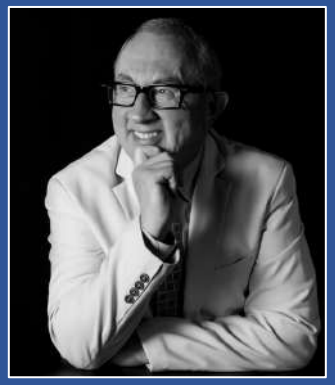
Eye Care For The Aniseikonic Patient

ABO/NCLE Level III - 2 hour



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Financial Disclosure Statement

Andrew Bruce . . .

- Has received honorariums from: VSP Optics
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- Served as Technical Education Advisor on CLSA Board of Directors
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- Has NO financial interest in any product presented in this course
- **All financial disclosures have been mitigated.**

Learning Objectives

- Discuss lens magnification effects and influential factors
- Define aniseikonia, review its related symptoms, explore its various types, and examine treatment options
- Examine binocular vision, retinal correspondence, the horopter, and Panum's area of fusion.
- Present Knapp's law and its implications for the proposed treatment of aniseikonia
- Provide a step-by-step guide to calculate ophthalmic lens magnification, and discuss iseikonic lens design
- Explain why contact lenses continue to be the most effective optical device for treating all aniseikonic patients.

Professional Liability

- Always work within the limits of your scope of practice
- Remember, only doctors can diagnose aniseikonia
- Prior to treatment, consult with prescribing doctor, and document their “ok to proceed”
- Aniseikonia can present as symptoms that can be related to more serious, non-vison issues
- Incorrect treatment due to an incorrect diagnosis can result in masked or delayed treatment of the actual cause
- Good doctor-optician communication makes for a strong relationship.

Refractive States

- Emmetropia
- Ametropia
  - Myopia - axial vs refractive
  - Hyperopia - axial vs refractive
  - Astigmatism - refractive.

Corrective Lenses and Magnification

- All lenses influence image size
- Plus vs. minus lenses
- Degree of influence depends on:
  - Lens thickness
  - Lens material
  - Base curve
  - Back vertex power
  - Back vertex distance.

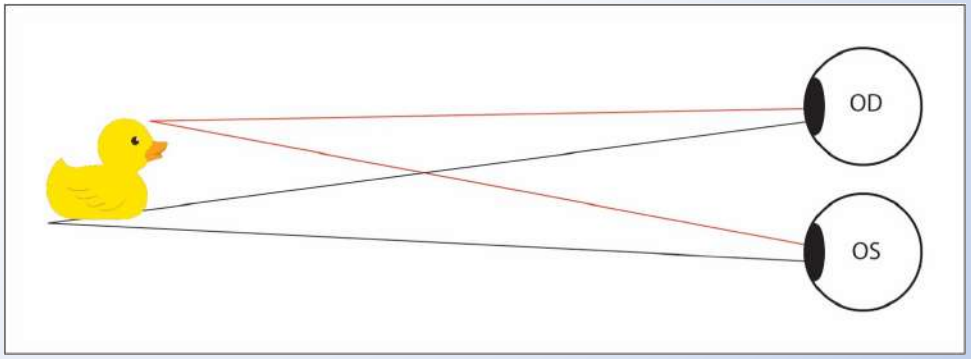
Introduction to Aniseikonia

- Ametropes with significantly different refractive states between each eye can experience complications from the disparities in image size/shape each eye receives
- Known as aniseikonia, a binocular condition defined as:

  "A relative difference in size and/or shape of the ocular images formed by the two eyes."

- Most patients experience < 1% aniseikonia
- > 2% clinically significant
- 3-5%+ highly symptomatic.

