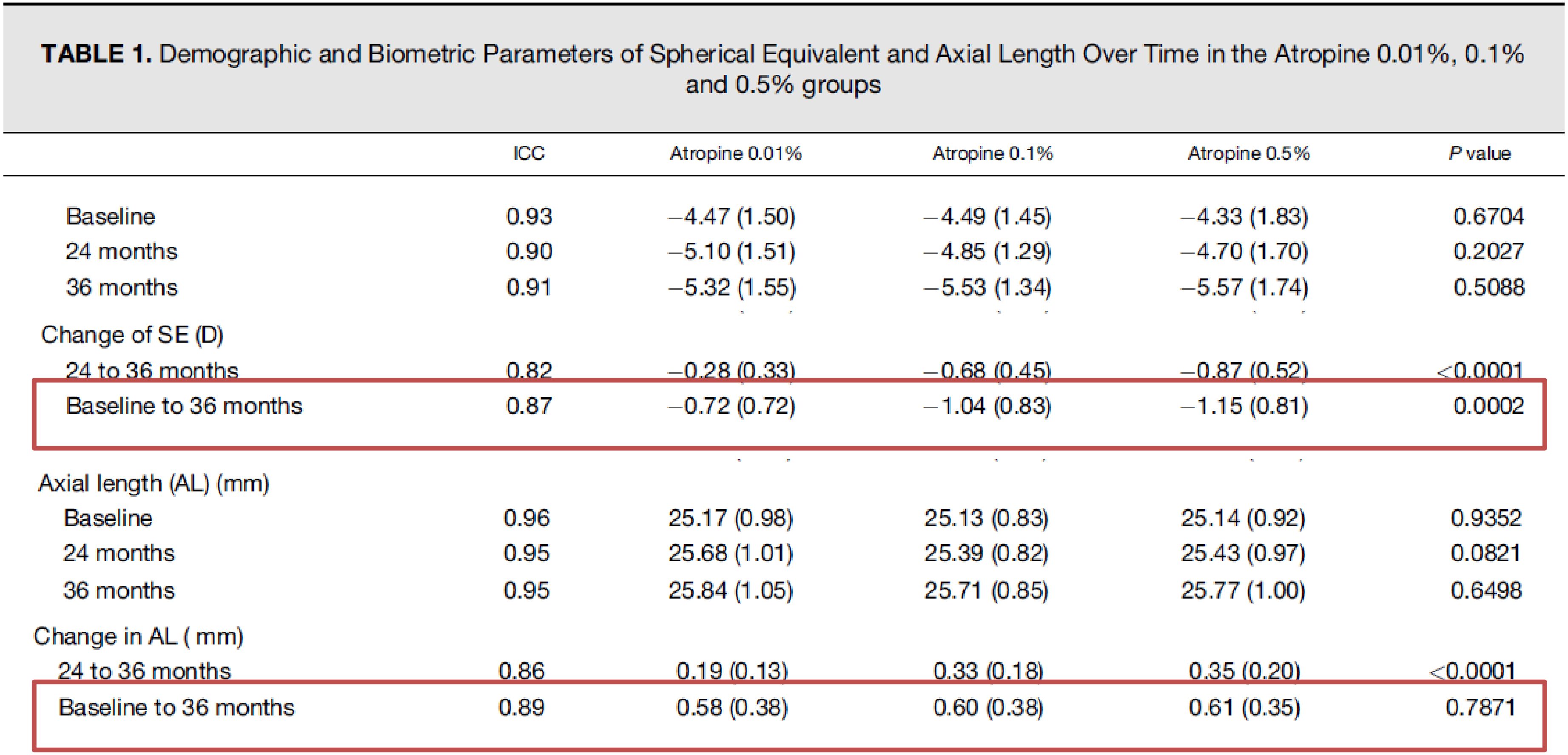
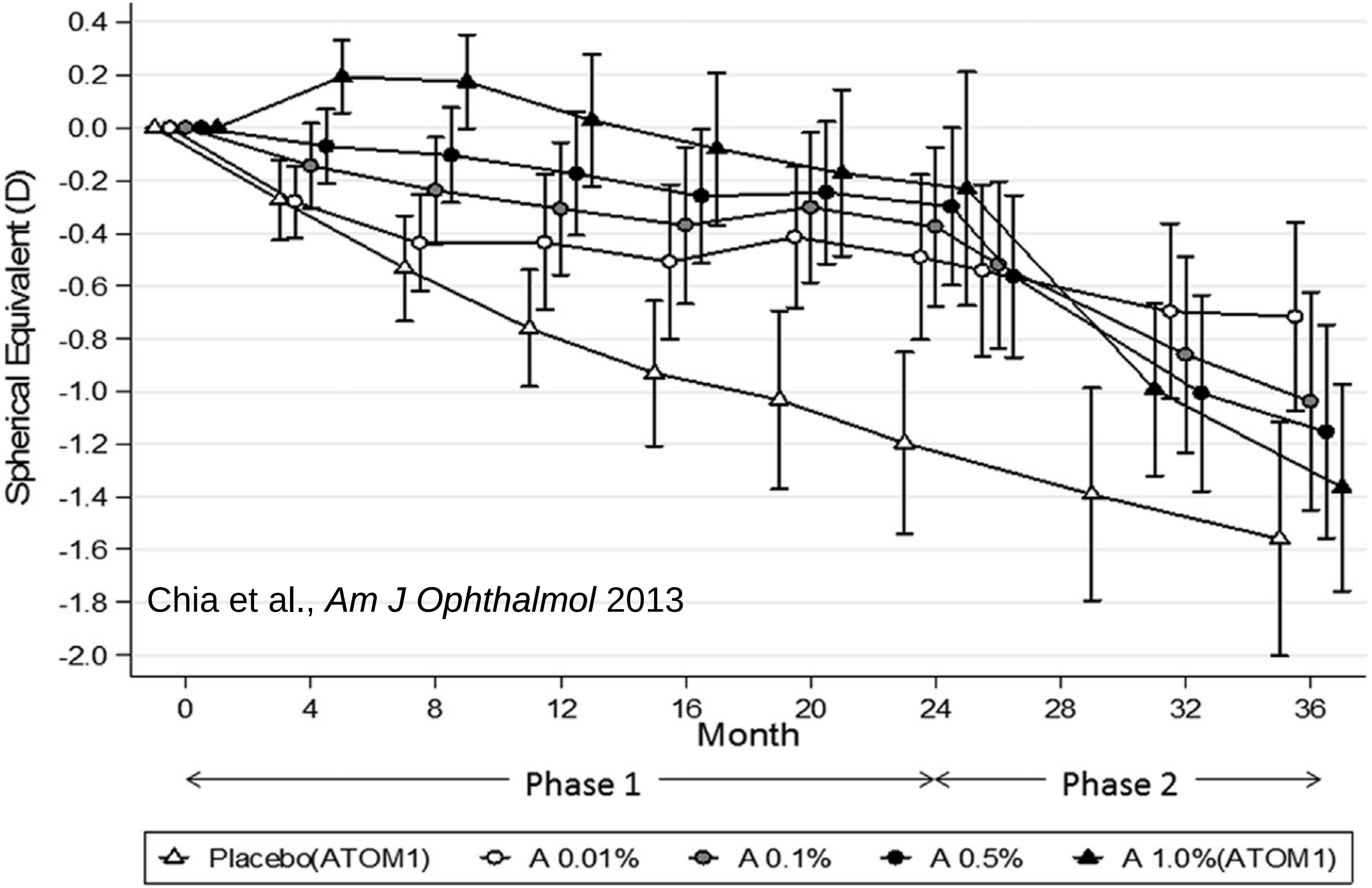


