

## THE INSTITUTE OF OPTOMETRY



"The Institute of Optometry is unique in being an independent self-financing charity dedicated to the promotion of clinical excellence, research, and education in optometry."  
Roberson (1989)

## What is normal binocular vision?

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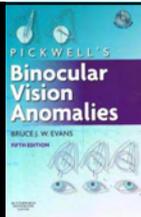
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Reference: Pickwell's Binocular Vision Anomalies, 5th Edition, Elsevier, 2007

## DISCLOSURE

- Paid lectures & KOL/product feedback programmes:
  - Alcon, American Academy of Optometry (UK), Association of Optometrists, Birmingham Focus on Blindness, Black & Lizars, Central (LOC) Fund, Cerium Visual Technologies, College of Optometrists, Coopervision, ESRC, General Optical Council, Hoya Institute of Optometry, International Institute for Colorimetry, IFS Fund for Prevention of Blindness, Johnson & Johnson, Leightons, London Vision Clinic, MRC, Norville, Optos, Paul Hamlyn Trust, Perceptive, Scrivens, Specsavers, Thomas Pocklington Trust.
  - Lecture content: always my own
- Author of Pickwell's Binocular Vision Anomalies, editions 3-5
- i.O.O. Sales Ltd markets IFS orthoptic exercises, which the speaker designed, and for which he receives a small royalty
- Community optometric practice in Brentwood, Essex



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Staff optometrists: Miss A. Shah BSc MSc MCOptom, Mr L. Marshall BSc (Phys) BSc (Optom) MCOptom  
Senior opticians: Mrs J. Powell FRCO, Staff opticians: Mr N. Cotton FRCO

Thank you!

## PLAN

Introduction

Why?

How?

What?

Conclusions

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for regular tweets on optometric research

## Masterclass: binocular vision & paediatrics

- Normal binocular vision, stereopsis, & non-strabismic conditions
- Strabismus & incomitancy
- Babies & infants
- School-age children
- Myopia control

**EYE & VISION MASTERCLASS WITH PLYMOUTH UNIVERSITY**  
HOYA  
Series 3: Binocular Vision and Paediatrics  
3.1: Normal binocular vision and stereopsis  
8-9 September 2017 (Friday 12 noon - Saturday 3 pm)  
School of Health Professions, Plymouth University

**NHS**  
Binocular Vision and Paediatrics: normal binocular vision and stereopsis in the newborn and exotropia  
(Babies, infants, children, and adolescents) (Free module content)  
www.nhs.uk/eyeandvision

Faculty:  
Professor Ian Cooper  
Professor Emerita  
Vivienne de Gooch  
Medical Graduate  
William Thompson  
Optometrist



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## OVERVIEW: WHY?





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## Orthoptics for the community optometrist

- Strabismus is rare, affecting <3% of children Leone et al. (2010)
- Heterophoria is present in most children (Leone et al. (2010) & is a normal finding in most cases Feier & Pickwell (1983); Jimenez et al. (2004)
- Even patients who appear to be orthophoric will, in 95% of cases, be heterophoric after prolonged occlusion Marlow (1930)
- Heterophoria usually is only of interest if it is decompensated Evans (2007)

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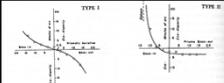
## How does binocular vision work?

- Normal retinal correspondence & Panum's fusional areas
- Stereopsis
- Binocular summation

## Corresponding retinal points aren't enough

- Normal participants during natural conditions make vergence errors of 30-120 mins arc (°) Cornell et al. (2003)
  - No participants reported diplopia despite vergence errors of up to 5 degrees
- Panum's fusional areas give some flexibility in sensory fusion to compensate for motor fusion errors Collewijn et al. (1991)
  - suppression probably also contributes Cornell et al. (2003)
- Fixation disparity is the spatial manifestation of Panum's fusional area and was first fully explored by Ogle Ogle et al. (1949; 1962)
- FD is the vergence error within Panum's area Jaschinski et al. (1999)

