Intermittent Exotropia and Accommodative Esotropia: Distinct Disorders or Two Ends of a Spectrum?
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In clinical diagnosis, we often imbue medical disorders with distinct personalities based on a constellation of findings with little understanding of their underlying causes. Our purpose here is to juxtapose intermittent exotropia and accommodative esotropia to consider the possibility that they represent a continuum of horizontal deviation, rather than distinct mechanisms of disease.

Over years of observation, we have come to view intermittent exotropia and accommodative esotropia as diametrical disorders of horizontal eye position that use common binocular control mechanisms. Intermittent exotropia is characterized by a gradual, progressive exodeviation of either eye that is present mainly during distance fixation or when the patient is inattentive.\(^1\) The measured deviation usually is greater at distance and, except in a small, definable group of patients with a high accommodative convergence-to-accommodation ratio,\(^2\) strabismus surgery targeted for the distance deviation produces surprisingly little risk for surgical overcorrection at near.\(^5\) This phenomenon is attributed to the observation that the resting position of the eyes (as determined under nondepolarizing paralyzing anesthesia) is abnormally divergent in patients with intermittent exotropia,\(^2,6\) so that extra fusional convergence effort is necessary to view near objects binocularly.\(^10,11\) In this condition, the measured near deviation is reduced artificially by a phenomenon that Kushner termed tenacious proximal fusion, meaning that fusional convergence initially masks the true esophoria at near until prolonged patching causes it to become manifest.\(^10,11\)

We believe tenacious proximal fusion is a manifestation of phoria adaptation, a compensatory mechanism that resets binocular alignment toward orthophoria, thereby compensating for developmental, environmental, or pathologic alterations in the binocular mechanism to restore the dynamic range (or fusion reserve) in which fast fusional vergence can function.\(^12\) Phoria adaptation operates independently of the immediate vergence system and thereby minimizes the need for vergence control. Although phoria adaptation is elicited classically by introducing prisms before the eyes to induce a vergence error, this compensatory mechanism also can function to reduce or eliminate the measured phoria. Patients with intermittent forms of strabismus, such as intermittent exotropia and accommodative esotropia, retain the ability to respond to vergence perturbations using this fusional mechanism. Phoria adaptation has been considered by some to be a cerebellar-dependent response,\(^13\) but midbrain vergence-related neurons also may play a role.\(^16\)

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Conversely, accommodative esotropia is characterized by a gradually progressive esodeviation that is often greater with near fixation.\(^7,14\) Accommodative esotropia has long been attributed to uncorrected hyperopia that increases accommodative effort with corollary accommodative convergence. Compared with other forms of strabismus, accommodative esotropia more often is associated with a high accommodative convergence to accommodation (AC/A) ratio, which generates a larger esodeviation during near fixation. In the absence of accommodative effort, patients with accommodative esotropia are conceptualized as having an esodeviation that is produced solely by their increased accommodative demand in the alert state, which is necessarily greater for near.

In patients with a greater near esodeviation, however, surgical correction targeted for the near deviation generally does not produce overcorrection of the distance deviation, suggesting that the true distance esodeviation must be greater than the measured distance esodeviation.\(^19\)–\(^23\) Accordingly, patients with larger near deviations may have a large distance esophoria, but be exhibiting a “tenacious” distance fusion, which again may be a healthy sign of phoria adaptation. That patients with accommodative esotropia can “eat up prisms,” allowing the examiner to build the measured esodeviation slowly with prism adaptation,\(^14\)–\(^16\) suggests that this is the case. The need to augment standard surgical doses for accommodative esotropia also suggests that these patients may be concealing a larger esodeviation than can be measured with prism and alternate cover testing (as opposed to controlling one, which would necessitate a corresponding phoria). Thus, the effects of phoria adaptation become admixed with those of disparity-driven nonaccommodative convergence (in intermittent exotropia) or blur-driven accommodative convergence (in accommodative esotropia) to produce some of the defining clinical signs of each condition.

Recent discoveries by Horwood et al\(^27\) and Horwood and Riddell\(^28\)–\(^30\) at the University of Reading have cast new light on the pathogenesis of intermittent exotropia and its juxtaposition to accommodative esotropia. These examiners used
a specially designed remote haploscopic video-refractor to manipulate blur, disparity, and proximal looming cues separately while simultaneously monitoring accommodation and vergence angles.\textsuperscript{27–30} To the surprise of many, these investigators found that disparity cues provide the primary drive for both convergence and accommodation in normal subjects.\textsuperscript{27,30} This observation may explain why monocular accommodation responses (which eliminate disparity cues) so often are worse than binocular ones.\textsuperscript{27} These investigators have found that patients with intermittent exotropia underaccommodate in the exodeviated state during distance fixation and overaccommodate in the orthotropic state during near fixation.\textsuperscript{28}

