International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Developmental Dynamics of Accommodation and Convergence in the Visual System

Priyanka Roy

Assistant Professor, Haldia Institute of Management

Abstract: ***Aim**: This review aims to explore current research on how the visual functions of convergence (eye alignment) and accommodation (focusing) develop in early life. These two visual processes are essential for clear, single vision with both eyes working together. If their development is disrupted, it can lead to vision problems such as strabismus (eye turn), accommodative disorders, and possibly interfere with the natural process of the eye growing towards correct focus (known as emmetropisation). **Method**: The review examines the unique challenges of studying these visual functions in infants, who cannot communicate or follow instructions like adults. As a result, researchers have had to use different approaches compared to adult studies. The review then discusses current findings on how these visual abilities develop and how closely they are connected in early life. **Results**: Accommodation begins with a default nearsighted (myopic) state in newborns, but becomes more accurate and adult - like by around 4 months of age. Vergence (the ability to align both eyes) also improves after this age but is seen to begin even earlier—before infants can use binocular disparity (a key depth perception cue). The early presence of vergence suggests alternative developmental mechanisms, which are explored in this review. Interestingly, the coordination between accommodation and vergence in infants shows more variation than what is typically reported in adults. However, this difference may not be entirely due to developmental immaturity—it could also stem from how these functions are measured in infants versus adults. **Conclusions**: Infant visual responses are marked by flexibility and variability. Rather than being signs of dysfunction, these may reflect a natural strategy that helps infants build a strong and adaptable binocular vision system as they grow. Studying how infants use visual cues may also offer valuable insights into the causes of conditions like strabismus and refractive errors.*

Keywords: Accommodation, Development, Emmetropisation, Infant Vision, Vergence, AC/A ratio, CA/A ratio, BSV, Refractive errors

1. Introduction

Understanding how the eyes work together to create clear, single vision is central to the field of orthoptics. Concepts like binocular single vision (BSV), fusion, accommodative strabismus, heterophoria, AC/A ratio, refractive errors, and convergence issues are commonly discussed in clinical settings. However, what ties all of these visual processes together are two essential mechanisms: vergence (eye alignment) and accommodation (focusing).

For binocular vision to develop properly, both eyes must be directed at the same object — a task made possible by accurate vergence. Likewise, for sharp vision to develop, the eye must focus clearly on the object, which requires precise accommodation. In this sense, these two systems form the foundation of how we see with both eyes.

Research into how vergence and accommodation develop during infancy may help us better understand the origins of common clinical problems such as strabismus and refractive errors. This review focuses on these key components of binocular vision development and their relevance to orthoptic practice.

2. Methodological Challenges in Infant Research

Studying vision in infants presents unique difficulties. Unlike adults, infants cannot follow instructions or provide verbal feedback. Moreover, their behaviour is often unpredictable — they may fall asleep, become fussy, or simply lose interest in tasks. Infants under two months of age are only occasionally in a calm, alert state, and meaningful results can only be collected during these short windows.

Selecting the right kind of visual stimulus is also complicated. Tasks suitable for newborns may bore older infants, and toddlers often have their own ideas about what they want to do. To ensure reliable results, tests must be age - appropriate and non - invasive, while also producing objective data since infants can't describe what they see.

Vergence and Eye Alignment in Infants

To achieve clear, single vision, infants must learn to move both eyes together to track objects in depth. In adult studies, vergence (eye movement coordination) is often measured using advanced tools like infrared tracking, magnetic search coils, or electro - oculography (EOG). These techniques are highly accurate but too intrusive for infants, as they involve contact lenses, electrodes, or require cooperation not possible in newborns.

Instead, researchers studying infants often rely on corneal reflection methods, using the first Purkinje image (the reflection of a light source on the cornea). As the eyes move, the position of the pupil changes relative to the corneal reflection, allowing researchers to estimate how the eyes converge or diverge. This method is non - invasive and more suitable for young subjects, though it still has limitations in accuracy.

Infants are often misjudged as having misaligned eyes (pseudo - strabismus) if adult visual norms are applied without correction for anatomical differences, such as angle lambda — a variable between the line of sight and the optical axis that differs greatly among infants and decreases with age. Only deviations larger than 2° are considered reliable for diagnosing true misalignment in infants.

