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Independent and reciprocal accommodation in anisometropic amblyopia

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Abstract

Accommodation is considered to be a symmetrical response, and to be driven by the least ametropic and nonamblyopic eye in anisometropia. We report a case of a 4-year-old child with anisometropic amblyopia who accommodates asymmetrically, reliably demonstrating normal accommodation in the nonamblyopic eye and anti-accommodation of the amblyopic eye to near targets. The abnormal accommodation of the amblyopic eye remained largely unchanged over seven subsequent testing sessions undertaken over the course of therapy. We suggest that a congenital dysinnervation syndrome may result in relaxation of accommodation in relation to near cues and might be a hitherto-unconsidered additional etiologic factor in anisometropic amblyopia.

Methods

Accommodation was studied using an autorefractor-based technique. A PlusoptiX S04 videorefractor set in a remote haploscopic device was used to present a detailed picture target at fixation distances between 25 cm (4 D and meter angles [MA] demand) and 2 m (0.5 D and MA demand). We use meter angles in our laboratory since we are researching accommodation and vergence responses in relation to target demand and test participants from infancy to adulthood whose interpupillary distances therefore vary widely. By using meter angles as a measure of vergence we can directly compare the appropriateness of vergence and accommodation in relation to target demand and can compare and plot them in the same terms over development. For example, 1.0 MA of vergence and 1.0 D of accommodation are both required at 1 m fixation, and 3 MA and 3 D at 33 cm, independent of interpupillary distance. Continuous recordings of refraction, eye position, and pupil size were collected at 25 Hz from both eyes simultaneously. The raw refraction, eye position, and interpupillary distance data produced by the PlusoptiX S04 were used to calculate diopters of accommodation and meter angles of vergence response at each fixation distance, taking into account a calculated angle lambda and interpupillary distance. Our equipment allowed responses to be recorded simultaneously from both eyes while the target could be presented both binocularly and monocularly. Full details of construction, calibration and data processing have been published elsewhere.¹ Visual acuity testing was performed with

crowding bars and confirmed with a pinhole to minimize any effect of poor accommodation on the measurement.

Case Report

A 4 and 10/12 year old girl was discovered to have anisometropic amblyopia when she presented to our laboratory as a presumed healthy control for our studies of accommodation development. She was asymptomatic, and no visual defect had been suspected. Past medical history and family history were notable for an aunt with anisometropic amblyopia. On examination, visual acuity was 6/60 (1.0 logMAR) in the right eye and 6/7.5 (0.1 logMAR) in the left eye using the Keeler crowded letters test. Ocular motility and binocular vision testing showed orthophoria and binocular convergence to 7 cm but absent stereopsis. Subsequent cycloplegic refraction showed anisometropic hyperopia of $+7.00 +0.25 \times 90$ in the right eye and $+2.00 +0.25 \times 90$ in the left eye.

Careful studies of the patient's accommodation were conducted. (Note that the patient had an interpupillary distance that developed from 5.69 cm to 5.81 cm over the testing period; thus each meter angle equals between 5.69 and 5.81°, as the vergence demand for each fixation distance increased with her interpupillary distance.) Figure 1 shows appropriate convergence of both eyes to every target distance and symmetric pupillary constriction. The left eye (filled triangles) accommodated by amounts appropriate for the target distance, while the amblyopic right eye (open squares) accommodated most for the 2 m target and then relaxed to approximate the cycloplegic refraction for the near targets. Mean right refraction over seven testing sessions at 2 m was +3.0 D (thus accommodating 4 D over baseline +7.0 D hyperopic refractive error) and was +5.15 D at 33 cm demand (thus only accommodating 2 D over the hyperopia). In comparison the left eye refraction was +0.5 D at 0.5 D demand and -1.82 D at 3 D demand (a stable accommodation lag of ≈ 1 D at both distances). Thus the left eye accommodated an average of 2.32 D for 3 D increase in accommodation demand, while the right eye simultaneously *anti*-accommodates by 2.12 D, with 2.5 D of anisometropia at 2 m and 6.9 D at 33 cm (Figure 2A). Adduction of each eye was symmetrical, which excluded off-axis errors of refraction contributing to the difference between the eyes.

Spectacles with the full correction were prescribed and worn well. After 4 months of refractive adaptation,² 6 hours daily total occlusion left eye was prescribed for 8 months but with no improvement beyond 6/12 part (0.35 logMAR) in the right eye despite self-reported good adherence to therapy. When tested with spectacles the aniso-accommodation reduced and the binocular response (Figure 2B) showed more anisometropia for distance than near, that is, the hyperopic correction corrected the anisometropia for near but overcorrected the right eye in the distance. When the left eye was occluded, both accommodation responses were flat and the amblyopic right eye refraction was ≈ -1.25 D, indicating that the right eye overaccommodated in relation to the left (Figure 2C). With the right eye occluded, the fixating left eye showed lead of accommodation for near targets, while the right eye accommodated in the appropriate direction but with a much lower gain (Figure 2D).

