Outline:

I. Cross-link between accommodation and convergence

II. Measurement

- Calculated ratio= IPDcm + Vdm*(Pn-Pf)
- Gradient ratio= Delta convergence/delta accommodation
  - Stimulus ratio= conv resp/accom stim = 3.61/1
  - Response ratio= conv resp/accom resp= 4.0/1

III. Linearity, Stability & Dynamics

IVI. Maddox components of accommodation that stimulate AC/A

V. Factors that change the AC/A

- Age, Change IPD, Fatigue, Drugs

VI. Convergence accommodation ratio (CA/C)

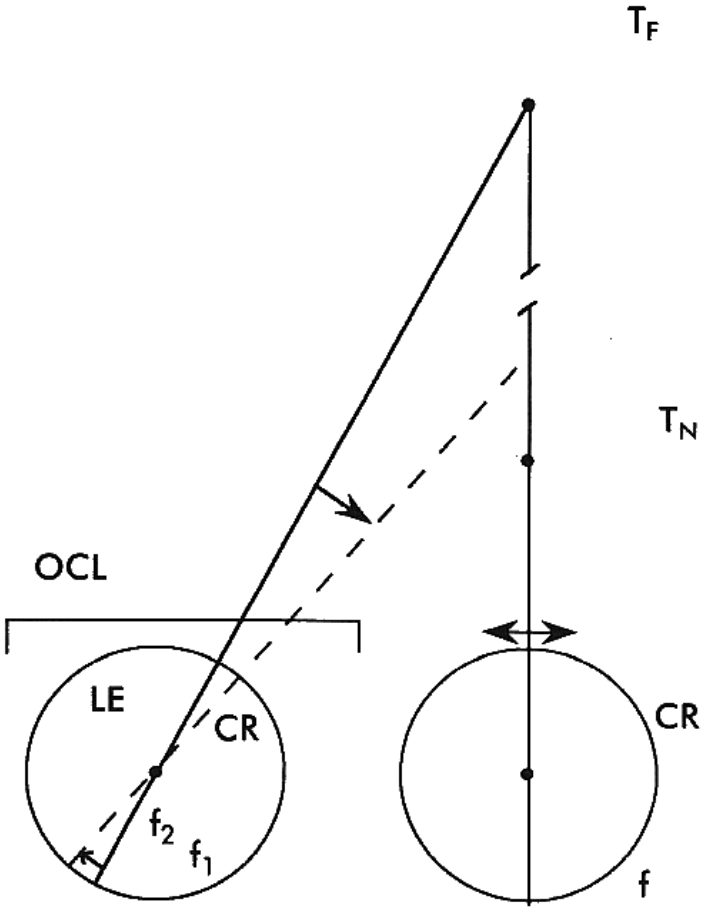
- Measurement, Effects of age, Dynamics

IX. Vertical vergence and lateral gaze linkage

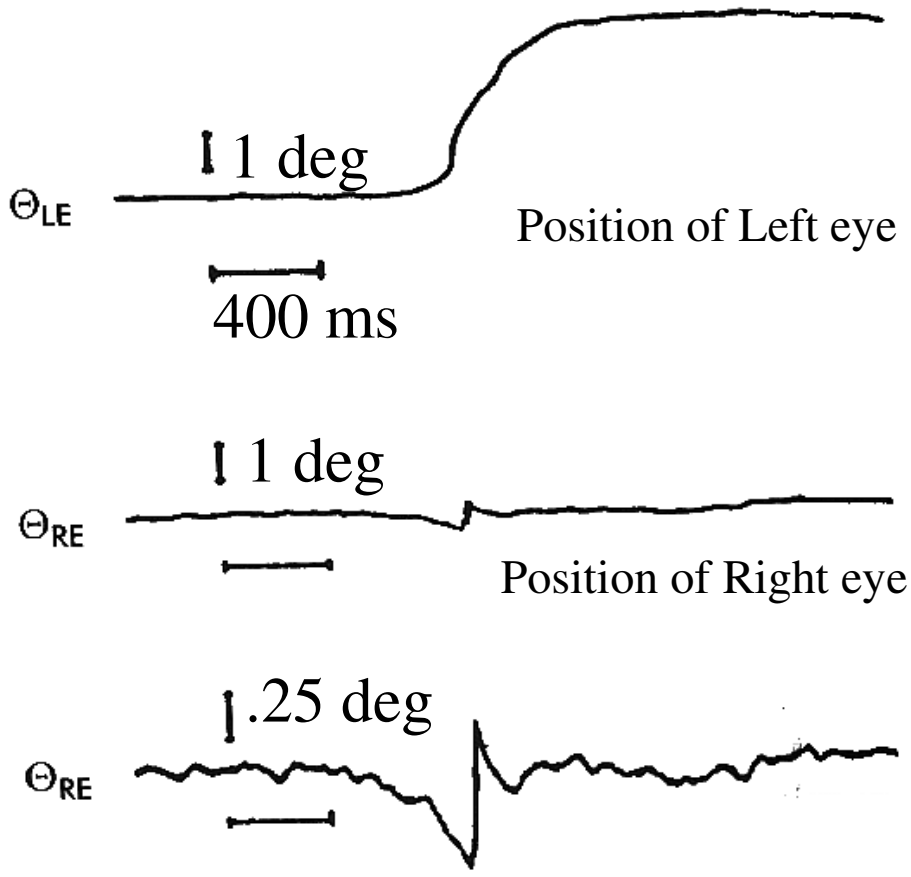
X. Cyclo vergence and vertical gaze

XI. Anomalies of Vergence

Accommodative Convergence Coordinates the near response

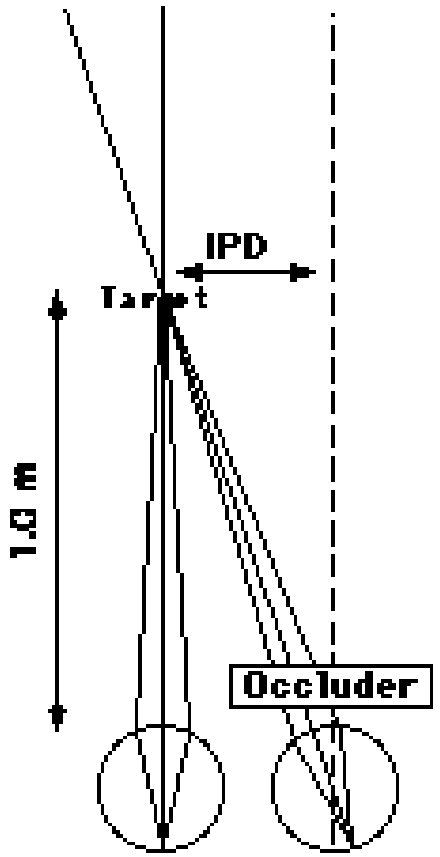


Müller accommodative vergence

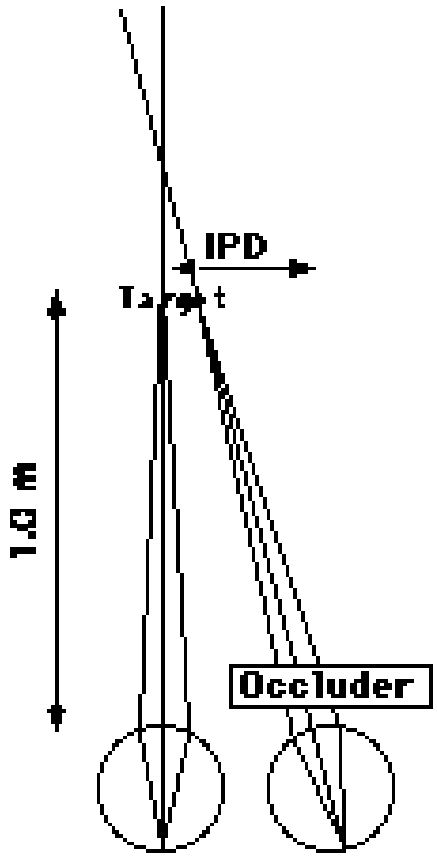


Magnified Position of Right eye to show details more clearly.

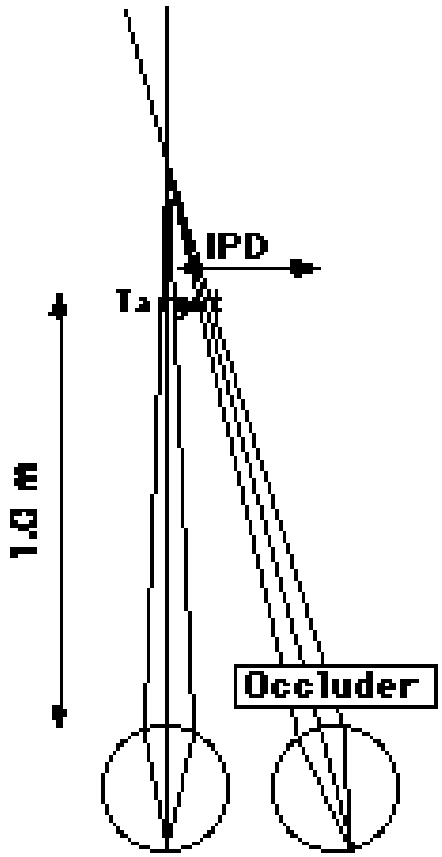
Ideal vs empirical AC/A ratio for symmetrical convergence.



