

Vision Science III Accommodation

Reading: Borish's chapter 4

Accommodation: The process whereby changes in the dioptric power of the crystalline lens occur so that an in-focus retinal image of an object of regard is obtained and maintained at the high resolution fovea.

Depth of focus: The variation in image distance in a lens or optical system which can be tolerated without incurring an objectionable lack of sharpness in focus. This lack of focus would stimulate accommodation.

Depth of field: The free space dioptric interval that defines the depth of field. The linear distance in object space for which the eye cannot detect blurring when focused on a given object. .

Stimulus to accommodate: The dioptric amount by which accommodation would have to change for an object to be conjugate to the retina.

Lag of accommodation: The extent to which the accommodative response is less than the dioptric stimulus to accommodate. It is normal to have an accommodative lag of 0.50 to 0.75D Under accommodation within the depth of focus. The accommodative system changes focus by the minimum amount to place the object just within the eye's depth of field/focus..

Lead of accommodation; The extent to which the accommodative response is greater than the dioptric stimulus to accommodate. It is not normal to have a lead of accommodation. Remember the system is set to be efficient.

Near point of accommodation: The closest point conjugate to the retina with exertion of maximal accommodation. Maximum amount of accommodation represented in space.

Far point of accommodation: The farthest point conjugate to the retina with exertion of minimum accommodation. No accommodation (which does not occur).

Amplitude of accommodation: The difference, expressed in diopters, between the far point and the near point of accommodation with respect to the spectacle plane, the entrance pupil or some other reference point of the eye.

Range of accommodation: The linear distance from the near point of accommodation to the far point of accommodation.

Consensual Accommodation: Simultaneous accommodation of the two eyes. Occurs in accordance with Hering's Law of Equal Innervation.

Presbyopia; “aged eye”. Slow normal naturally occurring age related irreversible reduction in maximal accommodative amplitude. Recession of the near point.

Proximal accommodation: Accommodation due to the influence of knowledge of apparent nearness of an object. There is no dioptric stimulus to accommodation and is more psychological in nature.

Convergence accommodation: Accommodation induced by the innate neurological linking and action of disparity vergence. Approximately 0.40D per meter angle.

Tonic accommodation; Accommodation found in the absence of blur, disparity and proximal inputs as well as any voluntary or learned accommodation. No stimulus needed, it reflects baseline neural innervation from the midbrain. Mean tonic accommodation in young adults is approximately 1.00D. Represents the normal tonus of the ciliary body at rest.

Empty field accommodation or dark field accommodation: accommodation which occurs in the absence of optical stimuli, such as in low levels of illumination or when viewing a clear cloudless sky.

Reflex accommodation; Automatic adjustment of refractive state to obtain and maintain a sharply defined and focused retinal image in response to a blur input.

Theories of accommodation:

- The interval of Sturm causes change in focus, accounts for 1.00 D
- Pupil size is cause of accommodation: only accounts for 1.00D.
- Corneal curvature changes with a change in focal point
- The anteroposterior position of the lens changes with a variation in focal point.

- The axial length of the eye changes
- And the winner: Changes in the shape and therefore power of the crystalline lens allow objects at various distances to be focused on the retina.

OVERLAY pg 78 and 79

Interesting to note that vision alone is not needed to stimulate accommodation, proximity, drugs such as glaucoma medication, auditory stimulus, aberration, convergence, voluntary effort.

4 components of Accommodation:

1. Reflex Accommodation: largest component of accommodation for both monocular and binocular situations.
2. Vergence Accommodation: Second major component of accommodation. Driven by the link between accommodation and Vergence.
3. Proximal Accommodation: Stimulated by perceptual cues, no retinal based visual feedback loop of blur.
4. Tonic accommodation: The accommodation remaining when there is no stimuli. Base line innervation from the midbrain. Average is 1.00D. Amount changes with aging.

Innervation of accommodation: Figure and 81

For Blur driven accommodation:

- Retinal cones stimulated by defocus
- Blur signals transmitted through magnocellular layer of the LGN to the visual cortex
- Signal also transmitted to parieto-temporal areas for processing
- Supranuclear signal goes on to midbrain/oculomotor nucleus/Edinger-Westphal nucleus where motor command formulated
- Motor command transmitted to ciliary muscle via oculomotor nerve III, ciliary ganglion, and then short ciliary nerve
- Change in state of contraction of ciliary muscle
- Crystalline lens deforms to attain in focus retinal image and clarity of vision.
- The zonular tension decreases causing the anterior surface of the lens to steepen, plus power increases. The Z axis lengthens, the lens moves forward
- The lens sinks towards gravity.
- When relaxing accommodation, the zonules tighten, flattening the lens and moving the focus to far.

