# 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

**0** Under accommodation: Hyperopic Lag-

#### A clinical application is the Duochrome test

## **Duochrome Test**



#### Hyperopia clearer

#### Myopia clearer

## 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

**O** Under accommodation: Lag-



# 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

AC Stim = +2.0 D

Time (seconds)



# Accommodation smooth tracking ability.

Prediction reduces time lags.

$$\cdots$$

(d) 2.0 Hz

(c) 3.0 Hz

1

# **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.





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?



## Depth of Focus





Chief ray limits retinal image size for all viewing distances





# Measuring Accommodation with Badal Optometer-Stigmascope



### Newton's Lensmakers equation: $P^2 = 1/(x * x')$

x= distance between object and primary focal point Solve for X' Calculate the accommodative stimulus (AS) and accommodative response (AR) relative the spectacle plane.

```
AS = 1/Td - (L + RE)
```

AR = CF - (L + RE)

 $CF = P - (SD \times P^2) = 10 - (SDm \times 100) \text{ or } 8 - (SDx64)$ 

Td= target distance from the spectacle plane (Badal secondary focal pt) RE= refractive error

Myopia (+ error) Hyperopia (- error) SD= Stigma distance to the **Badal lens** L= Spectacle lens power 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 \text{ cm} = .04 \text{ M}
L = -3D
P = 10D
AS = 1/Td - (L + RE)
   = 7 - (-3 + 0) = 10D
CF = P - (SDm \times P^2)
   = 10 - (.04 \times 100) = 6D or 8 - (.03 \times 64) = 6D
AR = CF - (L + RE)
   = 6 - (-3 + 0) = 9D
There is a 1D lag of accommodation (10D-9D)
```