Perfect match of Accom and Conv
AC/A = IPD

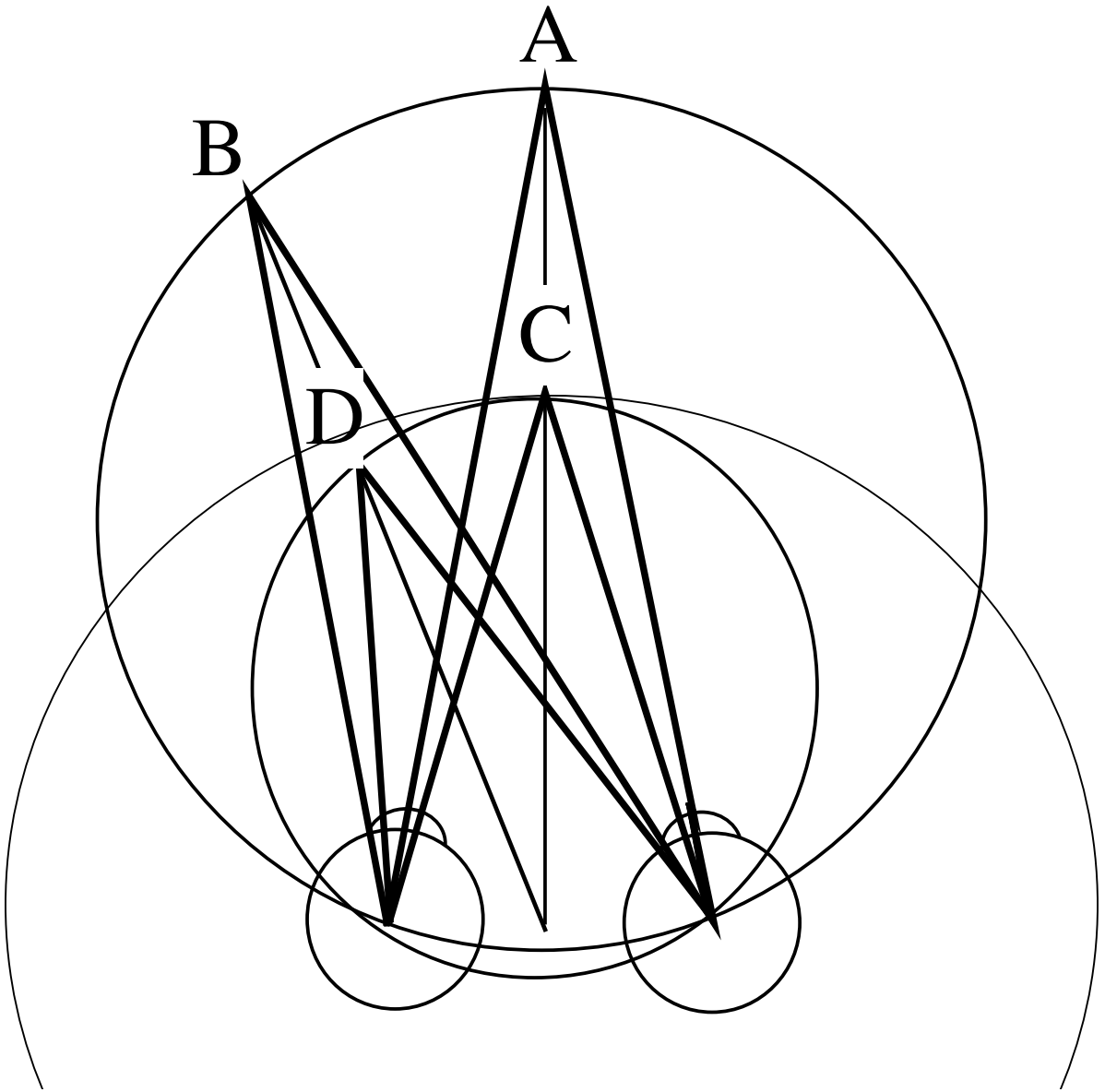


AC/A is usually less than perfect, 3.5 - 4 typical

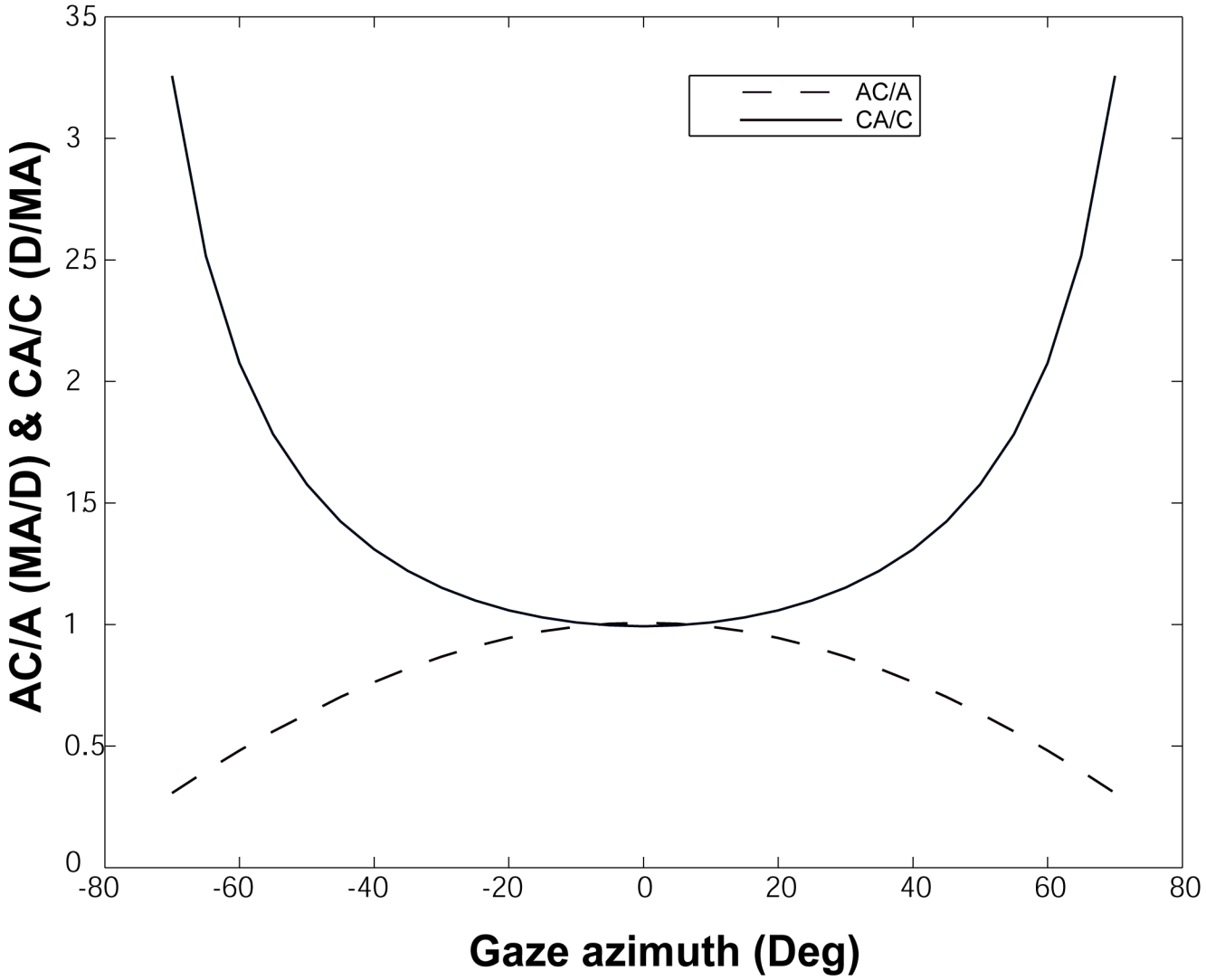


Lag of Accom can make AC/A appear low

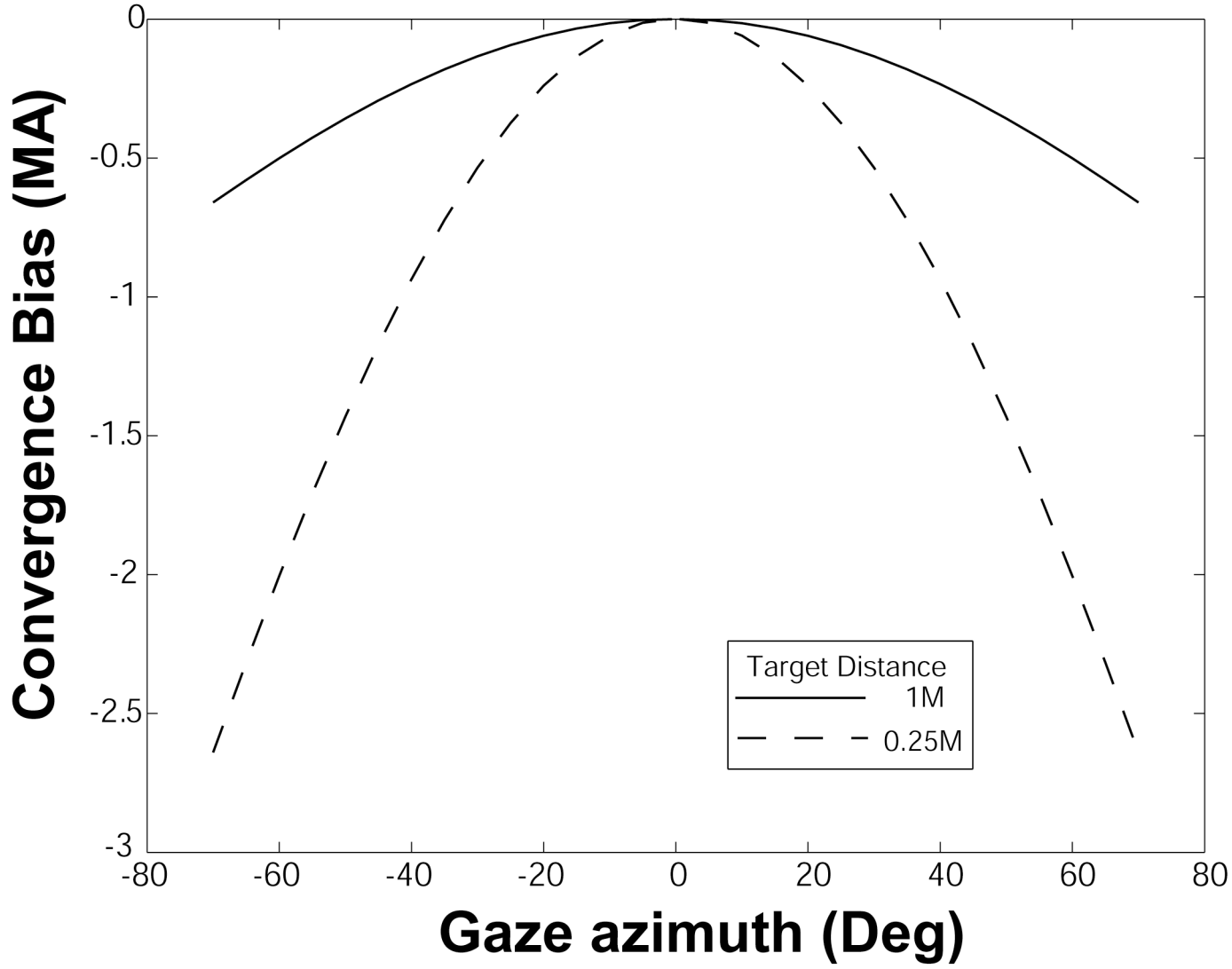
Iso Vergence & Isoaccommodation Circles



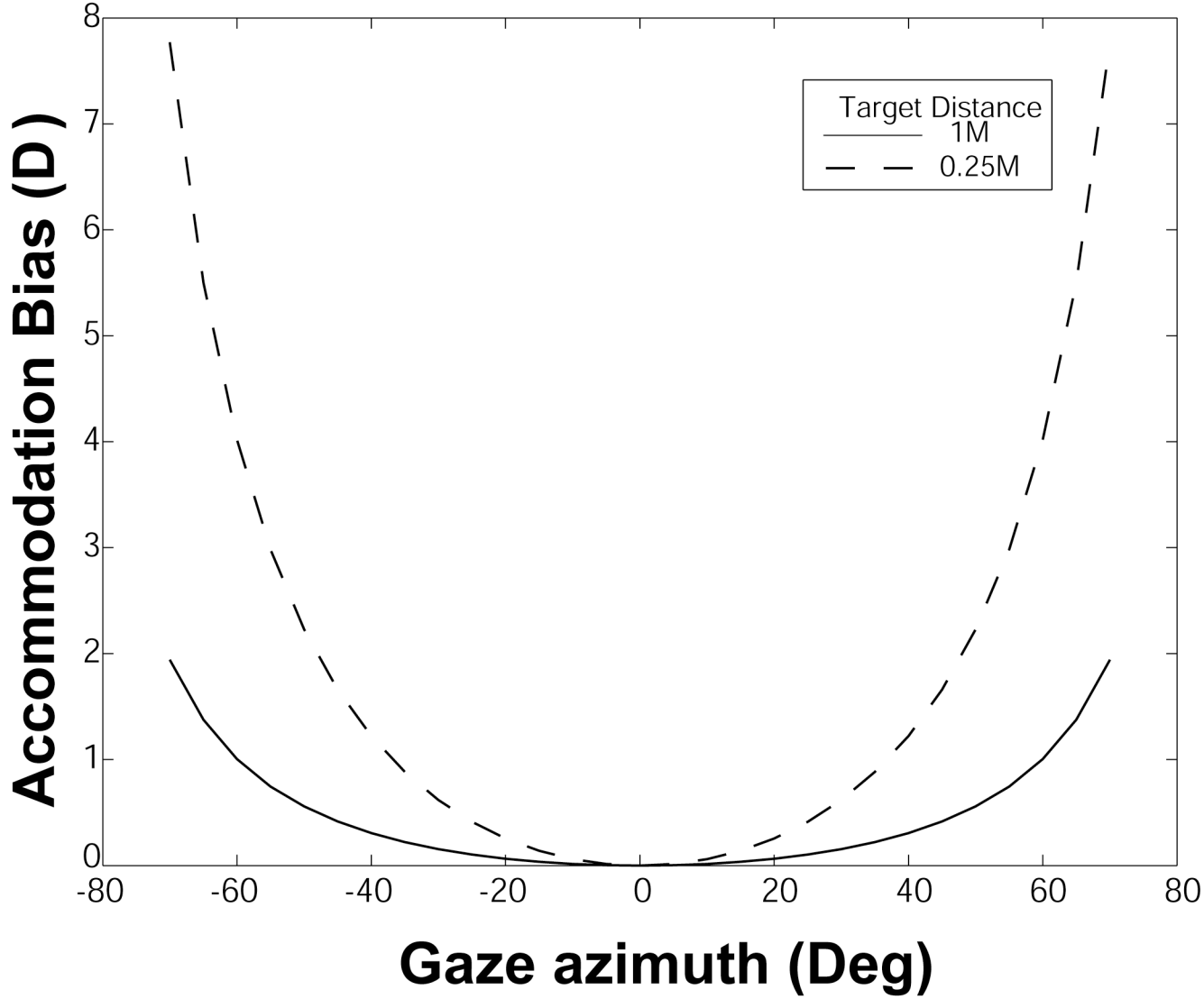
Ideal AC/A decreases w/ azimuth


Cross-coupling interactions and gaze azimuth
AC/A
CA/C
AC/A (MA/D) & CA/C (D/MA)
Gaze azimuth (Deg)
35
3
25
2
15
1
0.5
0
-80
-60
-40
-20
0
20
40
60
80