Accommodation in Infants

Measuring accommodation in infants is equally challenging. Even in adults, subjective reports of visual clarity are not always reliable. Since the early 20th century, researchers have known that just because someone says they can see clearly doesn't mean the eye has properly focused.

Modern studies rely on objective tools, such as optometers, photorefraction, or dynamic retinoscopy, to measure how well the eye accommodates. In infants, dynamic retinoscopy (measuring focus while the baby fixates on a near target) and photorefraction (using light reflections to assess focus) are the most commonly used methods. These tools must be carefully adapted to ensure both eyes are assessed simultaneously and accurately, particularly when studying relationships like the AC/A ratio (the link between accommodation and convergence).

Another complication is distinguishing between true refractive errors and temporary focusing inaccuracies. While cycloplegia (paralysis of the eye's focusing system using eye drops) can help clarify the diagnosis, frequent use is distressing for infants and may lead to higher dropout rates in long - term studies.

Development of Vergence

In adults, vergence movements are primarily driven by retinal disparity — the small differences between the images seen by each eye. However, infants don't seem to reliably detect these differences until around 12 to 14 weeks of age. This suggests that vergence development may be delayed until the brain becomes capable of processing binocular depth cues.

That said, the exact age at which full vergence responses emerge varies and depends on factors such as stimulus type, target motion, and measurement method. Some studies have shown that vergence movements may appear even before retinal disparity detection fully matures, possibly driven by other visual cues or innate mechanisms.

Studying visual development in infants is both complex and essential. While methodological limitations mean that infant studies cannot match the precision of adult research, they offer crucial insights into how vision systems mature. Accurate development of accommodation and vergence is foundational to binocular vision, and disruptions in these processes can lead to conditions commonly seen in orthoptic practice. Understanding how these visual systems emerge can inform better diagnosis, earlier intervention, and ultimately improve visual outcomes for children.

Early Development of Vergence in Infants: A Review of Key Studies

One of the earliest attempts to understand how infants develop vergence tracking—the eye movement that aligns both eyes on a single point—was made by Ling, who used motion picture recordings to observe infants' eye movements. He found no clear signs of vergence in infants under 3 months old. However, more detailed work by Aslin, using corneal reflection techniques, showed that infants as young as 1 month could produce some vergence movements, although these responses were weak until after the second month.

Later, Slater and Findlay refined this method by correcting for angle lambda (a measurement adjustment needed when studying infant eye position). They tested newborns in a darkened room with illuminated targets placed at distances of 12.5 cm, 25 cm, and 50 cm. Remarkably, even babies younger than 8 days (average age 6.4 days) demonstrated appropriate eye alignment toward the 25 cm and 50 cm targets. However, the responses lacked the precision required for high - quality binocular vision, which typically isn't fully developed until around 3 months of age.

Building on this, Hainline and colleagues used a method called off - axis photorefraction to evaluate both accommodation (focusing) and vergence in over 650 infants. Their study revealed that 75% of infants younger than 45 days were already making appropriate vergence responses to nearby targets. Interestingly, while their eye alignment was relatively accurate, their accommodation (focusing ability) was not well - developed—suggesting that vergence can occur independently of accommodation at this early age.

They proposed two possible explanations:

1) Held's "pre - stereoscopic" theory – suggesting that infants might achieve basic alignment by adjusting their eye position until the visual cortex receives highly similar signals from both eyes.
2) A simpler possibility – that each eye may independently rotate to center an object on the clearest part of the retina, producing a vergence - like behavior even without true binocular coordination.

Further support came from the Infant Vision Laboratory in Reading, where researchers used a remote haploscopic photorefractor. This system allowed researchers to measure vergence and accommodation in a non - invasive way while the infants viewed targets at varying distances (0.33m to 2m). Infants showed broadly appropriate vergence responses from the first weeks of life, although accuracy improved significantly by 6 months, particularly when adjusting to both near and far targets.

Another influential study by Thorn et al. differentiated between "first convergence" (any observable inward eye movement) and "full convergence" (precise, adult - like eye alignment to within 12 cm of the face). They found that only 50% of infants had achieved first convergence by 11.4 weeks, and full convergence appeared about two weeks later, closely following the development of stereopsis (depth perception based on binocular disparity).

What Cues Drive Early Vergence?