This unexpected finding of underaccommodation at distance does not arise from an inherent defect in accommodation, but presumably reflects the fact that the control of intermittent exotropia is driven primarily by retinal disparity (which is less at distance than at near).\textsuperscript{28} Patients with intermittent exotropia seem to use disparity-induced vergence cues to restore binocular alignment, with greater convergence stress demand during near fixation triggering overaccommodation, and possibly contributing to the development of myopia over time.\textsuperscript{31} Other investigators have used different methodologies to draw similar conclusions regarding the primary role of disparity-induced vergence in controlling intermittent exodeviations.\textsuperscript{32–34} That binocular disparity seems to provide a stronger cue than blur for both vergence and accommodation suggests that assessment of the convergence accommodation to convergence (CA/C) ratio may be more mechanistically accurate in normal subjects as well as in those with intermittent exotropia.\textsuperscript{28,35} Horwood and Riddell\textsuperscript{29,30} found patients with accommodative esotropia to be more responsive to blur than to disparity, causing their excessive accommodative demand to miscalibrate vergence position to produce an open-loop esodeviation that often is greater for near fixation. To the extent that they are driven by blur, assessment of the accommodative convergence-to-accommodation ratio provides a more accurate mechanistic assessment of the resulting esotropia at any given distance.\textsuperscript{29}

The confluence of these findings raises the question of whether intermittent exotropia and accommodative esotropia exist on a spectrum from disparity-driven convergence accommodation to blur-driven accommodation convergence (Fig 1). If so, there is no evidence that this duality results from inherent innervational differences. Rather, they seem to reflect only the physiologic demands placed on the binocular visual system by the nature of the deviation and refractive error. Long ago, Jampolsky\textsuperscript{36} first presented evidence and maintained that there is no active centrally mediated divergence and that apparent horizontal divergence movements of the eyes are effectuated by deconvergence. In this way, both the central convergence and accommodation centers function conjointly as an on-off system rather than a push-pull system. It may reflect the existence of a central convergence center alone that is, at its core, the neurologic substrate for intermittent exotropia and accommodative esotropia, which both involve the modulation of central convergence effort.

But why should intermittent exotropia be more sensitive to disparity and accommodative esotropia be more sensitive to blur? Evolutionarily, the crossed nasal retina is more attuned to blur because there is minimal disparity when each eye sees a different side, as is the case in fish and rabbits. However, the uncrossed temporal retina is attuned to binocular disparity in the midline, which may explain in part the expression of these compensatory responses under pathologic conditions in humans. These mechanisms fit well with the original evolutionary
functions of each hemiretina, which must be retained in humans even after the evolution of crossed chiasm segregates them into 2 hemispheres. The observation that both conditions are anchored to the accommodative system (indirectly or directly) may help to explain their gradual onset, their progressive nature, their occasional clinical overlap, and their clinical manifestations.

Does the presence of tenacious proximal fusion in intermittent exotropia and tenacious distance fusion in some cases of accommodative esotropia reflect an independent compensating role of phoria adaptation in resetting horizontal vergence tone? Although phoria adaptation usually is elicited by introducing prisms before the eyes to induce a vergence error, this neural adaptation also can function to reset the measured phoria and thereby negate strabismus. Strabismic patients may retain the ability to respond to perturbations using this mechanism, perhaps even in enhanced form. Furthermore, it makes physiologic sense that phoria adaptation must be confined to the specific range of fixation distance that constrains the deviation to fall within the limits of its compensatory fusional range. For this to be the case, both intermittent exotropia and accommodative esotropia must invoke a binocular stabilization mechanism (i.e., phoria adaptation) that conceals the basic phoria measurements that we extract after prolonged occlusion. Perhaps at a sensorimotor level, near convergence is more robust (because of proximal or other factors), so that the demands on phoria adaptation are actually less at near than at distance in intermittent exotropia.

Phoria adaptation would explain how a distance-near disparity in accommodative esotropia can be managed effectively with medial rectus recessions to target the near esodeviation without overcorrecting a much smaller distance esodeviation. This hidden mechanism would signify that some children with distance-near disparity have a distance esodeviation that “flies under the radar” of our routine clinical examination by prism and alternate cover testing. One test for this hypothesis would be to repeat prism and alternate cover testing after prolonged occlusion of one eye in patients with accommodative esotropia who have greater esodeviations at near than distance. If phoria adaptation is operative, one would expect prolonged occlusion of one eye to increase the distance esodeviation to approximate the near deviation, as suggested by results of a recent study. If phoria adaptation is not operative, one would expect prolonged occlusion of one eye to induce a large postoperative exophoria at distance when the near esodeviation is eliminated. We have not found this to be the case. As new physiologic discoveries emerge, we soon may come to see intermittent exotropia and accommodative esotropia as two sides of the same coin.

References


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