Ideal convergence bias along iso-accommodation circle



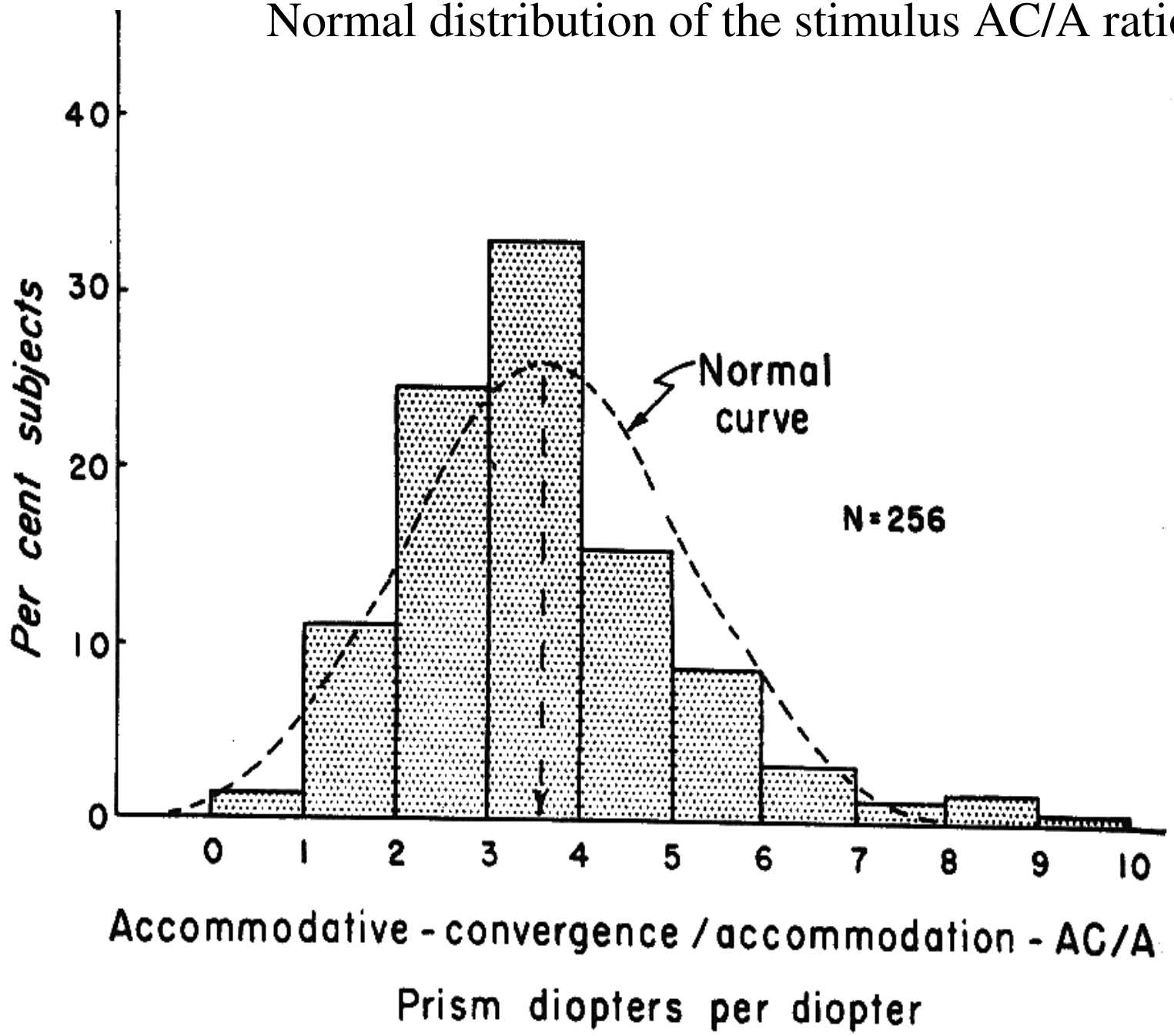
Ideal accommodation bias along iso-vergence circle



Stimulus AC/A ratio 3.6 Δ / 1D stimulus

Response AC/A ratio 4.0 Δ / 1D response

Normal distribution of the stimulus AC/A ratio



Two clinical measures of the AC/A ratio:

Calculated AC/A

AC/A = IPD cm + [Phoria (near) – Phoria (far)] x VD m

AC/A = IPD cm + [Phoria (near) – Phoria (far)] / MA

Gradient AC/A

AC/A= change in phoria / change in accommodation

AC/A = Phoria without the lens – phoria with 1D lens.