Accommodation measurement in infants: shows some general trends, but those infants are not being very cooperative in stating their results. Accommodation during first month is near 5.00D, then between 2 to 3 months it begins to approach adult like behavior. Tonic accommodation appears to be the same in infants and young adults...1.4D. Preterm babies show larger amounts of accommodation. The speed of accommodation is adult like by age of 3 months.

A gap in testing exists for children ages 1 to 4.5 yrs as they are difficult to assess.

From ages 5 to 10 more data exists.

Amplitude decreases with age: chart pp110, p108.

Lag of accommodation shows slow but progressive increase with age: table 4 2 p 82. Facility of accommodation improve with age, page 82 table 4 3

Does testing reflect real findings or maturity and cooperation of individual?

STEADY-STATE (STATIC) ACCOMMODATIVE STIMULUS-RESPONSE FUNCTION:

Figure 4-6

1. Initial nonlinear zone...Denotes response to the 0 to 1.50 stimulus. This represents the small tonic input and depth of

focus, the systems response is not 0, but .25 to .33. This represents the lead of accommodation where the system sets up for the least amount of work to place the depth of focus at the far target. Hyperfocal refraction and hyperfocal distance correspond to the point where the eye is still conjugate and still have a clear focus. Figure 4-7

2. Linear Manifest Zone....The response midregion over which as change in stimulus produces a relatively large and proportional change in the accommodative response. The slope of the linear response region ranges from 0.7 to 1.0. The lag of accommodation is apparent in this portion.
3. Nonlinear Transitional Zone; as the accommodative stimulus increases above the upper linear manifest zones, progressively smaller changes in accommodation occurs. This indicates a soft saturation in the system. More error in accommodation occurs due to the biomechanical limits of the crystalline lens.
4. Nonlinear Latent Zone; Further increases in accommodative stimulus level fails to produce additional change in accommodation. The hard saturation has occurred. This extends 2.00 D beyond the non linear transitional zone. This is the functional presbyopic zone. The system continues to try.
5. The Myopic Nonlinear Defocus Zone: In this zone, further amounts of noncompensated retinal defocus cause the system to reduce its effectiveness and leads to a gradual decrease in accommodative response sending the system towards its tonic level.
6. . Hyperopic Nonlinear Defocus Region: Stimulation beyond optical infinity produces a noncompensated hyperopic retinal

defocus that sets the system into tonic focus greater than the 0.25 expected for infinity. Back to the tonic level of 1.00.

BLUR sets off accommodation, but the system is even error controlled. The direction of the accommodation is controlled by a variety of factors. So the system with out influences is 50% accurate in direction of accommodation.

Review table 4-4

Review table 4-8 where the effect of a variety of target characteristics affects the response.

Real life is a composite of factors and the accommodative system works well.

More Vision Science:

Hung's Steady-State (Static) Model: **Figure 4-10**

The Input of Distance in both D and MA stimulates the reflex, proximal and vergence portions of the accommodative systems. Only the proximal system does not go through the retinal path.

The Threshold Dead space Operator: is the system component that tolerates error. It sets the level of what perceived blur would drive the system

Gain: the mechanism that controls the speed of response of the system.

Adaptive loop: Once the initial fast system response is completed, the adaptive loop is activated and it allows the system to sustain the response for a prolonged time.

Cross link Gain: multiplies the response output of the direct pathway gain taking into effect the AC/A and CA/C ratios. High gain to convergence from accommodation would result in esotropia, reduced gain might cause exotropia.

Tonic Input: midbrain baseline neural innervation, no visual feedback involved.

Summing Junction: Summation area of tonic, proximal, crosslink output to drive the system.

Peripheral Apparatus: The output of the summing junction proceeds to cortical and subcortical centers to form the neural signal to innervate the ciliary muscle and lens for accommodation and the extraocular muscles for vergence. Negative feedback pathway controls the system until steady state is achieved.