This leads to an important question: what cues guide vergence before the visual system can detect depth (disparity) ? Aslin tried to isolate the effect of disparity by using prisms that created a conflict between the images seen by each eye. Infants did not respond reliably to these disparity cues until after 4.5 months, which he attributed to

Paper ID: SR25629161107 DOI: https://dx.doi.org/10.21275/SR25629161107

immature spatial frequency sensitivity rather than poor eye movement control.

Coakes et al. similarly found that infants began to respond to base - out prisms (which require convergence to maintain alignment) between 2 and 3 months. Held theorized that the reason infants fail to respond earlier is because they lack eye - of - origin information—meaning their visual system hasn't yet developed the ability to tell which eye a signal came from, a function tied to the maturation of cortical binocular neurons between 11 and 16 weeks.

However, a follow - up study at the Infant Vision Laboratory offered a new perspective. Using larger prism powers and a highly engaging target (the illuminated face of a toy), they found appropriate vergence responses as early as 4 weeks. Notably, these early responses occurred more often in dark conditions than in lighted rooms. This suggests that attention and visual competition (multiple visual stimuli in well - lit environments) may influence whether infants show vergence behaviour.

Reconciling Conflicting Findings

When comparing studies on vergence development, two different developmental timelines emerge:

1) Some studies (e. g., Thorn et al., Aslin, Coakes) suggest that vergence appears after 3 months and is tied to the emergence of stereopsis and disparity processing.
2) Others (e. g., Slater, Hainline, Infant Vision Lab) report vergence - like responses as early as the first weeks of life, suggesting that basic vergence mechanisms are present before the visual system can process binocular depth.

These differences may stem from how and when the targets were presented. Studies showing earlier vergence typically used bright targets in dark rooms, minimizing distractions. Conversely, studies using continuous motion or well - lit settings may have unintentionally made it harder for infants to focus and respond appropriately.

3. Conclusion and Theoretical Implications

The fact that infants can show vergence movements within the first weeks of life suggests that the anatomical and neural systems for eye coordination are functional from birth. Early vergence, or "first convergence, " may not rely on the same cues that guide adult - like vergence, such as binocular disparity. Instead, these early responses may use simpler, monocular cues or reflex - like mechanisms aimed at aligning the eyes to enhance overall visual input.

Over time, as the brain matures, a more accurate, disparity - driven vergence system develops, enabling high - quality binocular vision and depth perception. Understanding these processes helps clarify not just how visual coordination emerges, but also how early problems in these systems could lead to long - term issues like strabismus or poor stereopsis.

More research using varied stimulus types and conditions is essential to further uncover the exact mechanisms that guide the transition from primitive to mature vergence in infancy.

Early Vergence Control and the Role of Brain Mechanisms

Some researchers have proposed that the early control of eye alignment—before full binocular vision develops—might be guided by deeper brain structures known as subcortical pathways, rather than the more complex cortical binocular systems. However, these ideas remain theoretical, as no direct experimental evidence currently supports them. Hainline also suggested that infants may initially use a monocular control system, where each eye operates somewhat independently in the early months before the brain can fuse images from both eyes into one.

Studies exploring how eye alignment develops have led to a model that includes two phases:

- The first vergence response is fast but imprecise.
- A second, slower, and more accurate vergence response emerges later and is believed to be driven by feedback from retinal disparity—the small differences between the images seen by each eye that the brain uses to judge depth.

This second response can only develop once the brain has the ability to detect disparity, typically after a few months. The initial fast response, however, appears to be independent of disparity, and might instead result from individual monocular fixation efforts. This early system could help explain how newborns maintain a rough alignment of their eyes even before their visual systems are fully mature. This dual - control theory helps account for the difference in timing between early, basic eye movements and later, refined coordination.

The Development of Accommodation in Infants

Unlike the somewhat inconsistent findings related to vergence, research on accommodation—the ability to focus on objects at different distances—has shown more consistent results, even across studies using different methods and visual targets.

Most infants are born with mild hyperopia (farsightedness), but during the first few months of life, they often behave as if they are myopic (nearsighted) because they fail to relax their eyes to see distant targets clearly. This suggests that, at first, infants mainly focus on near objects, and the ability to adjust focus for distance develops gradually.

Aslin and colleagues argued that this lack of distance focusing is not because the focusing system itself is immature, but rather due to sensory limitations. The infant's retina and visual pathways are still developing, which means their visual acuity and contrast sensitivity are low. As a result, when an infant's eyes do not focus properly, the resulting blur is not easily noticed by the brain. Therefore, the infant has little motivation to adjust their focus, even though the motor system for focusing might already be capable of making the change.

