Neuroplasticity in Action: Sustained Stereo Recovery After Vision Therapy Cessation in a 10-Year-Old Amblyope

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Background

Amblyopia is a developmental visual disorder where the brain favors one eye over the other, leading to reduced vision in the weaker eye. In **anisometropic amblyopia**, unequal refractive errors between the eyes (anisometropia) cause a chronically blurred image in one eye; the brain suppresses that eye's input and it fails to develop normal acuity[1-5]. Traditionally, amblyopia treatment was thought to be most effective only during a **"critical period"** in early childhood (up to ~7–8 years old). Many believed that after this age, the visual system's plasticity sharply declines, limiting treatment success. However, emerging evidence challenges this notion. Studies have documented significant improvements in older children and even adults with amblyopia, indicating that **neural plasticity** persists beyond the classic critical period[6-7]. Modern approaches leverage this residual plasticity using binocular visual stimulation rather than exclusively patching one eye[8-10]. Patching (occlusion of the better eye) can improve acuity in the weak eye, but it has drawbacks – especially in older children – including poor compliance and limited impact on binocular function (depth perception)[1-5]. Newer **vision therapy** techniques (e.g. therapeutic games, virtual reality, perceptual learning) aim to engage both eyes simultaneously, which can improve not only visual acuity but also stereopsis (3D depth perception)[1-5]. This poster presents a clinical case of a 10-year-old female with anisometropic amblyopia, illustrating that meaningful vision gains and stereopsis recovery are achievable **beyond the traditional age limits** when using a binocular therapy approach combined with optimal optical correction.

Case Description

Patient: 10-year-old girl (first examined at age 7) with no other ocular or systemic issues, diagnosed with anisometropic amblyopia. Her mother was concerned that the child was "past the critical period" for amblyopia treatment.

Initial Exam (March 30, 2022): Uncorrected vision was very poor in the left eye. With best optical correction (single-vision glasses), the right eye (OD) had mild myopia/astigmatism (–0.50 D) and saw 6/9 (20/30) distance acuity, while the amblyopic left eye (OS) had high myopia and astigmatism (–7.50/–2.25×180) and could only see 6/36 (20/120) even with glasses. The left eye's vision improved slightly to ~6/19 with a pinhole, confirming the reduction was primarily refractive/amblyopic. She had **no stereopsis** (failed global stereo "butterfly" test) at baseline, indicating essentially no depth perception. Her eye alignment showed a mild exophoria (tendency for the eyes to drift outward) at distance and near. Examination of ocular health was normal, so the vision deficit was functional (amblyopia) due to disuse from blur.

Initial Management: Full-time glasses were prescribed to provide full refractive correction. Traditional occlusion therapy was also tried: the dominant right eye (OD) was patched for a few hours each day to encourage use of the left eye. However, after several months, there was minimal improvement in left-eye visual acuity. This outcome aligns with published findings that patching in older children often has limited success and does not address binocular vision skills.[1-5]

The patient's mother, who is a medical doctor, researched alternative options and came to our office seeking a vision therapy–based approach. The patient also disliked patching, which is a common compliance barrier. Given the limited response and these practical challenges, we plan toward a binocular vision therapy (VT) approach.

Binocular Vision Therapy and Optical Strategy: A customized VT program was initiated to stimulate the amblyopic eye *while engaging both eyes together*. Therapy activities included exercises for ocular motility (improving pursuits/saccades), accommodation (focus flexibility), and **anti-suppression training** and stereopsis exercises (using tools like red-green filters, stereograms, or interactive computer programs) to encourage the brain to combine input from both eyes. Importantly, the optical correction was adjusted during therapy to enhance comfort and binocularity rather than simply giving the strongest prescription to the amblyopic eye.