Stereopsis

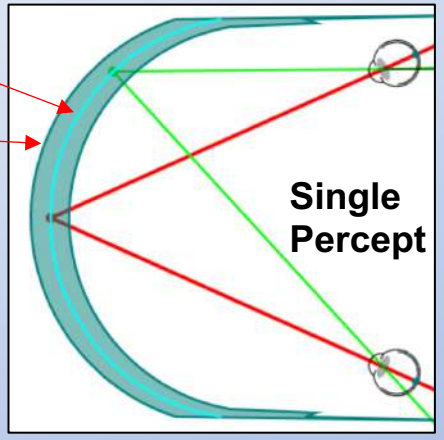


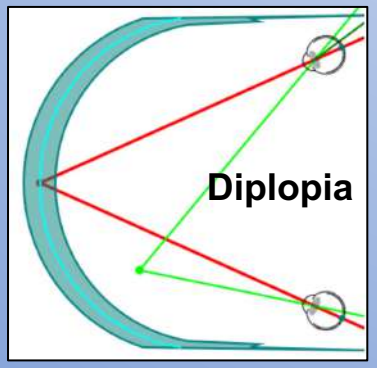
- Stereopsis provides a realistic impression of our environment - depth perception
- To produce a single mental percept from an object, retinal images from both eyes must undergo sensory fusion
- Significant disparity in size between right and left images interferes, resulting in *apparent* changes in environment
- To achieve sensory fusion, object points for each eye must fall within Panum's fusional space.

Horopter and Panum's Area

Horopter
The locus of object points in space simultaneously stimulating corresponding retinal points of the two eyes to result in a single percept

Panum's Fusional Space
Region in space surrounding a *horopter* in which images that appear at different points on the two retinas result in a single percept





Visual targets outside Panum's fusional space (in front or behind), will result in diplopia.

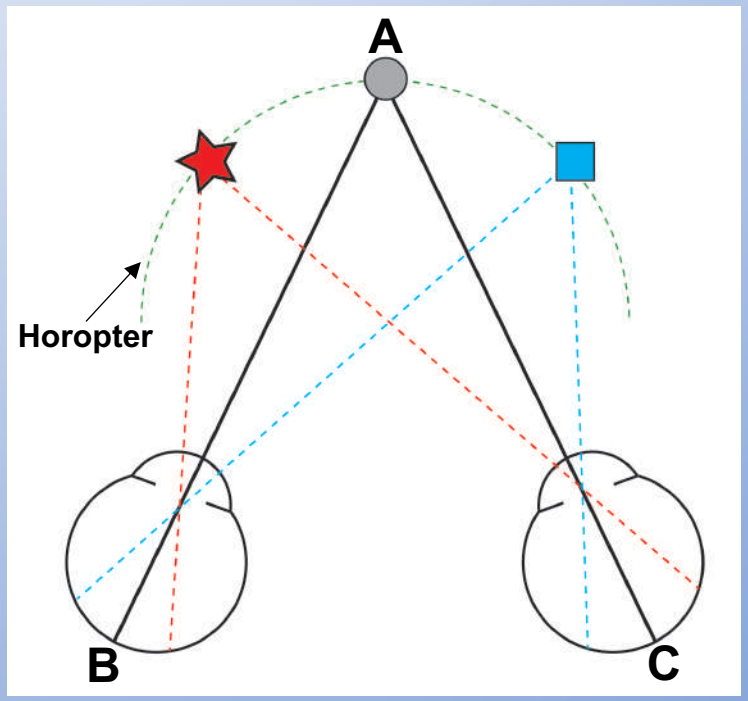
Binocular Vision and Retinal Correspondence

In simple terms . . .

In normal, single binocular vision, all objects on the horopter fall on corresponding retinal areas

All imaged on corresponding retinal points

- Right of fovea on both eyes
- On fovea for both eyes - B & C
- Left of fovea on both eyes.



Etiology of Aniseikonia

- Naturally occurring
- Unintended consequence of ocular surgery
- Sudden-onset - unilateral pseudophakia
- Longstanding binocular differences in ametropia.

Symptoms of Aniseikonia

- Patients often describe how their eyes “feel”
- Tired or sore eyes, tearing, photophobia, induced prismatic effects, and overall fatigue
- Nervousness, headaches, diplopia, disorientation, dizziness, and nausea
- Compromised stereoscopic vision.

Clinically Significant Aniseikonia

Many individuals function normally with subclinical levels

Indicators for Clinical Significance

- Symptoms not helped by, or occurs with the addition of corrective lenses
- High anisometropia or high astigmatism
- Physically altering factors, such as pseudophakia, monocular aphakia, scleral buckling, refractive surgery
- Complaints of distortion
- Improved visual comfort when one eye is occluded.