Further investigation by Currie and Manny aimed to understand which visual cues guide accommodation in early infancy. They used a method called eccentric photorefraction to test eight infants (aged 1.5 to 3 months) and compared their responses to those of adults. The study tested different

Paper ID: SR25629161107 DOI: https://dx.doi.org/10.21275/SR25629161107

cues—blur, proximity (how near an object is), and vergence (eye alignment) —both separately and in combination.

The results showed that many of the youngest infants did not adjust their focus properly for distant objects. Even at 3 months, improvements were modest. Interestingly, the level of accommodation in some infants was stronger than what could be explained by blur sensitivity alone. When visual cues conflicted (e. g., blur cues vs. proximity cues), accommodation responses were inconsistent, suggesting that proximity was a stronger driver than blur in early development.

A notable finding was that 57% of 3 - month - olds had better accommodation under binocular conditions, indicating that having both eyes open helped improve focus. This points to the idea that vergence and proximity cues may play a more important role than blur in guiding focus during early infancy. The study suggests that the accommodation system may be pre - programmed to focus on near objects, and as visual experience improves, the system becomes more flexible and accurate.

While the small sample size limits the generalizability of these findings, the research offers meaningful insight into how young infants begin to develop functional visual focus through interaction between multiple cues.

Larger - Scale Accommodation Studies and Special Populations

In a more extensive study, Hainline and colleagues used eccentric photorefraction to test 453 infants, measuring both vergence and accommodation responses to targets placed at various distances (from 0.25 m to 2.0 m). Before 6 weeks of age, many infants showed flat, myopic behaviour—not because they were truly myopic, but because they didn't yet relax their focus for distant objects. After 6 weeks, more infants began to show varied focus responses, typically using two levels of focus: one for near and one for far distances—similar to how adults unfamiliar with the test responded.

This large dataset also allowed researchers to explore how infants with refractive errors (like hyperopia) responded. Emmetropic (normal vision) infants showed the most accurate focus adjustments. Infants under 2 months of age were more likely to have flat or inaccurate responses. Hyperopic infants responded with correct direction of focus change but consistently under - accommodated—that is, they didn't focus enough at any distance. These findings align with previous results by Currie and Manny.

Another important area of study has been infants and children with Down syndrome. Woodhouse and colleagues conducted dynamic retinoscopy on a large group of children with Down syndrome and found that they consistently had reduced levels of accommodation compared to typically developing children. These findings may reflect a general developmental delay, or they could point to a more specific visual processing challenge associated with the condition.

4. Summary

Overall, the research reveals that:

- Vergence and accommodation develop along separate timelines.
- Early vergence may be guided by simple monocular mechanisms before the brain can process depth from both eyes.
- Accommodation to distance develops slowly, likely due to the infant's limited ability to detect blur rather than an inability to adjust focus.
- Visual cues such as proximity and vergence may play a larger role in early accommodation than previously thought.
- Infants with refractive errors or developmental conditions such as Down syndrome show consistent patterns of under - accommodation, highlighting the need for early detection and support.

Understanding how these visual systems develop not only sheds light on normal infant vision, but also helps in the early diagnosis and treatment of visual disorders. Continued research using larger and more diverse populations will deepen our understanding of how visual development unfolds during the critical first months of life.

5. Accommodation Development and Its Link to Vergence in Infancy

Understanding Patterns in Infant Accommodation

Findings from specific clinical groups have led researchers to consider that, by studying how accommodation develops in newborns and infants, we may be able to predict and possibly prevent certain visual disorders early on.

Data from the Infant Vision Laboratory support findings from other studies, showing that most infants under 8 weeks old display a consistent tendency to behave as if they are myopic (nearsighted). These young infants appear to experience a sudden improvement in their ability to relax focus and see distant objects. Infants who were seen at two - week intervals often shifted from having little to no change in focus ("flat" accommodation) to showing adult - like responses within a single visit. Interestingly, this improvement often matched what parents noticed at home, such as the baby beginning to look across the room.