Key Optical Intervention

- **Contact Lens Trial:** Early in therapy, the patient was fit with a contact lens in the left eye instead of glasses (OD wore glasses, OS wore a contact lens of lower power). This was done to reduce **aniseikonia** (the image size difference between eyes caused by high anisometropia). A contact lens sits on the eye, effectively eliminating vertex distance and thereby *reducing magnification disparity* compared to a thick high-power spectacle lens. The goal was to improve fusion by making the images from each eye more similar in size. With an OS contact lens of about –5.00 D (under-correcting her full –7.00 D need), her acuity was temporarily around 6/48 (very blurred), improving to 6/15 with a –2.00 D over-refraction. This partial under-correction was a deliberate tactic to ease her visual system into using the eye without overwhelming it with a high-prescription image.
- **Spectacle Under-Correction:** As therapy progressed and her visual function improved, we found that the left eye could achieve functional vision without full power. Rather than continually increasing the left lens power to the maximum refractive error, we **prescribed the least minus power that still yielded good acuity**. For example, by the end of active therapy **(Feb, 2023)**, her left eye was wearing approximately –6.50 D (under the full –7.50 D) and could achieve 6/9 (20/30) vision. Using a slightly reduced prescription likely helped minimize aniseikonia and suppression. (Notably, >5% difference in image size can disrupt binocular fusion[11], so avoiding extreme magnification disparity was beneficial.) Throughout, the right eye's small refractive error was fully corrected to provide a clear image but not so overpowered as to completely dominate binocular perception.
- **Progressive Additional Lenses (PAL):** The patient's glasses were later upgraded to multifocal lenses (PAL with +1.00 to +1.75 add for near). This addition served to reduce near-focus demand and prevent the better eye from straining or taking over at close distances. By easing accommodation, the PAL kept near tasks comfortable and allowed the amblyopic eye to participate, further reinforcing binocularity at all distances.

Over roughly 12–16 months, she attended weekly in-office VT sessions and completed daily home vision exercises. The combination of **consistent therapy, appropriate optical corrections, and patient motivation** (with family support) drove the vision therapy process.

Outcomes & Results

By the end of active vision therapy (Feb 2023, at age 9), the patient's **best-corrected visual acuity** (BCVA) in the amblyopic left eye had improved to **6/9** (20/30), from a baseline of 6/36 (20/120). This is a gain of 4 lines on the eye chart, exceeding the typical prognosis for a case like hers. The right eye maintained 6/6–6/7.5 throughout (essentially normal). Importantly, **binocular vision** was restored to a functional level.

She went from zero stereopsis (no depth perception) to measurable **stereoacuity of 100 arcseconds** during therapy, and ultimately **32 arcseconds** at follow-up. (For reference, 40" or better is considered normal 3D vision; she achieved near-normal stereo). This meant she could appreciate fine 3D details like stereo fly tests by the end.

The improvement in stereopsis **continued even after therapy was discontinued**: at a 8-month post-therapy check (March 2024) and one-year check (March 2025, now age 10½), her stereo remained at 32" or better, indicating the gains were stable and even slightly **self-improving over time** without ongoing intervention.

Other functional gains were noted as well. The patient's **eye alignment** at distance became orthophoric (perfectly aligned) by 2023, whereas she initially had a tendency toward exotropia (exophoria). At near, a mild exophoria persisted, but she was able to comfortably fuse images. Her **oculomotor skills** (eye tracking and focusing) improved: pursuit and saccade testing scores, which were slightly reduced initially (some ratings of 4/5), reached 5/5 (normal) by the end of therapy, reflecting better eye control. The child and parents also reported qualitative improvements – she had better depth judgment in everyday activities (e.g. no longer spilling water when pouring, improved sports performance) and increased reading fluency once her eyes worked together. No adverse effects (like double vision or patching-induced problems) occurred; on the contrary, she enjoyed many of the therapy games, which helped with compliance.

Discussion

This case demonstrates that **amblyopia can be successfully treated beyond the conventionally defined critical period**, especially using a binocular, neuroplasticity-based approach. At 10 years old, our patient was considered older than ideal for amblyopia therapy, yet she achieved vision outcomes better than expected. Historically, clinicians were taught that after age ~8, the visual system's plasticity is greatly diminished. While plasticity does decline with age, it is **not absent**. Research now shows significant improvements are possible in older children, teenagers, and even adults with amblyopia, undermining the old belief of an absolute age cutoff[6]. In a multicenter trial (PEDIG, 2005), even 7–12 year-old amblyopic children responded to treatment (about 50% showed meaningful vision improvement)[6]. Furthermore, innovative therapies tapping into binocular neural pathways have yielded improvements in patients well beyond childhood[7]. Our patient's success adds to this evidence, highlighting that **age alone should not deter amblyopia treatment** – the brain can adapt if given the right stimulation.