Calculated AC/A

IPD = 6cm
Pn = -4 exo
Pf = +1 eso
VD near = 0 .4 m

AC/A= 6 + [-4 – 1] / 2.5 = 4/1

IPD= 7
Pn = -4 exo
Pf = +1 eso
VD = 0.4 m

AC/A = 7 + [-4 – 1]/2.5= 5/1

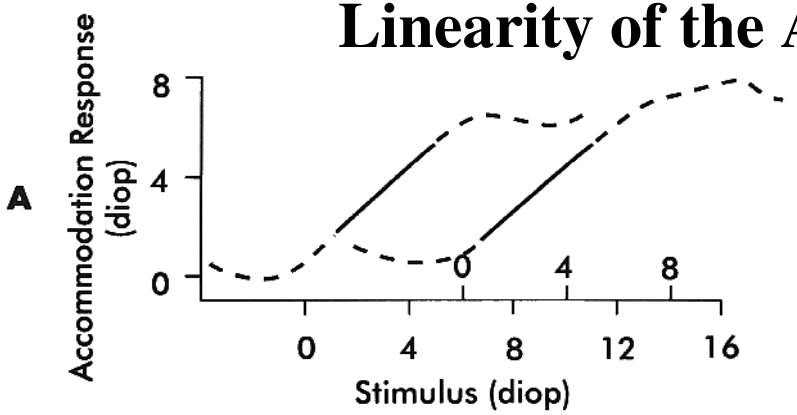
Gradient AC/A

Near phoria without added lenses = 3 Exo

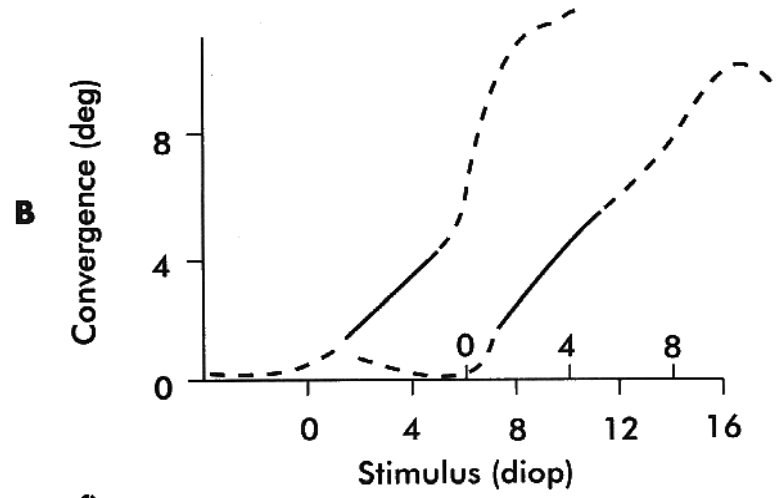
Near phoria with a +2D added lens = 12 Exo

[-3 – (-12)] / 2D = 9/2 = 4.5/1

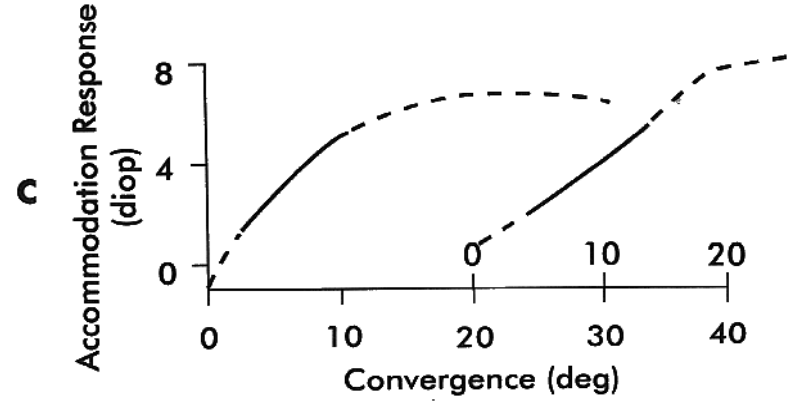
Linearity of the AC/A ratio



Accommodation stimulus-accommodative response function

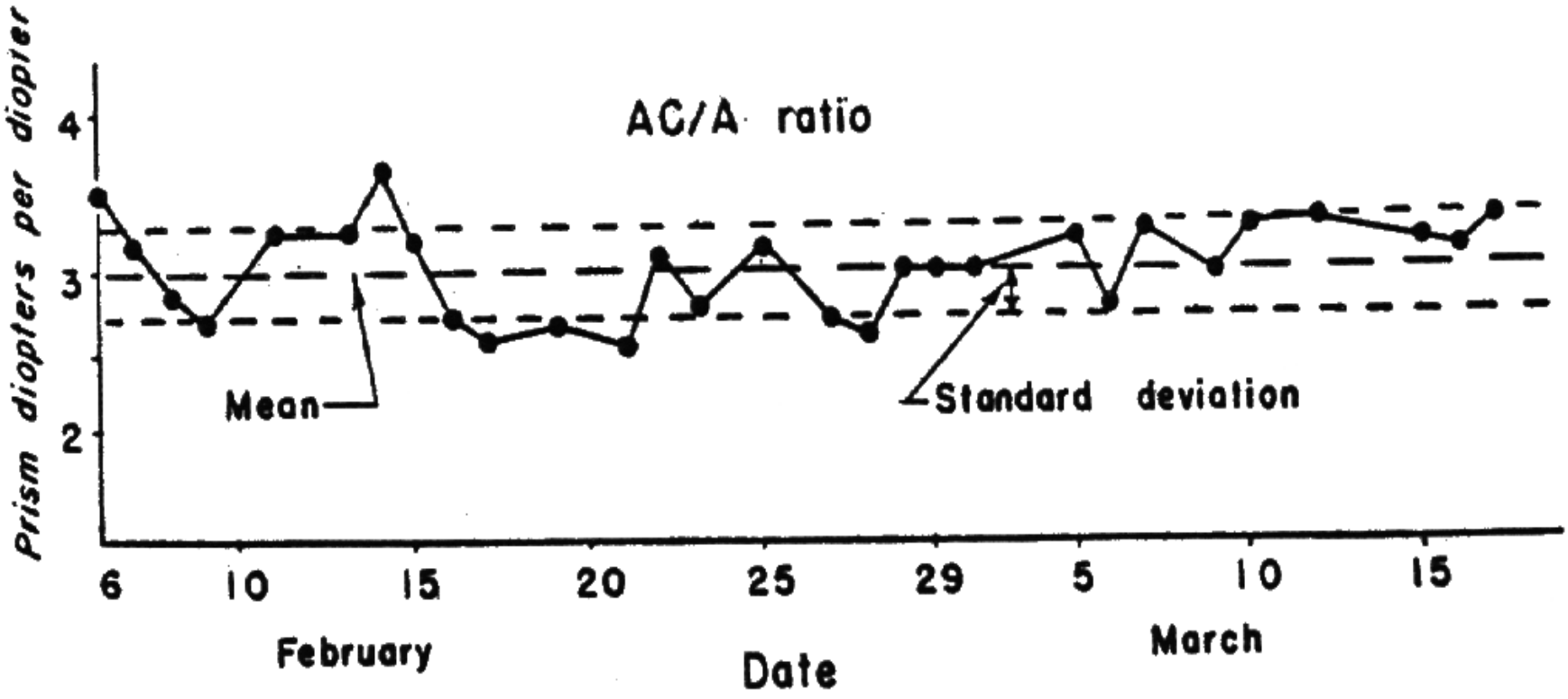


Accommodation stimulus-convergence response function



Response AC/A ratio is linear until the amplitude is reached and then it becomes infinite.

Temporal stability of the AC/A ratio over 2 months



Affects of Age on AC/A

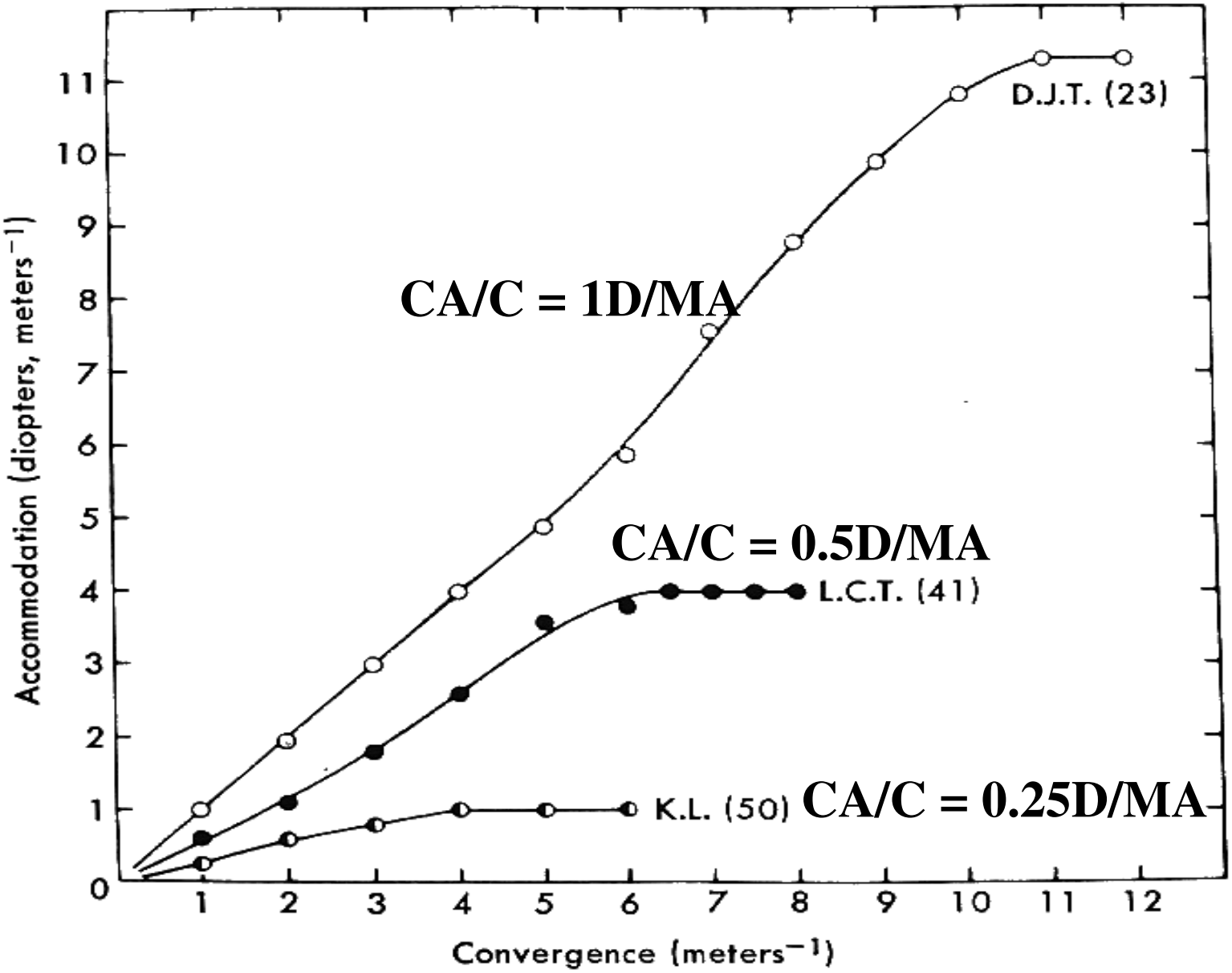
The AC/A increases with age because the amplitude of accommodation decreases with age and extra accommodative effort is needed near the amplitude of accommodation.