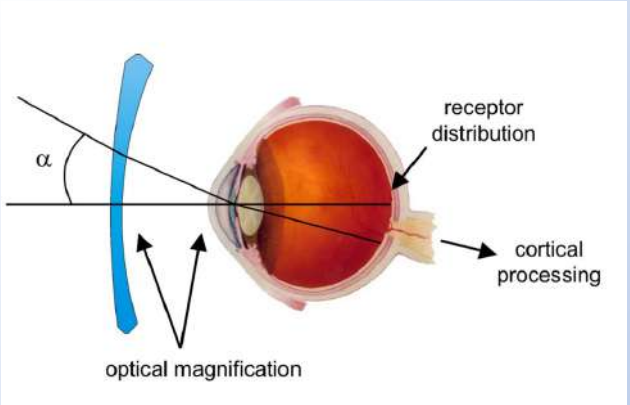
Types of Aniseikonia

- Physiologic/Non-symptomatic
- Anomalous
- Optical
  - Inherent
  - Induced.

Physiologic/Non-symptomatic Aniseikonia

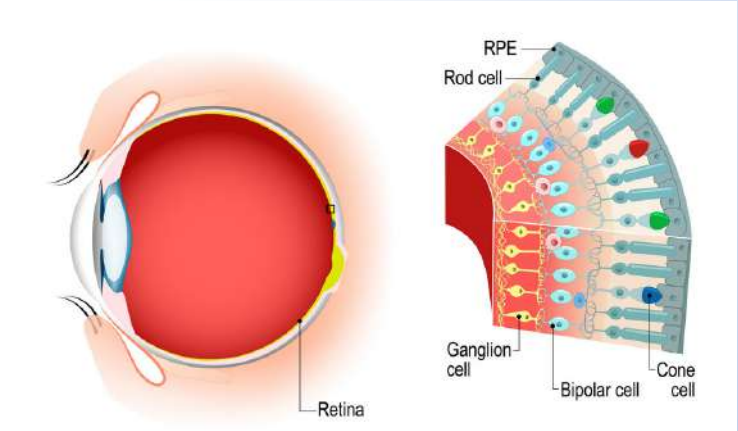
- Occurs in individuals whose eyes are identical in both axial length and refractive properties
- Results from lateral gaze
- Expected and normal
- Serves to provide visual clues that enhance spatial awareness and eye-hand coordination.

Anomalous Aniseikonia



- Any other type than physiologic, often simply referred to as *aniseikonia*
- Indicates an anomaly in either the eye's anatomic structure or caused by the optics of the eyes and/or corrective lenses.

Associated Anatomic Anomalies



- Unequal distribution of rods and cones in retina of one eye vs. the opposite eye, and their representation in visual cortex
- Retinal conditions:
  - Epiretinal membrane - macropsia
  - Macula edema - micropsia
  - Re-attached RD - micropsia
  - Macular holes - micropsia.

Optical Aniseikonia

Inherent Optical Aniseikonia

- Depends on the relative dioptric systems of the right and left eye

Induced Optical Aniseikonia

- Caused by magnification corrective lenses
- Disparities in refractive states of both eyes
- Primarily anisometropia and antimetropia
  - 1D anisometropia ≈ 1% aniseikonia.

Rx Anisometropia vs. Antimetropia

Anisometropia

A condition of unequal refractive state for both eyes

Ex. OD: +4.00 DS OS: +1.00 DS

Antimetropia

Mixed anisometropia

Ex. OD: +2.00 DS OS: -2.00 DS

- Generally considered clinically significant when spherical equivalent power difference >1D exists
- Both conditions can have axial or refractive origin.

Knapp's Law

"When a correcting lens is so placed before the eye that its second principal plane coincides with the anterior focal point of an axially ametropic eye, the size of the retinal image will the same as though the eye were emmetropic."

To simplify . . .

