Fundamentals of Accommodation & Convergence

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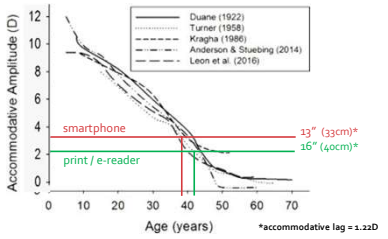
Accommodation

- Accommodation – physiological adjustment of focus
  - decreases with age[1]



*accommodative lag = 1.22D

[1]James S. Wolffsohn, Leon N. Davies, Presbyopia: Effectiveness of correction strategies, Progress in Retinal and Eye Research, Volume 68, 2019, Pages 124-143

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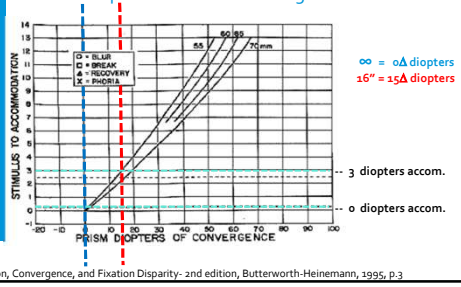
Convergence

- Convergence is expressed in prism diopters[6]
  - Orthophoria = correct convergence for demand



∞ = 0Δ diopters
16" = 15Δ diopters

3 diopters accom.

0 diopters accom.

[6] Goss, David A. Ocular Accommodation, Convergence, and Fixation Disparity- 2nd edition, Butterworth-Heinemann, 1995, p.3

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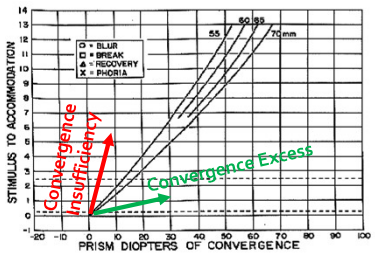
ACA Ratio

- ACA = steep slope indicates insufficiency[10]



[10] Goss, David A. Ocular Accommodation, Convergence, and Fixation Disparity- 2nd edition, Butterworth-Heinemann, 1995, p.15

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Morgan's Norms

- Dr. Merideth Morgan established "normal" phorias in the 1940-60s[15]

Tests	Expected	Standard Deviation
Distance Lateral Phoria	1 exophoria	+/-2 prism diopters
Base In (Distance) - Blur	n/a	n/a
Base In (Distance) - Break	7 prism diopters	+/-3 prism diopters
Base In (Distance) - Recovery	4 prism diopters	+/-2 prism diopters
Base Out (Distance) - Blur	9 prism diopters	+/-4 prism diopters
Base Out (Distance) - Break	19 prism diopters	+/-8 prism diopters
Base Out (Distance) - Recovery	10 prism diopters	+/-4 prism diopters
Near Lateral Phoria	3 exophoria	+/-3 prism diopters
Base In (Near) - Blur	13 prism diopters	+/-4 prism diopters
Base In (Near) - Break	21 prism diopters	+/-4 prism diopters
Base In (Near) - Recovery	13 prism diopters	+/-5 prism diopters
Base Out (Near) - Blur	17 prism diopters	+/-5 prism diopters
Base Out (Near) - Break	21 prism diopters	+/-6 prism diopters
Base Out (Near) - Recovery	11 prism diopters	+/-7.00 prism diopters
AC/A ratio	4:1	+/-2.00 prism diopters
Accommodation: Push Up	18 - (1/3) x age	+/-2.00 D
Accommodation: Fused Cross Cylinder	+0.50 D	+/-0.50 D
Accommodation: NRA	+2.00	+/-0.50 D
Accommodation: PRA	-2.37	+/-1.00 D

[15] Morgan MW. The analysis of clinical data. *Optom Weekly*. 1964;55:27-34;55:23-25

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Morgan's Norms

- General observations
  - A small amount of exophoria is normal
    - ✓1Δ up to 3Δ at distance
    - ✓3Δ up to 6Δ at near
  - Normally, it takes considerable prism to create blur at near
    - ✓13 ΔBI
    - ✓17 ΔBO
  - ACA Ratios can fall between 2-6Δ/1 diopter of accommodation

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Case Study - 43 year old wearing 1st PAL

- Returns to office complaining of
  - Headache & asthenopia
  - Occasional blur
- Re-dotting the lenses reveals
  - FRP is perfectly placed
  - Lenses are straight, well-mounted
  - Frame fit is good (8 panto, 7 wrap, 12mm vertex)
- Recheck reveals 20/15 distance, so ADD is "bumped"
  - Symptoms become worse
  - New lenses are "unusable"
- What is a *possible* explanation?