The CA/C ratio is usually not measured clinically because it is not part of the Maddox classification and traditionally it has not been included in the clinical analysis of binocular vision.

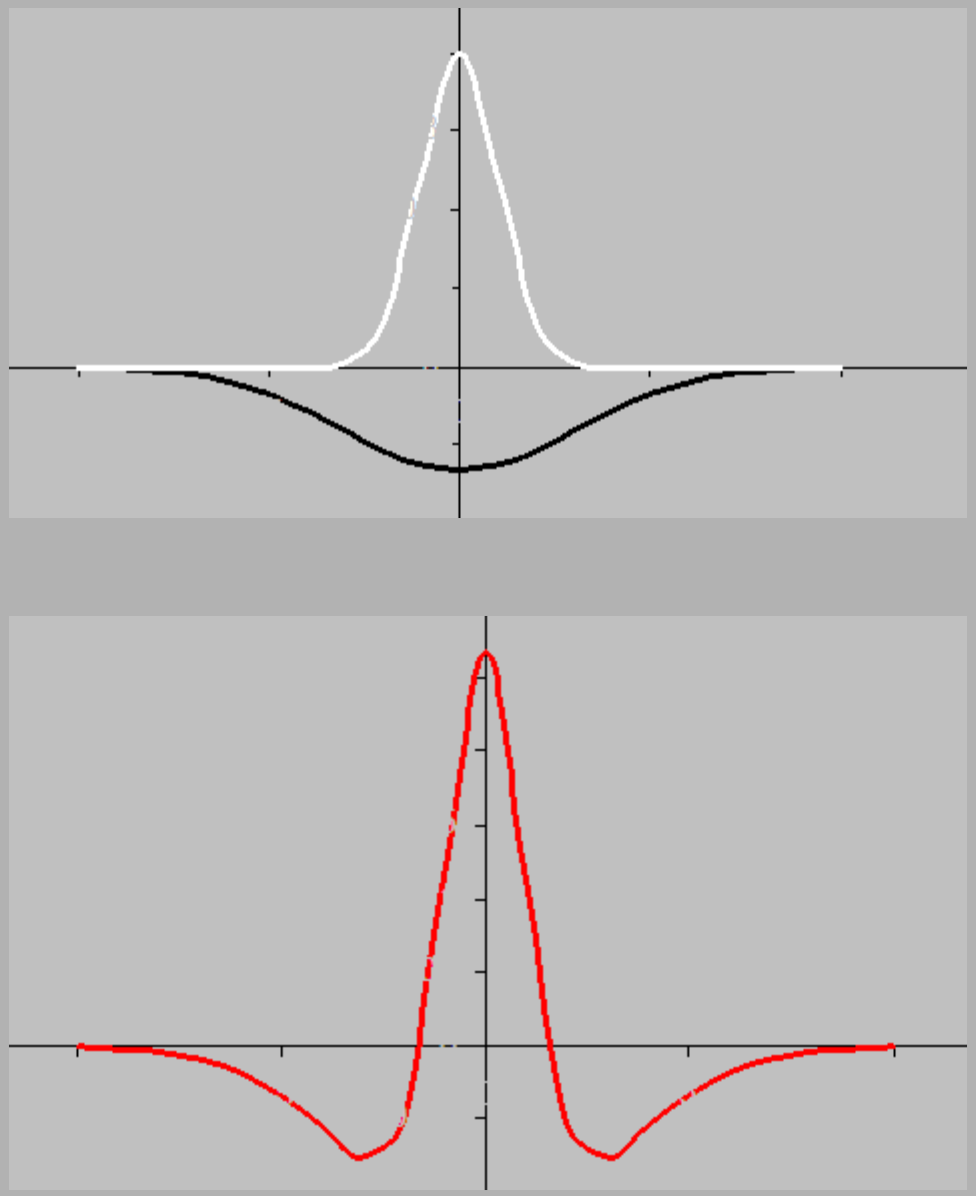
The CA/C can be measured clinically by stimulation convergence with a photograph of an out-of-focus vertical bar. Its too blurred to stimulate accommodation but it stimulates convergence. Changes of accommodation stimulated by convergence are measured with retinoscopy.

Typical values for the CA/C are (1 MA /1 D) in the early 20s, but it declines as the amplitude of accommodation declines with age.

The CA/C ratio decreases with Age (loss of amplitude of accommodation)

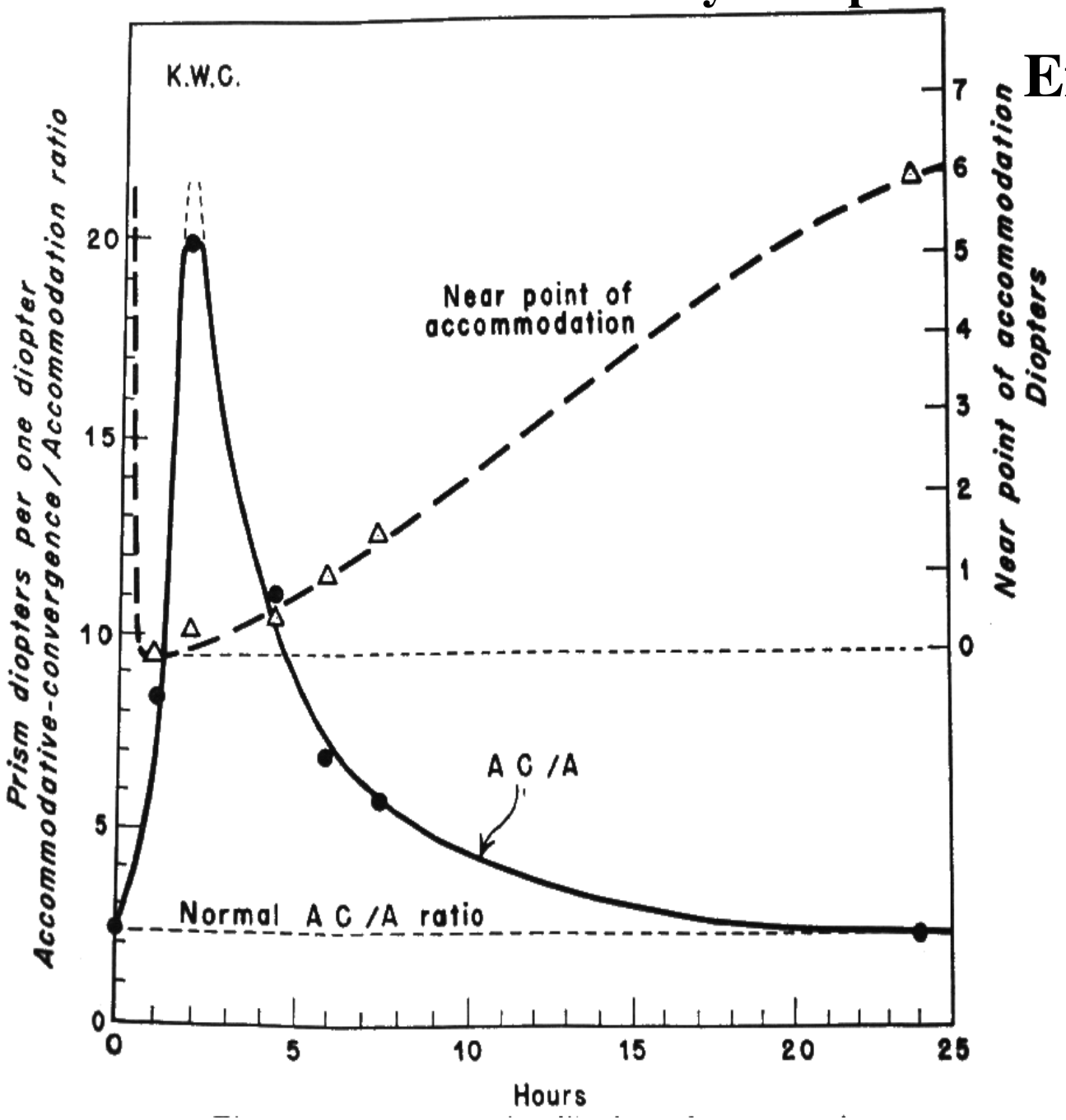


Difference of Gaussians (DoG)

