Static and dynamic properties of accommodation.
Maddox components (response categories) of accommodation: From “The clinical use of prisms”

1) Tonic- 1.5 D bias: Intrinsic baseline bias or balance point between autonomic inputs (sympathetic & parasympathetic).
   Manifest as the myopias (night, space, & instrument)
   Adaptable bias = accommodative spasm

2) Proximal- response to perceived distance

3) Optical reflex- response to defocus
   magnitude (even error signal) direction (odd error signal)

4) Convergence-accommodation
   cross-link with convergence guides accommodation
3 Factors Contributing to Night Myopia aka Dark Focus

- **Tonic Accommodation:** Increased parasympathetic mostly due to empty field
- **Spherical Aberration:** from large dilated pupils
- **Chromatic aberration and the Purkinje Shift in spectral sensitivity with dark adaptation**
Chromatic aberration, blur circles and error of accommodation

- Zero error

- Over accommodation: Myopic Lead

- Under accommodation: Hyperopic Lag-

A clinical application is the Duochrome test
1) Space Myopia: AKA

Empty field myopia- pilot problem

Blur or fog myopia- clinician problem with plus balance refractive technique

2) Instrument Myopia

Perceived near distance of enlarged images stimulates too much proximal accommodation.

3) Tonic Accommodation is adaptable

Accommodative Spasm Myopia: Neural adaptive response to prolonged near work.
Proximal accommodation responds to perception of distance during large voluntary shifts of attention (Coarse adjustment).

Initial accommodation response to distance that is refined later by an optical reflex accommodation response to defocus.

Most accommodation is a proximal response
Optical Reflex Accommodation (fine adjustment)

Even error signals - amount of defocus - contrast loss
Odd error signals - sense the direction for optical reflex (defocus driven) accommodation.

Chromatic aberration - not consciously seen
Astigmatism (with the rule)
Temporal hunting cycle (2Hz)
Odd-error chromatic aberration
Direction cue to accommodation

- Zero error
  - Over accommodation: Lead
  - Under accommodation: Lag-
Temporal Frequency Spectrum for Accommodative Nystagmus

Trial and error hunting cycle to sense the correct direction to accommodate.
Convergence Accommodation
(next lecture)

Dynamics of accommodation
Dynamics of Accommodation:
Latency (300 ms) & response time (1 sec)
Saccades increase the velocity of accommodation and shorten latency

AC Stim = -2.0 D

![Graph showing eye movements and accommodation for AC Stim = -2.0 D]

AC Stim = +2.0 D

![Graph showing eye movements and accommodation for AC Stim = +2.0 D]
Accommodation smooth tracking ability.

Prediction reduces time lags.
**Consensual Accommodation** demonstrated by effect of Cycloplegia on Yoked Accommodation

Normally, a covered eye will accommodate just like the viewing eye.

If viewing eye is cyclopleged, then covered eye makes excessive response, driven by increased effort to accommodate.
Differential Accommodation in Asymmetric Viewing

Near objects off to the side are closer to one eye than the other, requiring different amounts of accommodation in each eye to be simultaneously clear.
Laboratory #1

Accommodation stimulus-response function.

Questions to think about during the laboratory exercise:
How accurate is accommodation?
What is the error (lag) of accommodation?
What optical factors influence the magnitude of the error?
How accurate are your clinical measures of refractive error?
What clinical techniques bias the error of accommodation?
Lead & Lag of Accommodation

A

Depth of Field causes A and B (and all states in between) to look the same

B

Far targets usually focus in front of retina (lead produced by refractive correction + bias)

C

Near targets usually focus behind retina (lag)

D
Depth of Focus

Distal limiting position

Proximal limiting position

Maximal size of blur disk

D

S

P

HH'

s

p

d
Accommodative Response Function
Chief ray limits retinal image size for all viewing distances

Nagal Optometer

Badal Optometer
Haploscope
Measuring Accommodation with Badal Optometer-Stigmascope

Newton’s Lensmakers equation: $P^2 = 1/(x \times x')$

$x$ = distance between object and primary focal point

Solve for $X'$
Calculate the accommodative stimulus (AS) and accommodative response (AR) relative to the spectacle plane.

\[ \text{AS} = \frac{1}{Td} - (L + \text{RE}) \]

\[ \text{AR} = \text{CF} - (L + \text{RE}) \]

\[ \text{CF} = \text{P} - (\text{SD} \times \text{P}^2) = 10 - (\text{SDm} \times 100) \text{ or } 8 - (\text{SD} \times 64) \]

\( Td \) = target distance from the spectacle plane (Badal secondary focal pt)
\( \text{RE} \) = refractive error
    - Myopia (+ error)
    - Hyperopia (− error)
\( \text{SD} \) = Stigma distance to the \textbf{Badal lens}
\( \text{L} \) = Spectacle lens power
\( \text{P} \) = Badal lens power
Calculate the accommodative stimulus (AS) and accommodative response (AR)

Td= 0.14 M
RE= zero

Myopia (+ error)
Hyperopia (− error)

SD= 4 cm = .04 M
L= - 3D
P= 10D

\[ AS = \frac{1}{Td} - (L + RE) \]
\[ = 7 - (-3 + 0) = 10D \]

\[ CF = P - (SDm x P^2) \]
\[ = 10 - (.04 x 100) = 6D \quad \text{or} \quad 8 - (.03 x 64) = 6D \]

\[ AR = CF - (L + RE) \]
\[ = 6 - (-3 + 0) = 9D \]

There is a 1D lag of accommodation (10D-9D)
Conjugate Points

A

Object distance

B

Image distance