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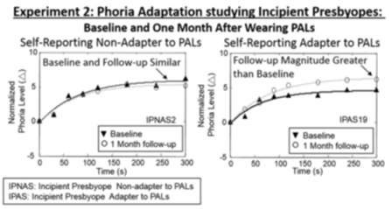
ALL PALs Require Adaptation

- Providing an ADD power alters the wearer's near phoria
- At least one study confirms successful adaption to PALs requires phoria elasticity[20]
  - "Successful PAL adapters become more esophoric with PAL wear."



[20]Alvarez TL, Kim EH, Granger-Donetti B. Adaptation to Progressive Additive Lenses: Potential Factors to Consider. Sci Rep. 2017;7(1):2529. Published 2017 May 31. doi:10.1038/s41598-017-02851-5

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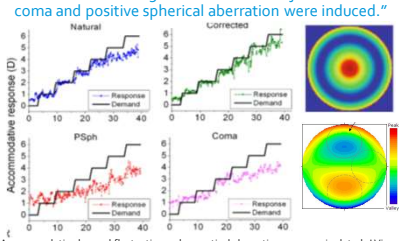
HOAs Challenge Accommodation

- Higher order aberration (HOA) is known to increase accommodative lag[21]
  - "Accommodative lag increased in all subjects when coma and positive spherical aberration were induced."



[21]Gambra E, Sawides L, Dorronsoro C, Marcos S. Accommodative lag and fluctuations when optical aberrations are manipulated. J Vis. 2009 Jun 9;9(6):4.1-15. doi: 10.1167/9.6.4. PMID: 19761295.

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Citations

[1] James S. Wolffsohn, Leon N. Davies, *Presbyopia: Effectiveness of correction strategies, Progress in Retinal and Eye Research*, Volume 68, 2019, Pages 124-143
[2] https://media.pearsoncmg.com/bc/bc_marieb_ehap_10/art_activities/figure_8.4a/figure_8.4a.html
[3] Alejandro L, Rosenfeld M, Estrada JM, Medrano SM, Marquez MM. *Lag of accommodation between 5 and 60 years of age*. Optom Vis Perf 2017;5(3):103-8.
[4] Goss, David A. *Ocular Accommodation, Convergence, and Fixation Disparity-* 2nd edition, Butterworth-Heinemann, 1995, p.135
[5] Ibid
[6] Ibid, p.3
[7] Ibid, p.67
[8] Ibid, p.70
[9] Schor CM, Ciuffreda KJ, eds. *Vergence Eye Movements: Basic and Clinical Aspects*. Boston, MA: Butterworth-Heinemann; 1983:15-21
[10] Goss, p.15
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[16] Sheard C. *The Sheard Volume – Selected Writings in Visual and Ophthalmic Optics*. Philadelphia, PA: Chilton; 1957:267-285.

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Citations

[17] Goss, pg. 49
[18] Miyao, Masaru & Shiomi, T. & Kojima, Takehito & Uemoto, K. & Ishio, Hiromu & Takada, Hiroki. (2012). *While viewing 3D video-clips, accommodative focus and convergence are in harmony*. Proceedings of the International Display Workshops. 2. 1208-1211.
[19] Finchim, EF & Walton, J. *The Reciprocal Actions of Accommodation and Convergence.* From the Institute of Ophthalmology, Judd Street London and the Northampton Polytechnic St John Street London, 1957.
[20] Alvarez TL, Kim EH, Granger-Donetti B. *Adaptation to Progressive Additive Lenses: Potential Factors to Consider*. Sci Rep. 2017;7(1):2529.
[21] Gambra E, Sawides L, Dorronsoro C, Marcos S. *Accommodative lag and fluctuations when optical aberrations are manipulated.* J Vis.2009 Jun 9;9(6):4.1-15.
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[23] Israel, H. E. (1923). *Accommodation and Convergence under Low Illumination.* Journal of Experimental Psychology, 6(3), 223–233.
[24] Ibid
[25] Owens DA, Liebowitz HW. *Accommodation, convergence, and distance perception in low illumination*. Am J Optom Physiol Opt. 1980 Sep;57(9):540-50.
[26] Gwiazda J, et.al. *A randomized clinical trial of progressive addition lenses versus single vision lenses on the progression of myopia in children. Invest Ophthalmol Vis Sci.* 2003 Apr;44(4):1492-500
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