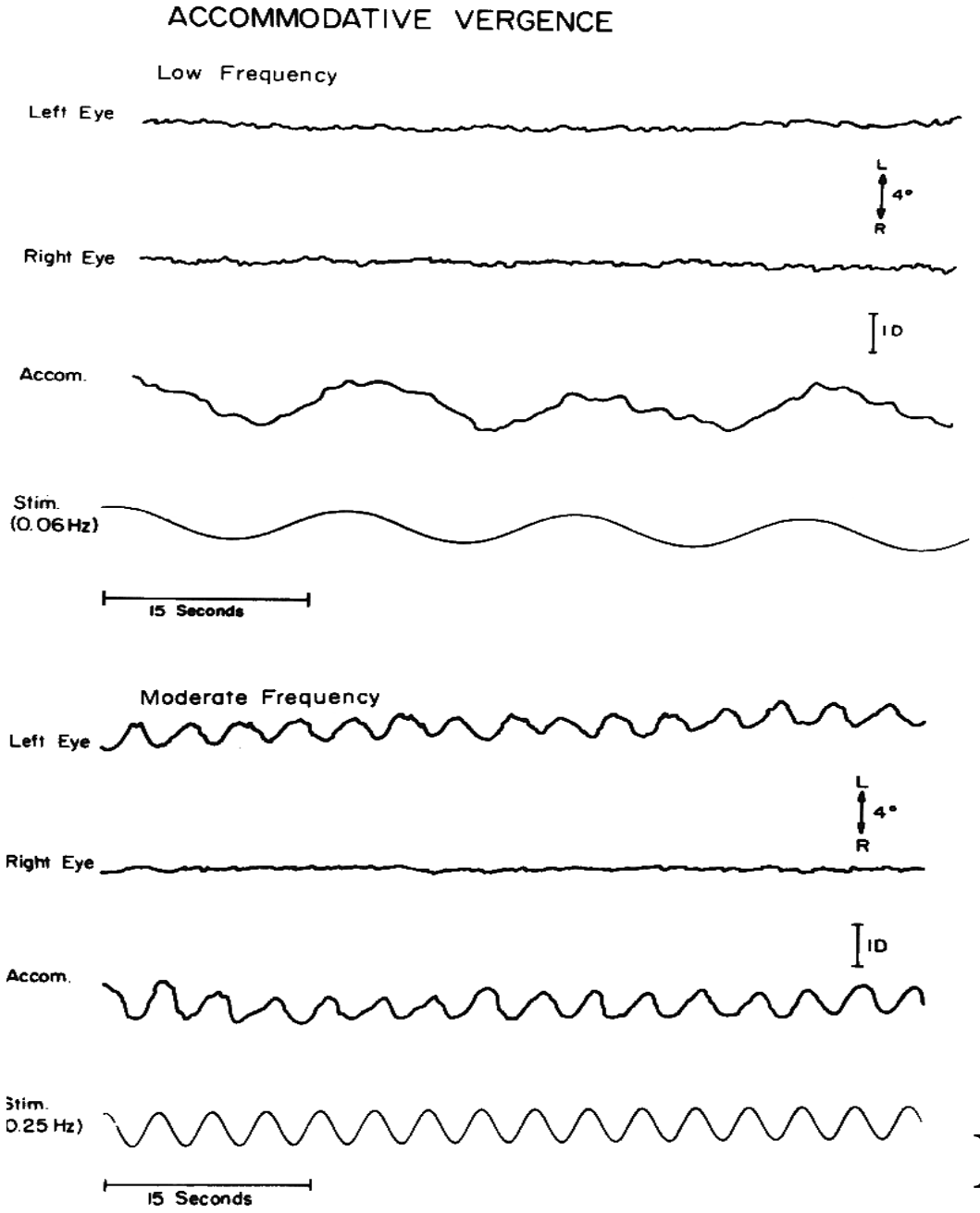


Elevation of AC/A ratio by Atropine

Effects of Drugs



Amplitude of the AC/A increases with velocity of Accommodation

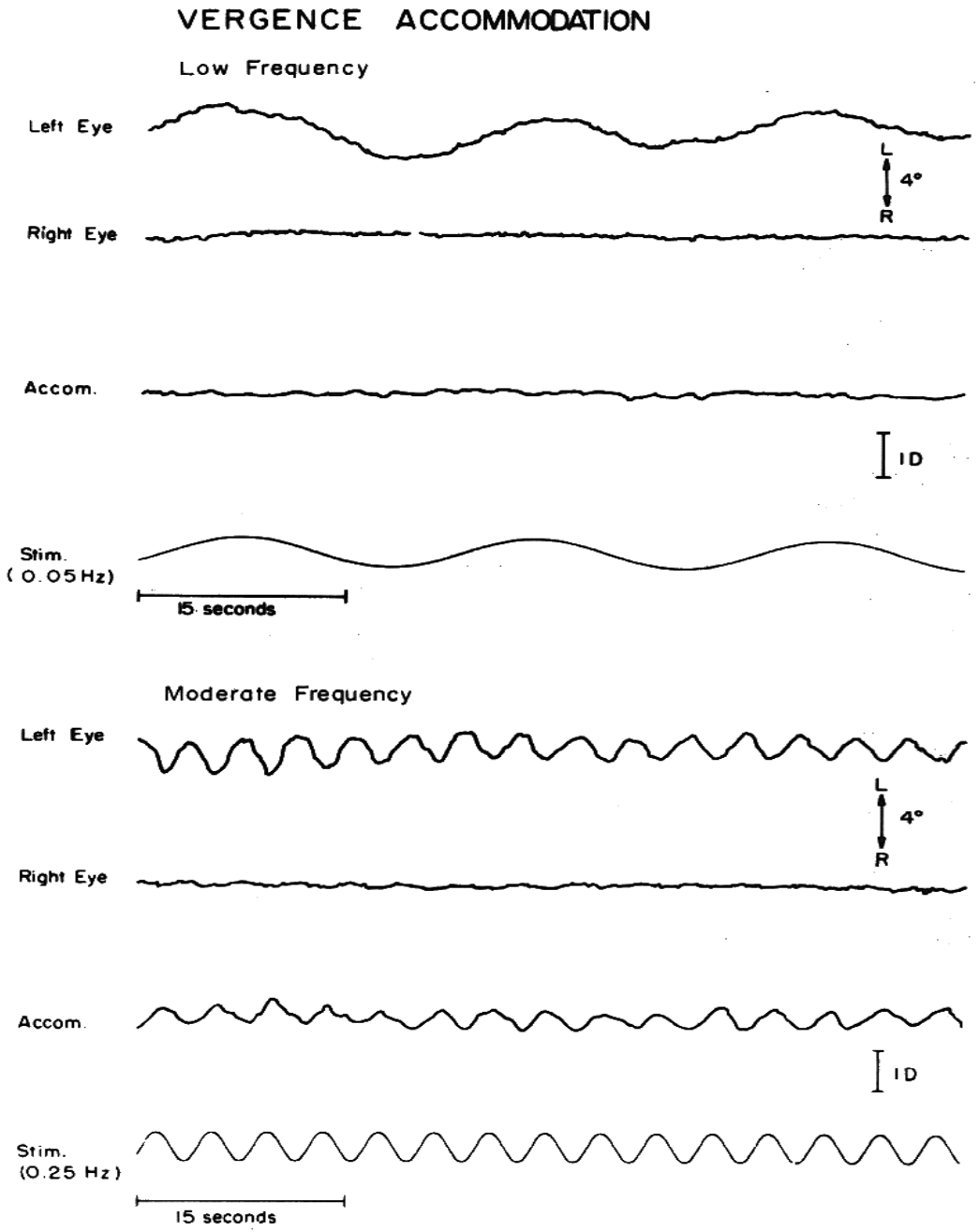


AC/A=0 Δ /D

AC/A= 4 Δ /D

Dynamics of AC/A

Amplitude of the CA/C increases with velocity of convergence



CA/C = 0 D/MA

CA/C = 1D/MA

Dynamics of CA/C

Fast accommodation stimulates AC/A
but slow accommodation does not.

Fast and slow accommodation are controlled separately.

Fast accommodation is referred to as **phasic** accommodation.

Slow accommodation is referred to as **tonic** accommodation.

Slow accommodation produces adaptive changes of the resting focus.

Fast convergence stimulates CA/C but slow convergence does not.

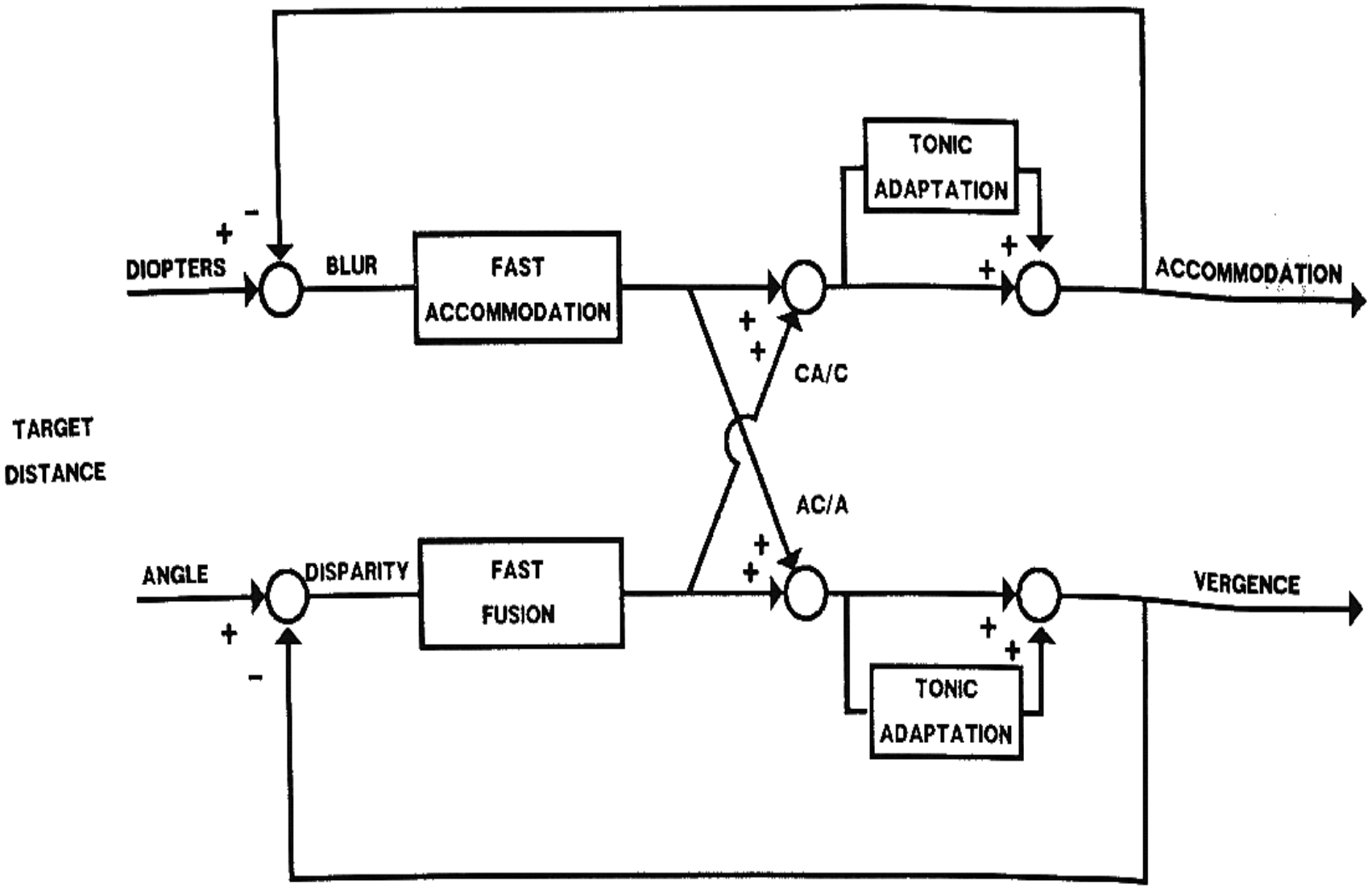
Fast and slow convergence are controlled separately.