A key factor in this case was the shift from a traditional monocular approach (patching) to a **binocular therapeutic strategy**. Conventional patching primarily forces the amblyopic eye to work but does little to train binocular cooperation or stereopsis[1-5]. In older children, patching alone often plateaus in gains or fails due to compliance issues (as we initially observed). By contrast, our vision therapy integrated both eyes in most activities. This likely **reduced suppression** of the amblyopic eye and encouraged fusion, resulting in restored stereoscopic depth perception – a benefit patching rarely achieves on its own[1-5]. The improvement of stereopsis from none to 32" is particularly noteworthy because stereoacuity is a **binocular function**; its recovery indicates true binocular visual cortex reorganization. Even after formal therapy ended, the patient's stereopsis improved further (from 100" at end of therapy to 32" later), suggesting that once the visual system was rebalanced, normal daily binocular use continued to strengthen her depth perception. This aligns with the idea that there may be a period of **consolidation and ongoing plasticity** following therapy, where the patient continues to adapt and improve with experience (akin to how motor skills improve with practice after coaching stops).

Another lesson is the importance of **optical management in anisometropic amblyopia**. Simply prescribing the full refractive correction for a high-anisometropia case can present challenges: the strong lens can cause **aniseikonia** (image size difference) and be visually uncomfortable, leading to suppression of that eye. In this case, we strategically under-corrected the amblyopic eye's myopia once it reached functional acuity, using the **minimum lens power that allowed 20/30 vision**. This counterintuitive step (using *less* than full prescription) paid off by making binocular fusion easier. The patient's left eye, at ~–6.50 D, saw 6/9, which is remarkable – it implies her brain learned to interpret a slightly blurred retinal image much better than before. Reducing the prescription also reduced the spectacle magnification. For instance, dropping from –7.50 D to –6.50 D cuts a few percent off the image size difference. Considering that >5% image size disparity can break fusion[11], even small reductions help. Additionally, our temporary use of a contact lens for the left eye demonstrated how **contact lenses** can mitigate aniseikonic effects by eliminating vertex distance (thus reducing magnification difference)[11]. In practice, young children may not always tolerate contacts, but even a short-term trial in this case showed the concept's validity. In future cases of high anisometropia, one might consider long-term contact lens wear or **spectacle magnification balancing techniques** (such as size lenses or partial corrections) to address aniseikonia and improve comfort.

Finally, the use of a multifocal add in her glasses underscores a holistic approach: we anticipated that if near work was too difficult or if the eyes had unequal accommodative demand, it could impede binocularity. The progressive additional lens ensured that near tasks were low-stress and both eyes could remain engaged at near distances. This is a reminder that amblyopia therapy isn't just about visual acuity – it's about **integrating the amblyopic eye into all visual activities** (distance, near, motion tracking, depth, etc.) in a natural, comfortable way. The comprehensive approach addressed focusing, eye movement, and alignment problems alongside acuity, which likely contributed to the robust outcome.

Date	03/30/2022 (FIRST VISIT)	04/13/2023	03/14/2023
Habitual Rx and VA	Single Vision Spectacle	Single Vision Spectacle	PAL
	OD: -0.50/-0.50x30 (6/9 PH 6/7.5+, N5@40cm)	OD: -0.75/-0.75x180 (6/9 PH 6/7.5, N5@40cm)	OD: -0.75/-0.75x180 (6/6, N4.5@40cm)
	OS: -7.50/-2.25x180 (6/36 PH 6/19+, N6@40cm)	OS: -8.00/-2.00x180 (6/12 PHNI, N5@40cm)	OS: -8.00/-2.00x180 (6/12 PHNI, N5@40cm)
			ADD +1.00
Unaided VA			OD: 6/9-3
			OS: 6/150
Cover Test @6m	XP	XP	Ortho
Cover Test @30cm	XP	XP	XP
Pursuit	4,4,4,5	5,5,5,5	5,4,5,5
Saccade	5,5,4,5	5,5,5,5	5,5,5,5
Colour Vision (Ishihara)	PASS	PASS	PASS
Stereopsis	FAIL Butterfly	600" see arc ,unable perceive butter fly	63" Butterfly
Subjective Rx	OD: -0.25 (6/7.5)		OD: PL/-0.50x180 (6/6)
	OS: -9.00 (6/36)		OS: -6.50 to -7.00/-2.00x180 (6/9 to 6/12+)
Stress Point Retinoscope	OD: +1.00	OD: +1.00	OD: +1.50
	OS: +1.00	OS: +1.00	OS: +1.50
Fusional Vergence (D)			
PFV (BO) :	NA	x/18.4/9.6	x/23.4/8.2
NFV (BI) :	NA	x/13.2/6.8	x/11.4/1.8
Fusional Vergence (N)	NA		
PFV (BO) :	NA	x/9.8/4.4	x/17.8/2.6
NFV (BI) :	NA	x/7.4/4.6	x/16.8/5
NRA	NA	OD: blur	OD: +3.00/+1.50
		OS: blur	OS: +1.25/0
		OU: +1.25/+0.75	OU: +2.25/+0.75
PRA	NA	OD: blur	OD: -5.50/-1.25
		OS: blur	OS: -1.50/0
		OU: -1.50/-0.25	OU: -6.00/-4.25