If ametropia is axial related, the retinal image size will be larger or smaller than a normal emmetropic eye. According to Knapp's law, using ophthalmic lenses eye will return image size to normal

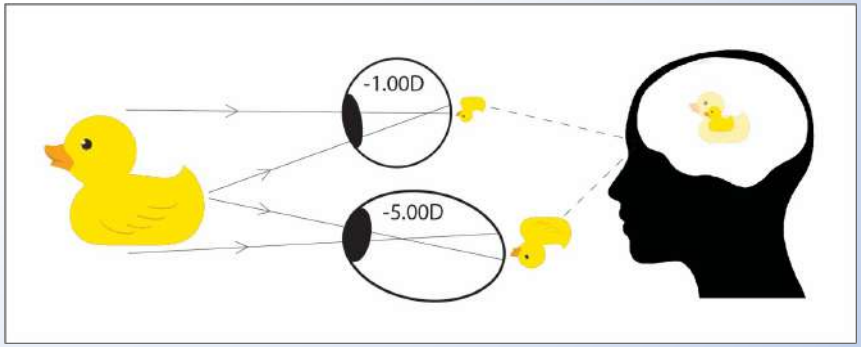
Contact Lenses

Best corrective device for refractive aniseikonia

Ophthalmic Lenses

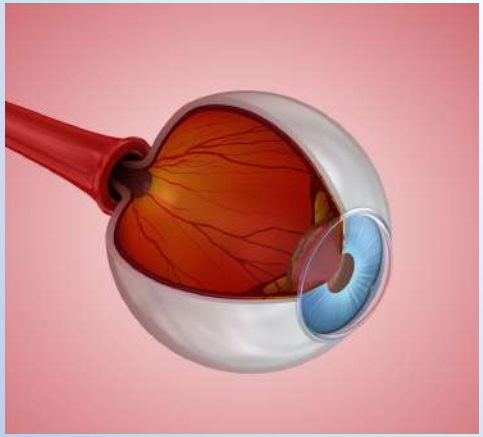
Best corrective devices for axial aniseikonia.

Axial-Related Anisometropia



UNCORRECTED

- Refractive properties provided by cornea and crystalline lens considered same for both eyes
- Optical theory states image size will be different from emmetropic eye because axial length is different - larger for myope, smaller for hyperope
- Aniseikonia WILL exist when uncorrected axial ametropia differs between each eye.



Refractive-Related Anisometropia

UNCORRECTED

- Axial lengths of each eye are considered equal
- Resulting image size essentially equal to that of an emmetropic eye
- Aniseikonia will NOT exist, when uncorrected.

Anisometropia and Aniseikonia Overview

	Presence or Absence of Aniseikonia in Uncorrected and Corrected Anisometropia		
	Uncorrected	**Spectacle Correction**	**Contact Lens Correction**
Axial Anisometropia	Present	Absent	Present
Refractive Anisometropia	Absent	Present	Absent

NOTE: Anisometropia can be related to both axial and refractive properties.

Treatment of Axial Anisometropia

- Anisometropia related to axial ametropias WILL result in axial-related aniseikonia
- Magnification effects provided by ophthalmic lenses can offset this aniseikonia, returning image sizes to normal
- Knapp's law indicates that ophthalmic lenses prove the most effective treatment for axial-related aniseikonia, NOT contact lenses!

WHAT!!!

Clinical Practice vs Knapp's Law

ALL IS NOT LOST!

- Clinical practice finds aniseikonia to still be present after ophthalmic lenses are used to correct axial ametropias
- Clinical practice also demonstrates contact lenses to be superior in the correction of ALL anisometropia
- Ophthalmic lenses result in significantly greater degrees of aniseikonia than contact lenses
- Contrary to Knapp's law, clinical practice proves contact lenses to be most effective treatment of axial aniseikonia.

Treatment of Refractive Anisometropia

- Anisometropia related to refractive ametropias will NOT result in aniseikonia
- If ophthalmic lenses used, magnification effects will result in induced optical aniseikonia
- Spectacle Magnification & Relative Spectacle Magnification are at minimum when VD minimum, and since contacts minimize VD, they minimize induced optical aniseikonia
- For refractive anisometropia, clinical practice agrees with Knapp's law: contacts most effective treatment option.