Unlike Hainline et al., who reported more of an "all - or - nothing" accommodation behaviour, the Infant Vision Lab found a more gradual transition in accommodation abilities. While vergence (eye alignment) improved steadily over the first six months, accommodation accuracy typically reached adult - like levels by around three months. Across all ages, accommodation responses were generally less precise than vergence, and both were significantly disrupted by occlusion (blocking one eye). Even adults unfamiliar with the task showed similar disruptions, suggesting that accommodation is highly dependent on visual input.

The Link Between Accommodation and Vergence

Accommodation (focusing) and vergence (eye alignment) are closely connected systems. One connection, known as the AC/A linkage, describes how focusing on a near object

Paper ID: SR25629161107 DOI: https://dx.doi.org/10.21275/SR25629161107

can automatically cause the eyes to turn inward (converge). This is relatively easy to study by covering one eye (to eliminate depth perception) and introducing blur to stimulate accommodation. The stimulus AC/A ratio measures the change in eye alignment divided by the change in accommodation needed.

However, measuring the response AC/A ratio—which requires tracking both accommodation and vergence changes simultaneously—is more complex and less frequently reported.

It is important to note that this connection works in the opposite direction too: vergence can drive accommodation, known as the CA/C linkage. Testing this is even more challenging because one must measure focus while presenting a vergence stimulus that doesn't also trigger accommodation. Techniques such as using pinhole filters to reduce blur or non - accommodative targets like Gabor patches can help isolate this effect. Measuring CA/C requires precise, simultaneous tracking of both accommodation and vergence.

Studies on AC/A and CA/C in Infants

Aslin and Jackson were among the first to study AC/A linkages in infants. They observed that even as early as 2 months of age, infants would show vergence responses to an approaching patterned stimulus, even when one eye was occluded. While they didn't directly measure accommodation, they proposed that the eye movement was being driven by the AC/A connection. They suggested that the AC/A ratio is present at birth but becomes more refined as the infant grows, possibly adapting to changes such as increasing distance between the eyes (interpupillary distance). However, their study did not include newborns, nor did it isolate the role of proximity cues, so these conclusions remain somewhat speculative.

In another study, Aslin and Dobson examined whether accommodation and vergence become separated when visual input is removed. They used photorefraction and corneal reflection methods to study infants (aged 3–12 months) and adults. Subjects looked at a lit target at both 25 cm and 150 cm, and then the same was repeated in complete darkness. They found that vergence in darkness was highly variable and did not correlate with accommodation, indicating that without visual cues, the normal link between these two systems may break down.

Larger - Scale Research on Vergence and Accommodation

A significant study by Hainline and colleagues included 752 infants under 1 year old. Using photorefraction, they studied responses to illuminated toys placed at various distances (from 25 cm to 200 cm). They found that vergence was often accurate from birth, but accommodation typically remained fixed around 30 cm, regardless of how far the target was. These results suggested that in neonates, accommodation and convergence are not yet tightly linked, but begin to coordinate after around 2 months of age.

This study also identified four broad behavioural patterns in infants:

1) Good accommodation and vergence – seen in 35% of infants under 45 days and over 70% by 60 days.
2) Good vergence but poor accommodation – found in about 50% of the sample.
3) Better accommodation than vergence – present in about 6% of infants.
4) No change in either response, likely due to inattention – seen in 12% of cases.

Thus, while individual differences were significant, many young infants were able to align their eyes but struggled with adjusting focus.

Currie and Manny were the first researchers to study both binocular and monocular accommodation in infants, enabling them to explore the direction of influence between these systems. They discovered that blur alone was not a strong enough cue to trigger proper accommodation in most infants, especially the youngest. In fact, infants tended to accommodate better when both eyes were open, indicating the importance of the CA/C linkage—where eye alignment drives focus.

They also found that proximity cues played a meaningful role in the infants' responses. For some infants, the AC/A linkage (focus driving eye movement) was rarely active, while the CA/C linkage (eye movement driving focus) was more commonly used. This suggests that in early infancy, accommodation is more often influenced by how the eyes align rather than by blur or focus demands alone.

Recent Insights into CA/C Linkage

A more recent study by Bobier and colleagues investigated the CA/C ratio in infants aged 3 to 6 months and compared them with adults. They used a video - based refractor to measure accommodation changes caused by placing a base - out prism in front of one eye while the infant focused on a non - accommodative target. At the same time, they used corneal reflection to measure vergence responses.