Date	19/07/2023	05/03/2024	05/03/2025
Habitual Rx and VA	PAL	PAL	PAL
	OD: PL (6/6-, N4.5@40cm)	OD: PL (6/6-1, N4.5@40cm)	OD:-0.12
	OS: -7.25/-1.50x180 (6/12 PH 6/9, N6@40cm)	OS: -7.25/-2.00x180 (6/15 PHNI, N10@40cm)	OS: -6.25/-1.50x180
	ADD +1.75	ADD +1.75	ADD: +2.50
Unaided VA	OD: 6/6-	OD: 6/6-1, N4.5@40cm	OD: 6/6-3 , N4.5@40cm
	OS: 6/120	OS: 6/150, N18@15cm	OS: 6/9 5-3, N4.5@40cm
		OU: 6/6, N4.5@30CM	OU: 6/6
Cover Test @6m	Ortho	Ortho	Ortho
Cover Test @30cm	XP	XP	XP
Pursuit	5,5,5,5	5,5,5,5	5,5,5,5
Saccade	5,5,5,5	5,5,5,5	5,5,5,5
Colour Vision (Ishihara)	PASS	Pass	Pass
Stereopsis	100" Butterfly	32 " butterfly	32 " butterfly
Subjective Rx	OD: PL (6/6-)	OD: Pl /-0.50x180 (6/6)	OD:+0.25/-0.75 (6/6)
	OS: -6.50 to -6.75/-1.50x180 (6/9-)	OS: -6.25/-2.00x180 (6/12)	OS: -6.50/-1.50x180 (6/9.5-3)
Stress Point Retinoscope	OD: +2.50 to +3.50	OD: +3 to +5.75	OD:+1.50 to +4.00
	OS: +2.50 to +3.50	OS: +3 to +5.75	OS: +2.50 to +6.50
Fusional Vergence (D)			
PFV (BO) :	x/13.2/9	BO:x/12/8	BO:x/11.2/-1.2
NFV (BI) :	x/4.2/0.2	BI:x/6/2	BI:x/6.6/2
Fusional Vergence (N)			
PFV (BO) :	x/5.2/0	x/6/4	BO:x/13.8/-1.8
NFV (BI) :	x/7.6/4	Bi :x/10/7	BI:x/7.4/1.8
NRA	OD: +5.00/+2.50	OD: +5.00/+2.75	OD: +6.00/+2.75
	OS: +3.75/+2.50	OS:+6.25/+3.00 @25cm	OS: +6.75/+2.75
	OU: +5.00/+2.75	OU:+4.75/+1.75	OU:+6.00/+3.00
PRA	OD: -6.75/-5.00	OD: -6.00/-4.00	OD:-6.25/-3.75
	OS: -3.00/0	OS: -4.25/0 @25cm	OS: -7.00/0
	OU: -6.75/-5.00	OU:-5.25/-2.75	OU:-8.75/-4.25

Conclusion

This case highlights that **vision therapy combined with tailored optical correction can yield significant improvements in anisometropic amblyopia even beyond the early childhood years**. The patient achieved better acuity and stereopsis than her initial prognosis, defying the outdated notion that treatment after age 8 is futile. **Neuroplasticity** in the visual system persists into later childhood and adolescence, and with proper stimulation, the amblyopic brain can rewire to improve vision[6-7]. Clinicians should consider modern binocular approaches for older children with amblyopia, rather than resigning to suboptimal vision. Importantly, therapy should be **binocular and functional**: training the two eyes to work together yields benefits (like depth perception recovery) that monocular patching alone cannot achieve[1-5].