Discussion

Accommodation is considered to be a symmetrical response,³ and in anisometropia, to be driven by the least ametropic and nonamblyopic eye, although a limited capacity for aniso-accommodation has been reported,⁴⁻⁵ and Rook and colleagues⁶ have recently reported aniso-accommodation in amblyopia. Our patient with anisometropic amblyopia not only accommodated asymmetrically but also reliably and repeatedly demonstrated anti-accommodation of the amblyopic eye to near targets, while the nonamblyopic eye accommodated normally.

To our knowledge this is the first report of such reciprocal accommodation between the eyes and shows that accommodation is not necessarily a consensual response. The greater the accommodation in the less-hyperopic eye, the greater the relaxation of accommodation in the amblyopic eye. The effect was reduced after spectacle prescription, possibly because correction of the hyperopia in the nonamblyopic eye reduced accommodative demand overall, but the response slope of the amblyopic eye remained much flatter than in the nonamblyopic eye ($t(6) = 3.9, p = 0.008$). Correction of the full anisometropia appeared to overcorrect the hyperopia for distance while equalizing refraction for near.

Whether the anisometropia was causal or secondary to the accommodative anomaly is unclear, but the stability of the responses over the course of refractive and occlusion therapy suggests an innervational etiology, possibly due to a dysinnervation syndrome, although since pupil reactions were typical, the anatomical site is unclear. Reverse progressive lenses in the right eye may be a treatment option in the future but aniseikonia and the residual amblyopia may limit the ability of such treatment to improve binocularity.

This case may not be unique; indeed, we only discovered the anomaly because we used the PlusoptiX S04 in PowerRefII mode, which makes simultaneous recordings from both eyes. We probably would have missed this case if we had been using the standard clinical practice of performing uniocular measurements (Figure 2C-D). It is possible that if more patients with anisometropic amblyopia are tested in this way, the phenomenon may prove to be more common than previously believed.

Literature Search

A literature search in English was carried out using PubMed/MEDLINE (1947- present), ISI Web of Knowledge (1900- present) Psych Lit and Google Scholar. Search terms included anisometropia, anisometropic, amblyopia, anisometropic amblyopia, accommodation, aniso-/ reciprocal / asymmetric / asymmetrical accommodation, misdirection.

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References

1. Horwood A, Riddell P. The use of cues to convergence and accommodation in naïve, uninstructed participants. *Vision Research*. 2008; 48(15):1613–24. [PubMed: 18538815]
2. Stewart C, Moseley M, Fielder A, Stephens D, MOTAScooperative. Refractive adaptation in amblyopia: quantification of effect and implications for practice. *Brit J Ophthalmol*. 2004; 88(12): 1541–2. [PubMed: 15548808]
3. Charman W. Aniso-accommodation as a possible factor in myopia development. *Ophthalmic & Physiol Optics*. 2004; 24:471–9.
4. Marran, L.; Schor, C. Binocular accommodation. In: Franzen, O.; Richter, H.; Stark, L., editors. *Accommodation and Vergence Mechanisms in the Visual System*. Birkhauser Verlag; Basel: 2000. p. 245-56.
5. Marran L, Schor CM. Lens induced aniso-accommodation. *Vision Research*. 1998; 38:3601–19. [PubMed: 9893793]
6. Rook C, Oystreck D, Loudon SE, Hunter DG. Comparison of the accommodative response in amblyopic and non-amblyopic eyes. *Invest Ophthalmol Vis Sci*. 2009; 50:S4704.

FIG 1.

Typical simultaneous recordings of unocular accommodation (accom) and pupil diameter, and binocular vergence made (without correction) to a binocular target moving between 2 m and 25 cm (target demand 0.5 D to 4 D) and meter angles [MA] demand). Y-axis: Combined scale in diopters for accommodation, meter angles for vergence, and millimeters (mm) for pupils. Positive figures denote accommodation (myopic refraction) and convergence, negative figures denote hyperopia and divergence. X-axis: seconds of recorded data. The child had an inter-pupillary distance of 5.69 cm when tested, so each meter angle equals 5.69° of vergence.

FIG 2.

A and B, Response means over 8 visits without and with refractive correction.

Anisotropic accommodation reduces with correction. Target visible to each eye. C, Example of occluded left eye, fixing amblyopic right eye. D, Example of occluded right eye, fixing nonamblyopic left eye; accommodation measured in diopters and vergence in meter angles (MA). Positive figures denote accommodation (myopic refraction) and convergence; negative figures denote hyperopia and divergence. All recordings were made simultaneously from both eyes although in the occluded conditions the target was only visible to the unoccluded eye.