TABLE 1. Demographic and Biometric Parameters of Spherical Equivalent and Axial Length Over Time in the Atropine 0.01%, 0.1% and 0.5% groups

	ICC	Atropine 0.01%	Atropine 0.1%	Atropine 0.5%	*P* value
Baseline	0.93	−4.47 (1.50)	−4.49 (1.45)	−4.33 (1.83)	0.6704
24 months	0.90	−5.10 (1.51)	−4.85 (1.29)	−4.70 (1.70)	0.2027
36 months	0.91	−5.32 (1.55)	−5.53 (1.34)	−5.57 (1.74)	0.5088
Change of SE (D)					
24 to 36 months	0.82	−0.28 (0.33)	−0.68 (0.45)	−0.87 (0.52)	<0.0001
Baseline to 36 months	0.87	−0.72 (0.72)	−1.04 (0.83)	−1.15 (0.81)	0.0002
Axial length (AL) (mm)					
Baseline	0.96	25.17 (0.98)	25.13 (0.83)	25.14 (0.92)	0.9352
24 months	0.95	25.68 (1.01)	25.39 (0.82)	25.43 (0.97)	0.0821
36 months	0.95	25.84 (1.05)	25.71 (0.85)	25.77 (1.00)	0.6498
Change in AL (mm)					
24 to 36 months	0.86	0.19 (0.13)	0.33 (0.18)	0.35 (0.20)	<0.0001
Baseline to 36 months	0.89	0.58 (0.38)	0.60 (0.38)	0.61 (0.35)	0.7871

Table 1, Chia et al., *Am J Ophthalmol* 2013

0.6 mm translates to about -1.50 D of progression, like ATOM controls



Chia et al., *Am J Ophthalmol* 2013

Potential Impact of Delayed Onset

Myopia Management Option:

Multifocal soft contact lenses

Percentage reduction in progression of myopia compared to standard correction e.g. single vision spectacles.

49%

If treated with **Multifocal soft contact lenses** that provides **49%** control, then the level of myopia at **17** may be:

-3.97D

If myopia control treatment is not commenced immediately, the final level of your child's myopia at **17** may be:

-7.31D

https://calculator.brienholdenvision.org/

Conclusions and Questions

- Time outdoors reduces the risk of the onset of myopia but not the rate of progression.
- Delaying onset (time outdoors or low-dose atropine) may be an effective strategy for myopia control.
- Long-term data from outdoor intervention trials will be very valuable.
- Myopes may have reduced ability to benefit from time outdoors in addition to spending less time outdoors.
- Born that way or is this from time outdoor habits?
- How young to start and how much time outdoors is beneficial?
- Why can myopes benefit from optical treatments but not benefit from time outdoors?

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