From an optical standpoint, this case suggests that more correction is not always better – **optimize the prescription for binocular vision, not just monocular clarity**. Reducing anisometropic disparity (through contact lenses or partial Rx) can improve compliance and fusion[11]. Each amblyopic patient is unique, and treatment plans should be individualized. In summary, even if a child is "past the critical period," do not hesitate to treat; with persistence and the right techniques, **amblyopia is treatable at older ages** and patients can attain functional vision improvement and stereopsis, vastly improving their quality of life.

Key Takeaways:

- **Amblyopia Treatment is Age-Expandable:** Significant visual improvements can be achieved in children over 7–8 years old – and even in adults – leveraging the brain's residual plasticity[6]. Age alone should not exclude patients from therapy.
- **Binocular Vision Therapy is Game-Changing:** Engaging both eyes in treatment (through games, exercises, or VR-based therapies) can improve binocular functions like stereopsis in a way patching cannot[1-5]. This case's restoration of 3D vision exemplifies the success of a binocular approach.
- **Optical Optimization is Crucial:** Manage anisometropia thoughtfully. Use contact lenses or minimal effective prescriptions to reduce aniseikonia and suppression risk[11]. Small optical tweaks can have big functional impact on the patient's ability to use the amblyopic eye.
- **Neuroplastic Gains Can Sustain and Grow:** Once binocular vision is established, patients may continue to improve post-therapy through natural use. The ongoing improvement in our patient's stereopsis after therapy cessation underscores the lasting, self-perpetuating nature of neuroplastic changes.

Overall, this case reinforces that **amblyopia is not strictly bound by a young age limit**. With modern, patient-tailored interventions, even a 10-year-old amblyope with severe anisometropia achieved vision beyond expectations – a hopeful message for practitioners and families alike. The brain's capacity to change, adapt, and improve vision can be harnessed at any age given the right approach and perseverance.

Reference

1. Birch EE: Amblyopia and binocular vision. Prog Retin Eye Res. 2013, 33:67-84. 10.1016/j.preteyeres.2012.11.001

2. Holmes JM, Clarke MP: Amblyopia. Lancet. 2006, 367:1343-1351. 10.1016/S0140-6736(06)68581-4

3. Brar GS, Bandyopadhyay S, Kaushik S, Raj S: Efficiency of occlusion therapy for management of amblyopia in older children. Indian J Ophthalmol. 2006, 54:257-260. 10.4103/0301-4738.27951

4. Al-Zuhaibi S, Al-Harthi I, Cooymans P, Al-Busaidi A, Al-Farsi Y, Ganesh A: Compliance of amblyopic patients with occlusion therapy: a pilot study. Oman J Ophthalmol. 2009, 2:67-72. 10.4103/0974-620X.53035

5. Kim JG, Lee SY, Lee DC: Short-term effects of occlusion therapy and optical correction on microvasculature in monocular amblyopia: a retrospective case-control study. Sci Rep. 2023, 13:12191.

6.Maconachie GD, Gottlob I: The challenges of amblyopia treatment. Biomed J. 2015, 38:510-516.

7. Bui Quoc E, Kulp MT, Burns JG, Thompson B: Amblyopia: A review of unmet needs, current treatment options, and emerging therapies. *Surv Ophthalmol.* 2023, 68:507–525.

8. Li L, Xue H, Lai T, Xue Y, Luo G: Comparison of compliance among patients with pediatric amblyopia undergoing virtual reality-based and traditional patching method training. Front Public Health. 2022, 10:1037412. 10.3389/fpubh.2022.1037412

9. Molina-Martín A, Leal-Vega L, de Fez D, Martínez-Plaza E, Coco-Martín MB, Piñero DP: Amblyopia treatment through immersive virtual reality: A preliminary experience in anisometropic children. Vision (Basel). 2023, 7:10.3390/vision7020042

10. Chan HS, Tang YM, Do CW, Ho Yin Wong H, Chan LY, To S: Design and assessment of amblyopia, strabismus, and myopia treatment and vision training using virtual reality. Digit Health. 2023, 9:20552076231176638. 10.1177/20552076231176638

11. Stokkermans TJ, Day SH: Aniseikonia. *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. Updated 2023 Aug 8.
PMID: 36256755 (Bookshelf ID: NBK585108)

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