The results showed that infants had higher CA/C ratios than adults. In other words, their eye alignment caused stronger accommodation responses than in older participants. The researchers attributed this to several factors typical of infancy, including greater accommodative flexibility, broader depth of focus, and stronger vergence cues.

6. Conclusion

In summary, the development of accommodation and vergence systems in infants is both complex and fascinating. Early behaviours suggest that these two systems are not tightly linked at birth. Accommodation tends to lag behind vergence and is less accurate during the first few months of life. Over time, as infants gain more visual experience, these systems become better coordinated.

- The CA/C linkage (eye alignment influencing focus) appears to play a larger role than the AC/A linkage during early infancy.
- Blur alone is not a reliable trigger for infant accommodation.
- Proximity cues and binocular vision are significant in helping infants develop more accurate visual focus.

- Clinical research also hints at possible early detection of visual abnormalities through the observation of accommodative patterns.

These findings not only enhance our understanding of visual development but also open doors for early screening and intervention in infants at risk of visual or developmental disorders.

Accommodation and Vergence in Infancy: Linkages, Development, and Variability

Convergence - Accommodation Dynamics

Although some researchers have suggested that infant accommodation may be driven by blur cues, this idea is not supported by recent findings. In particular, the results from studies using prisms that do not produce blur suggest that infants may instead rely on convergence - driven accommodation (CA/C linkage) rather than responding directly to blur.

At the Infant Vision Laboratory, a device called the remote haploscopic photorefractor has been used to measure how accommodation and vergence interact in infants. This system allows for the assessment of the response AC/A ratio by measuring both accommodation and vergence while one eye is occluded, thereby removing the disparity cue for vergence but keeping the blur cue available to the uncovered eye.

In a study involving 133 infants aged 1 to 12 months, about half of the participants showed an active AC/A linkage—meaning both vergence and accommodation changed in response to visual demand, even without disparity cues. Occlusion not only disrupted vergence but often also weakened accommodation, suggesting that convergence might be more influential in driving accommodation than previously assumed.

Interestingly, this pattern was also observed in young adults tested under the same conditions, indicating that this is not merely a developmental immaturity, but rather a feature of how the visual system may function in more naturalistic settings. Longitudinal studies using the same equipment have shown that in early infancy, accommodation and vergence are strongly linked, but this connection becomes weaker over the first six months. Early on, infants appear to use all available cues—disparity, blur, and proximity—to guide both focusing and eye alignment. As development progresses, these visual systems become more specialized, with disparity driving vergence and blur driving accommodation.

This flexibility in early development may allow infants who follow atypical visual pathways to still develop functional vision. For example, if blur or disparity cues are unreliable, infants may depend more on proximity cues or alternative pathways, such as the CA/C linkage, to support visual behaviour.

Variability in Visual Behaviour

One of the most striking observations from infant studies is the high level of variability in how accommodation and vergence are used—even in typically developing infants. Infants differ significantly not just from one another, but also within themselves from one moment to the next. This contrasts with most adult studies, where participants are trained, tasks are controlled, and variability is minimized to produce consistent, reproducible results.

In infant research, however, minimal constraints are placed on attention and behaviour, revealing a true picture of natural visual variability. Although this inconsistency is often attributed to developmental immaturity, it might also reflect a more general truth: visual responses—even in adults—are variable when the task does not demand precision.

There is growing evidence that adult visual behaviour becomes less consistent when tested under infant - like, less constrained conditions. Therefore, direct comparisons between infant and adult data are difficult unless adults are studied using the same methods as infants.

7. Conclusions and Clinical Implications

At birth, both vergence (eye alignment) and accommodation (focus adjustment) are underdeveloped. While infants are capable of roughly aligning their eyes for different distances, accurate vergence responses take several months to mature, typically not reaching adult - like precision by six months of age. Before the brain's disparity detection mechanisms (important for depth perception) mature—usually between 12 and 16 weeks—infants may rely on independent eye movements or primitive neural mechanisms to coordinate their eyes.

Accommodation, on the other hand, shows faster development, usually improving significantly between 2 and 3 months. By this point, many infants demonstrate focus responses close to adult levels when responding to natural targets. The initial "flat" myopic behaviour seen in new - borns—where they over - focus for near vision—usually gives way to more accurate, adult - like accommodation.