Estimating Source of Ametropia / Anisometropia

Refractive Related

Significantly different k's, between each eye

Anisometropia due to development of a monocular cataract

Routine refractive changes in adults

Axial Related

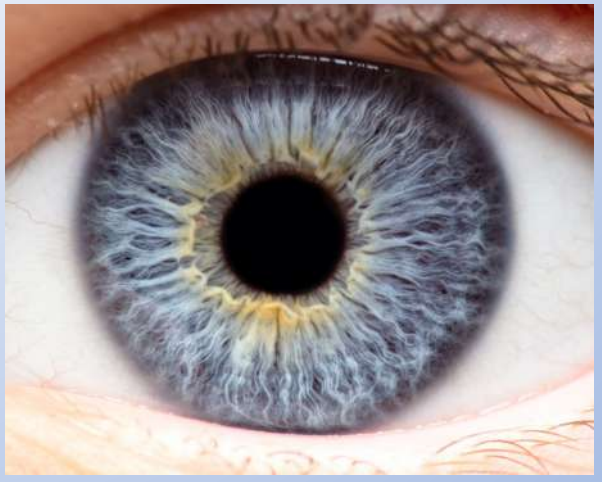
Similar k's between each eye

Clinically significant anisometropia

Ametropia > +/-4D.

The Influence of Axial Length on Aniseikonia

- The average axial length is approximately 23.30mm
- Axial lengths of each eye should differ no more than 0.3mm



Assuming central corneal power same for each eye at normal axial lengths

1mm axial length diff. ≈ 3D diff. in ametropia.

Ophthalmic Lens Treatment of Aniseikonia

- Although contact lenses prove most effective treatment option for managing aniseikonia, could glasses by used?
- What if patient cannot, or doesn’t want to wear contacts?
- Then what?
- An ophthalmic lens solution must be provided.

Spectacle Magnification (SM)

Definition

A type of angular magnification brought about by a single spectacle lens

- Compares image size formed by a single eye wearing a corrective lens to image size in the same uncorrected eye
- SM = $\frac{\text{Retinal image size in corrected eye}}{\text{Retinal mage size in same uncorrected eye.}}$
- SM expressed as a ratio
- SM >1.0 = positive magnification
- SM < 1.0 = minification

Relative Spectacle Magnification (RSM)

Definition

For object at infinity, ratio of retinal image size of corrected ametropic eye to that of a standard emmetropic eye

- If an ametropic eye corrected by an ophthalmic lens produces an image *different in size* than normal, this magnification is referred to as RSM
- Normal image size is based on image size provided by a standard emmetropic eye with *+60.00D* refractive power
- RSM = $\frac{\text{Image size for a corrected ametropic eye}}{\text{Image size for a standard emmetropic eye.}}$

Calculating Spectacle Lens Magnification

Two factors must be considered:

- Power Factor, M_p - due to lens power
- Shape Factor, M_s - due to lens shape

- Magnification effects for ALL lenses will always be:
  - > 1.0 for a plus lens
  - <1.0 for a minus lens

- Contact lens magnification much less than ophthalmic lens, due to significantly reduced VD and thickness.

Magnification Due to Shape Factor

$$M_s = 1/\ 1 - (t/n)D_1$$

t = Lens center thickness, meters

D_1 = Front surface power or base curve, Diopters

n = Lens material refractive index

Influential Factors/Parameters

Base Curve (BC)

Center Thickness

Refractive Index

Steepen Base Curve or Increase Thickness

- Plus lens = increase magnification
- Minus lens = decrease minification

Flatten Base Curve or Decrease Thickness

- Plus lens = decrease magnification
- Minus lens = increase minification.

Magnification Due to Power Factor

$$M_p = 1/1 - (hD)$$

D = Sphere equivalent lens power, Diopters
h = Vertex distance, meters

Influential Factors/Parameters

Dioptric Power
Vertex Distance (VD)

Dioptric Power

- Plus lens magnifies = **+** magnification
- Minus lens minifies = **-** magnification/minification

Increase Vertex Distance

- Plus lens = increase magnification
- Minus lens = increase minification

Decrease Vertex Distance

- Plus lens = decrease magnification
- Minus lens = decrease minification.