Fast convergence is referred to as **phasic** convergence.

Slow convergence is referred to as **tonic** convergence.

Slow convergence produces adaptive changes of the phoria.

Not all components of accommodation and convergence stimulate cross-links. Phasic stimulates cross links but tonic does not. The balance of activity of Phasic and Tonic determine the AC/A ratio

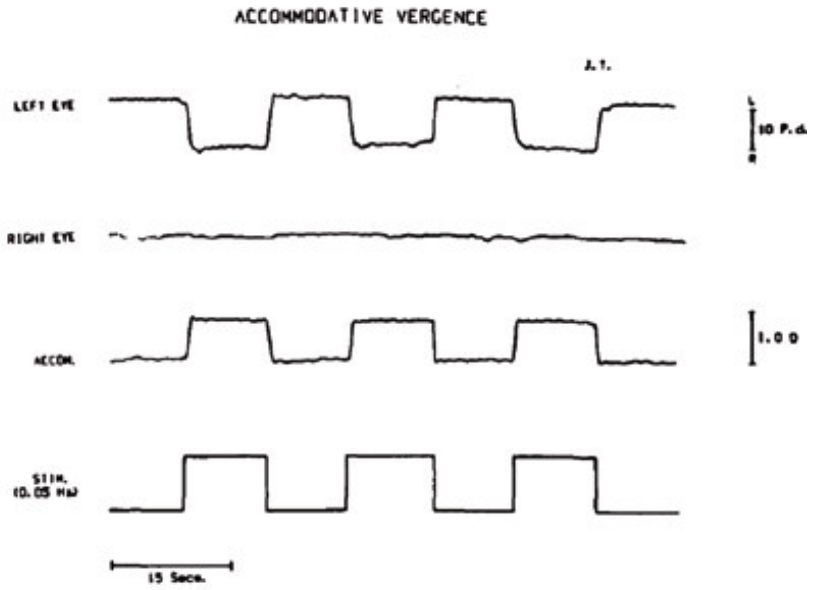


Fatigue of accommodation and convergence can cause temporary changes in the AC/A ratio:

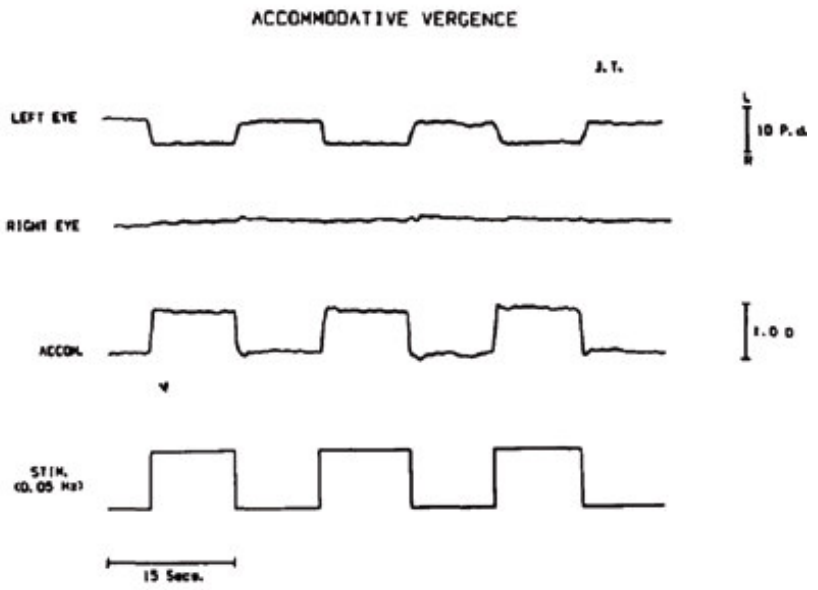
A high AC/A decreases when tonic convergence is fatigued.
A low AC/A increases when tonic accommodation is fatigued.

With fatigue, phasic activity is not relieved by tonic adaptation and the cross-link interactions change.

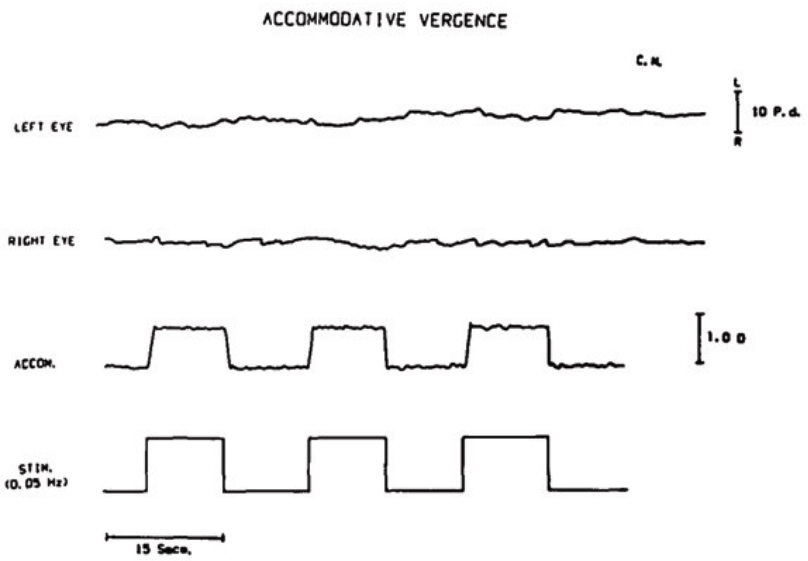
Accommodative convergence is high before fatigue of convergence



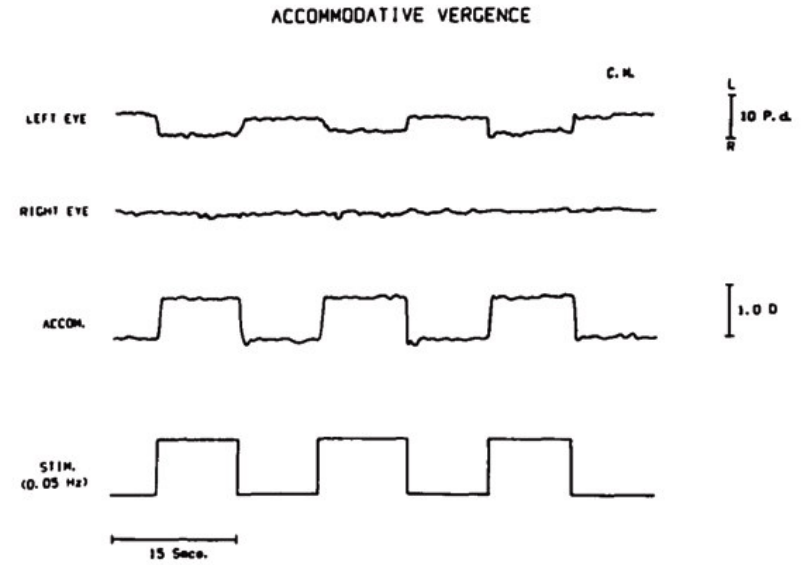
Accommodative convergence is low after fatigue of convergence