TYPE I



TYPE II

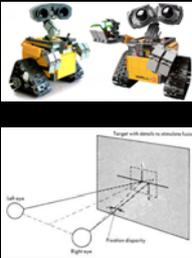


TYPE III



TYPE IV

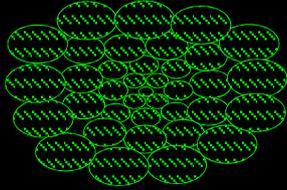




**FIGURE 2-13.** Testing arrangement to determine fixation disparity. (From Hartman et al., Ogle et al.; Observations on accommodative convergence, especially its nonlinear relationships. Am J Ophthalmol. 47:455, 1956.)

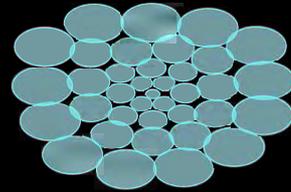
## Panum's areas (PAs)

- normally each Panum's area (PA) on 1 retina corresponds with an equivalent one in the other eye
- central PA's smaller than peripheral



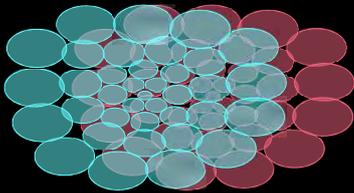
## Fully compensated phoria

- perfect binocular vision; no fixation disparity
- corresponding PAs aligned



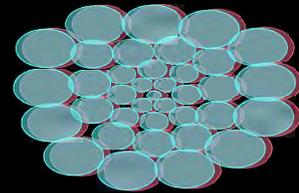
## Strabismus

- even largest corresponding PAs no longer aligned
- must be diplopia or global suppression or ARC



## Small fixation disparity

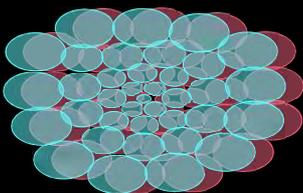
- still binocular single vision; all corresponding PAs aligned
- no foveal suppression; may be symptoms



**DANGER: OVER-SIMPLIFICATION ALERT!**

## Larger fixation disparity

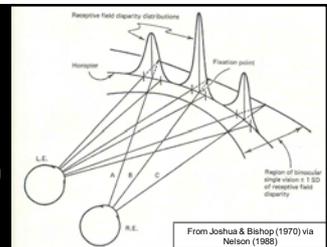
- still binocular single vision over most of retina;
- smallest corresponding PAs not aligned
- likely to be foveal suppression or symptoms



Dimensions of PAs changes with stimulus & sensory correspondence changes

## A proper model (Bishop's)

- Proposed corresponding points are points covered by the most common single-unit tuning
  - Zero disparity tuning giving optimal response
  - Hypothetically, defines limits of sensory fusion (Panum's areas) as the disparity tunings lying  $\pm 1SD$  from the mean tuning (i.e., from the horopter)
- Sensory fusion is the achievement of single vision from slightly dissimilar monocular images
- Stereopsis is a response to disparate stimulation of the retinal elements
- Retinal disparity drives motor fusion



## How does binocular vision work?

- Normal retinal correspondence & Panum's fusional areas
- Stereopsis
- Binocular summation



Are these examples of purely bad parking by bad drivers or examples of poor stereopsis?

(Image adapted from the internet)

## Binocular summation

- An increase in the binocular response compared with the monocular
  - Occurs when each eye has similar sensitivity
  - 2 is better than 1 (Pardhan et al., 1990)
- When one eye's image is degraded, the binocular response decreases until 2 is worse than 1
- Clinical significance:
  - In cataract: high contrast testing: BE = best eye  
Low contrast testing: BE < best eye (Pardhan, 1993)
  - Second eye cataract surgery improves binocular summation as well as stereoacuity (Laidlaw & Harrad, 1993)
  - Uncorrected Rx in one eye may make 2 worse than 1, especially for low contrast & detailed targets

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## DISSOCIATED HETEROPHORIA

fusional reserves → motor fusion ← sensory fusion → fusion lock

COMPENSATED or NOT



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