It's important to note that infants' visual behaviour resembles that of naïve, untrained adults. Both groups often fail to focus precisely unless the task requires it. This pattern is also observed in individuals with conditions such as Down syndrome or hyperopia (farsightedness). As such, the textbook expectations of clear AC/A and CA/C ratios are rarely seen in infants, and even among adults, measurements of these ratios can vary significantly depending on how they are tested.

This variability suggests that accommodation and vergence systems are more flexible and individualized than previously thought. Some people may rely more on convergence to drive focus, while others may do the reverse—or depend on proximity cues. This personalized approach could explain the range of responses seen in clinical patients.

Why This Matters for Vision and Eye Care

The individual variation in how infants develop and use their accommodation and vergence systems may hold important clues for diagnosing and managing visual disorders. Because blur is known to play a role in emmetropization—the natural process through which the eye grows to achieve clear vision—understanding how infants respond to blur, depth, and alignment could help explain why some children develop refractive errors like myopia or hyperopia.

By continuing to study how these systems develop—both in typical infants and in those with visual impairments—we may improve our understanding of how to better detect, predict, and treat visual problems. These findings could ultimately enhance orthoptic treatments, inform screening strategies, and offer personalized interventions for children at risk of abnormal visual development.

References

[1] Adler P., Scally A. J., Barrett B. T. Test–retest reproducibility of accommodation measurements gathered in an unselected sample of UK primary school children. Br J Ophthalmol.2013; 97: 592–597. doi: 10.1136/bjophthalmol - 2012 - 302348. [DOI] [PubMed] [Google Scholar]

[2] Maxwell J., Tong J., Schor C. M. Short - term adaptation of accommodation, accommodative vergence and disparity vergence facility. Vision Res.2012; 62: 93–101. doi: 10.1016/j. visres.2012.03.013. [DOI] [PMC free article] [PubMed] [Google Scholar]

[3] Insufficient Accommodation: Does It Occur Before The Onset Of Myopia In Children?. Jane Gwiazda, Joseph Bauer, Frank Thorn, and Kenneth Grice. **SaC.4** Vision Science and its Applications (VSIA) 1997

[4] Russell G. E., Wick B. A prospective study of treatment of accommodative insufficiency. Optom Vis Sci.1993; 70: 131–135. doi: 10.1097/00006324 - 199302000 - 00009. [DOI] [PubMed] [Google Scholar]

[5] The Influence of the AC/A Ratio and Phoria on Accommodative Esotropia. John Semmlow, Annie Putteman, Jean - Louis Vercher, Gabriel Gauthier, and P. - V. Bérard. **SaC.5** Vision Science and its Applications (VSIA) 1997

[6] Scheiman M., Mitchell G. L., Cotter S., et al. A randomized clinical trial of vision therapy/orthoptics versus pencil pushups for the treatment of convergence insufficiency in young adults. Optom Vis Sci.2005; 82: 583–595. doi: 10.1097/01. opx.0000171331.36871.2f. [DOI] [PubMed] [Google Scholar]

[7] AC/A Ratio, Age, and Refractive Error in Children. Donald O. Mutti, Lisa A. Jones, Melvin L. Moeschberger, and Karla Zadnik. **SuA7** Vision Science and its Applications (VSIA) 1999

[8] Rouse M., Borsting E., Mitchell G. L., et al. Validity of the convergence insufficiency symptom survey: a confirmatory study. Optom Vis Sci.2009; 86: 357–363. doi: 10.1097/OPX.0b013e3181989252. [DOI] [PMC free article] [PubMed] [Google Scholar]

[9] BraddickO. J. *et al.* **A photorefractive study of infant accommodation. Vision Res.** (1979).

[10] Convergence insufficiency treatment study group Long - term effectiveness of treatments for symptomatic convergence insufficiency in children. Optom Vis Sci.2009; 86: 1096–1103. doi: 10.1097/OPX.0b013e3181b6210f. [DOI] [PMC free article] [PubMed] [Google Scholar]

[11] Griffin J., Grisham J. Butterworth - Heinemann; Boston, MA: 2002. Binocular Anomalies: Diagnosis and Vision Therapy. [Google Scholar]

[12] Photorefractive Evaluation of Infant Accommodation and Convergence. P. M. Riddell, J. Grose - Fifer, L. Hainline, and I. Abramov. **WC2** Noninvasive Assessment of the Visual System (NAVS) 1991