Example

Rx: OD: +1.00 DS OS: +5.00 DS

SM = M_s x M_p = (1/1 – (t/n)D_1) **x** (1/1 – (hD))

t = center thickness D_v = Lens power h = vertex distance n = refractive index D_1 = BC

OD: t = 3.0mm **D_v** = 1D **h** = 12mm +*3mm* **n** = 1.5 **D_1** = 6.00D

M_t = (1/1 – (0.003/1.5) x 6) **x** (1/1– (1x0.015)) = 1.027

Mag % = (M_t -1) x 100

Mag OD = 2.7%

OS: t = 7.2mm **D_v** = 5D **h** = 12mm +*3mm* **n** = 1.5 **D_1** = 8.00D

M_t = (1/1 – (0.0072 /1.5) x 8) **x** (1/1– (5 x 0.015)) = 1.124

Mag % = (M_t -1) x 100

Mag OS = 12.4%

Mag difference = Mag % OS – Mag % OD = 12.4% - 2.7% = **9.7%** .

How to Proceed

- The clinically significant 4D of anisometropia is likely refractive
- 9.7% difference in magnification would likely result in highly symptomatic aniseikonia, with little chance of sensory fusion
- So, how should you proceed if contact lenses are not an option?
- Design your patient a pair of iseikonic lenses.

An Ophthalmic Solution
Iseikonic Lens Design

- Ophthalmic lens solution to minimize magnification differences between each eye and correct aniseikonia to an asymptomatic level
- Lens parameters that can be manipulated during design:
  - Base curve
  - Center thickness
  - Vertex distance
  - Material index of refraction
- Dioptric power also influences magnification but is not subject to manipulation, for obvious reasons.

Influence of BC and VD

Base curve has the largest influence on image size

- Flatter BCs produce less positive magnification
- For every 1D, VD also reduced by ≈ 0.6mm

Decreasing VD

For a plus lens decreases magnification
For a minus lens decreases minification

Example

- Anisometropic patient given flattest BC for most-plus eye and steepest for least-plus, reduction in VD alone will reduce aniseikonia by 2-3%.

Example Modifications

Rx: **OD: +1.00DS**
OS: +5.00DS

- **OD:** steepen BC / **OS:** flatten BC
- **OD:** standard 1.5 index / **OS:** 1.74 index
- **OD:** match thickness (1.5 index) to new **OS** (1.74 index)

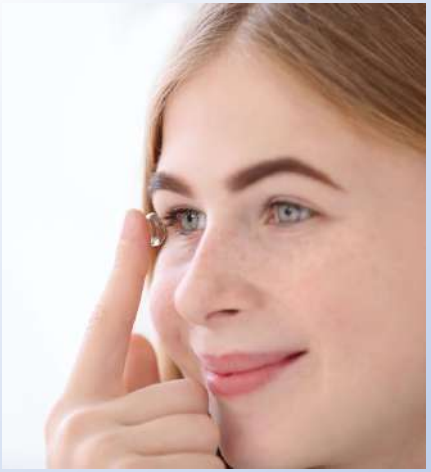
Vertex Distance

OD: specify bevel placement towards back surface
OS: specify bevel placement towards front surface

Are you playing with fire?

Process time consuming and labor intensive, but well-worth the satisfaction of making a difference for your patient.

Why Are Contacts Most Effective Treatment?



- Consider an infinitely thin lens, placed at the entrance of the pupil . . .
  - Both factors used to calculate lens magnification would result in a spectacle magnification of 1x
  - Closest we can get to this ideal, is by using either a contact lens or intraocular lens.

Think Outside The Box
Contacts and Glasses

- Consider a presbyopic patient experiencing aniseikonia, unsuccessful with multifocal contacts
- Contacts will correct and balance distance vision, managing the aniseikonia and eliminating the potential for vertical imbalance with just an ophthalmic PAL
- Progressive would mostly just provide their near add power and any residual astigmatic correction.

To Take Away . . .

- Symptomatic aniseikonia, when left unmanaged, can result in a wide range of complications
- Patients experiencing symptoms of induced aniseikonia, at final dispensing, might just need time to adapt
- Active adaptation will be more effective than sedentary
- Clinical practice continues to support contacts as the most effective for treating the aniseikonic patient
- If need be, put on your creative hat to design your patient iseikonic lenses as an ophthalmic solution.

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Thank You!

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