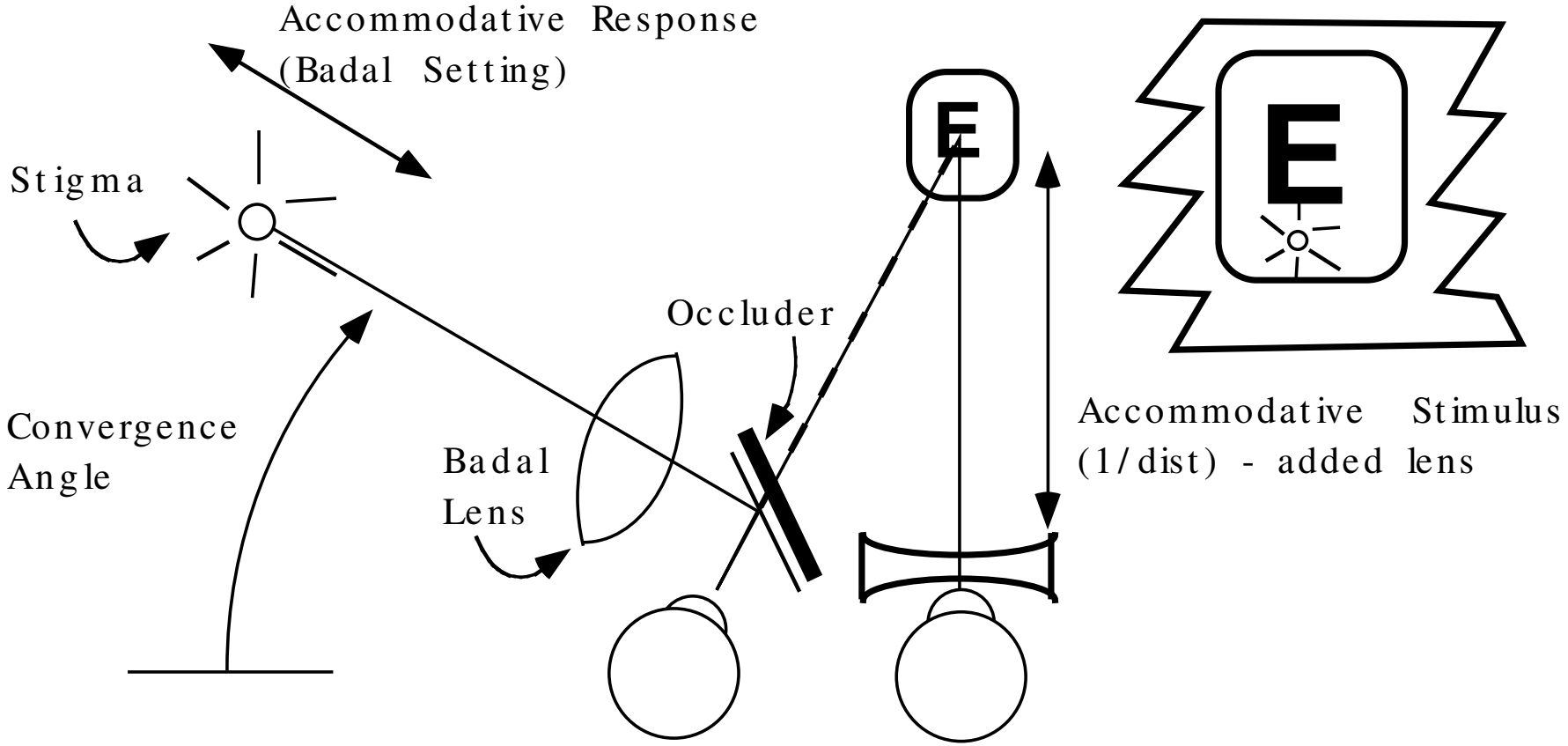
Accommodative convergence is low before fatigue of accommodation



Accommodative convergence is higher after fatigue of accommodation

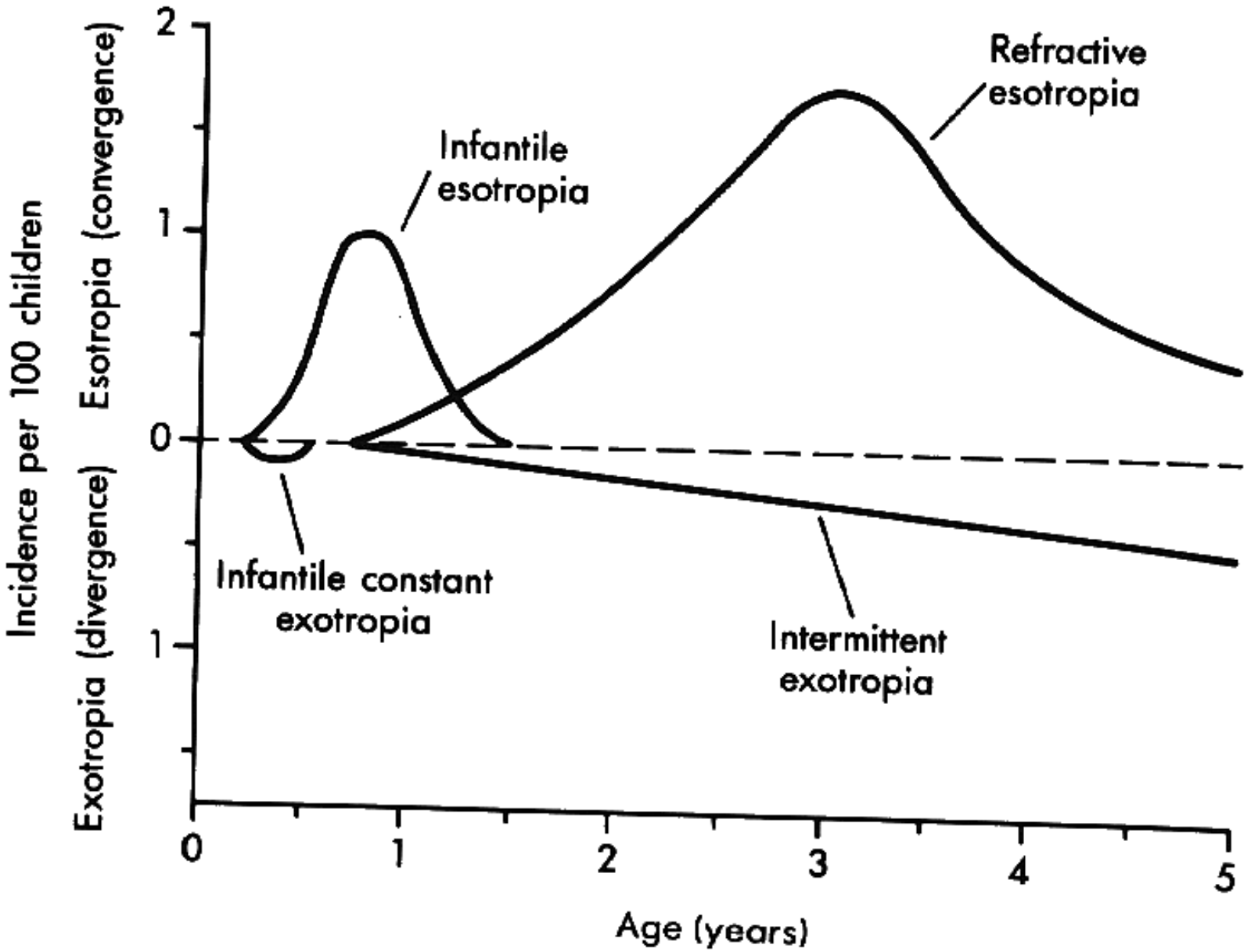


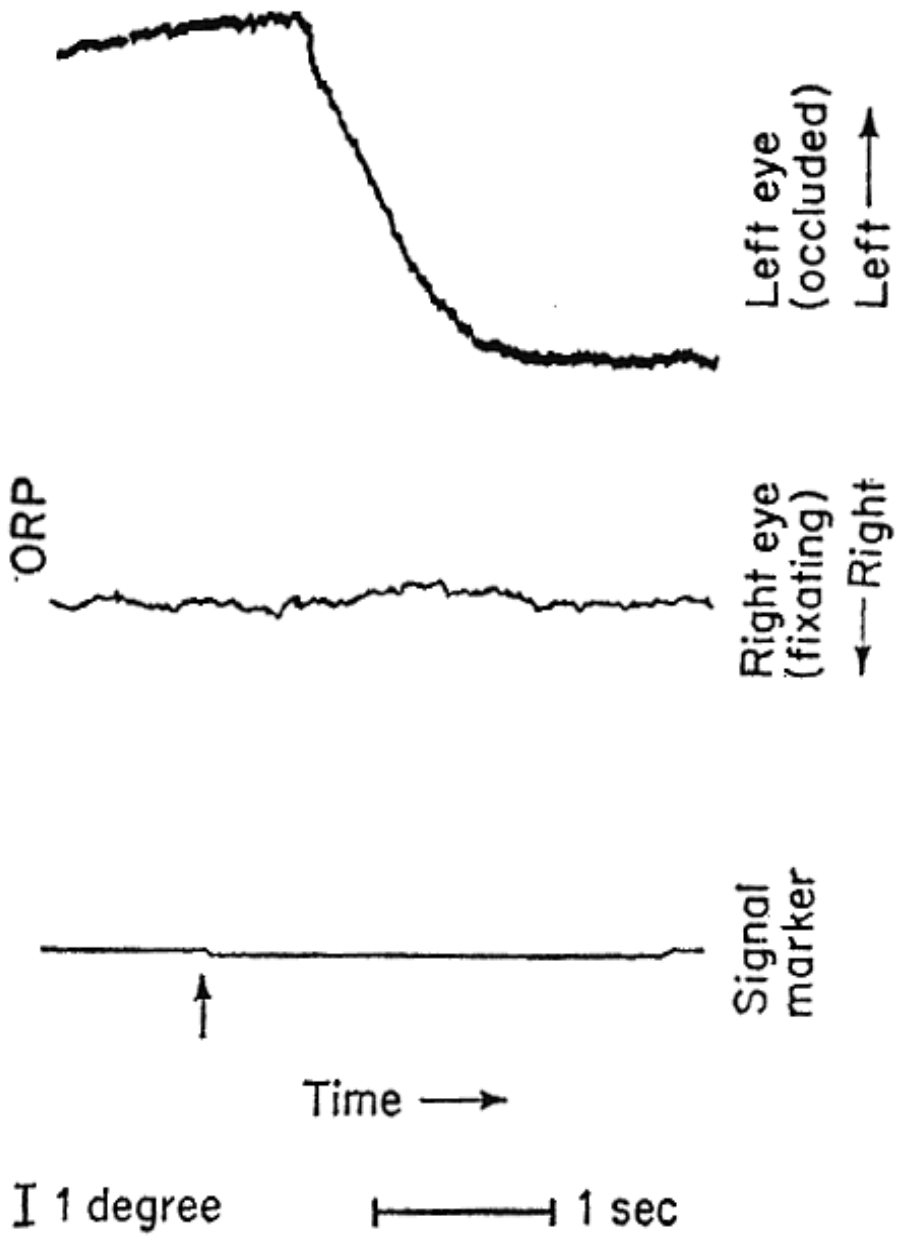
Lab # 2- Accommodative Convergence



Align the left stigma with **E** to measure convergence

Focus the right stigma to measure accommodation


Incidence per 100 children
Exotropia (divergence)
Esotropia (convergence)
2
1
0
1
Refractive esotropia
Infantile esotropia
Infantile constant exotropia
Intermittent exotropia
0
1
2
3
4
5
Age (years)


Left eye
(occluded)
Left
ORP
Right eye
(fixating)
Right
Signal
marker
Time
1 degree
1 sec