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# Suppression in Amblyopia - Cause or Consequence?

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## Opinion

Visual dysfunction in amblyopia is often associated with the presence of strong suppression. Suppression appears when both eyes are opened. Suppression transforms the structural-binocular system into a functional-monocular one. Quantification of suppression is a critical step in developing new treatments for amblyopia, which is based on the perception of global movement associated with the function of the exstrastriate dorsal visual cortex. Therefore, the first and most necessary step to restore binocular vision should be considered suppression elimination. This conceptually new understanding of amblyopia is now becoming the basis for a large amount of diverse research that will ensure the development of more effective treatment methods aimed primarily at eliminating suppression and restoring binocular vision.

Amblyopia is considered a neurodevelopmental disorder of the brain's visual cortex, resulting from abnormal visual experience in early childhood, leading to a chronic deficiency of cortical processes, even after elimination of the amblyogenic factor [1,2]. Amblyopia can affect not only visual acuity but many other monocular and binocular visual functions, including impairments in Vernier acuity, stereopsis, contrast sensitivity, and global motion perception [3,4]. It is still unclear whether there are different or single pathogenetic mechanisms for developing of different types of amblyopia. According to existing concepts, amblyopia occurs due to a mismatch between the images of each eye; information from one eye becomes more privileged, while the image from the other eye is actively suppressed by the visual cortex [5]. Suppression results in decreased visual acuity in that eye and compromises binocular vision. However, the question arises whether low visual acuity is the cause or consequence of binocular vision impairment?

In recent years, numerous data have accumulated that give rise to a change in understanding the pathogenesis of amblyopia. It is assumed that the primary and leading factor in the development of amblyopia is the impairment of binocular vision, which leads to the onset of suppression with the further development of visual impairment. In early studies, the involvement of the primary and secondary visual cortex in patients with amblyopia has been shown [6-12]. Evidence suggests a deficiency in the processing of visual information at high levels of the visual system in amblyopia, in the areas of the parieto-occipital and temporal cortex [13]. These higher-level visual processing areas that process the binocular signal are part of the cortical neural network involved in the 3D vision of the object. The study of the brains' visual cortex revealed a reduction in the number of binocularly controlled neurons in the primary visual cortex V1 and a decrease in the number of neurons controlled by the amblyopic eye. It was found that the weakening of binocular cortical connections can cause impaired fixation of one eye in strabismus [6,14]. Other authors investigated binocular interaction in the V1 region and found increased binocular suppression [15,16]. The increase in suppression may be associated with a decrease in the number of binocularly controlled neurons in the V1 region since the weakening of suppression by the GABA receptor blocker bicuculline promoted recovery of more than half of cortical neurons [17]. Numerous electrophysiological studies have shown a decrease in the amplitude of visual evoked cortical potentials (VECP) and their normal or delayed peak latency upon stimulation of the amblyopic eye. Thus, a decrease in the response of the visual cortex may be associated with impaired binocular vision in patients with amblyopia. A group of researchers has shown that in patients with anisometropic or strabismic amblyopia, interocular suppression can be minimized by presenting high contrast stimulus elements to the amblyopic eye and lower contrast elements to the fellow eye. It suggests a structurally intact binocular visual system that is functionally suppressed [18].

Current decade the concept of suppression and visual processing in amblyopia has changed dramatically. Suppression plays a significant role in impaired monocular and binocular visual functions in patients with amblyopia [19]. Suppression is understood as the inhibitory effect of the nonamblyopic or sound eye upon the amblyopic eye in vision when both eyes are opened. In 1930-1980, suppression was a hot topic raised in many works [20-22] that carefully investigated the functional scotoma, its size, and location in various types of strabismus. It is believed that the scotoma involves that part of the field of view of the deviated eye, which corresponds to the foveolar region of the fixing eye; sometimes the scotoma expands and includes the foveal area of the deviated eye. According to E.S. Avetisov [cit from Ghani M.Kh., 1964] there is a partial inverse correlation between amblyopia and functional scotoma in concomitant strabismus. Functional scotoma occurs more often in the absence of amblyopia (i.e., with alternating strabismus) and less often in monolateral strabismus, when there is amblyopia. With the monoliteral strabismus, the function of the amblyopic eye is so sharply and persistently suppressed that there is no interocular competition.

Therefore, there is no need for the leading eye to render an inhibitory effect on the weak image perceived by the amblyopic eye. In alternating strabismus, when the competition between retinocortical projections from both eyes is more robust, the functional scotoma is also stronger since it relieves the patient of "chaos" in the visual field. With a relatively high visual acuity of the amblyopic eye, an additional inhibition of its function occurs, and a functional scotoma appears in the field of view of this eye. Recently, there has been a resurgence of interest in suppression research, which has radically changed the concept of suppression. It includes new and weakly dichoptic (simultaneous and separate stimulation of both eyes) ways to measure it [23]. Previously, suppression was determined only qualitatively, and it was possible to identify its presence or absence using the 4-point Worth color test or the Bogolini test, etc. To date, new methods are offered for the quantitative measurement of suppression based on the assessment of global information processing [24]. Visual processing is a complex physiological mechanism that includes local and global processes of visual processing. Abnormal visual processing we can associate with the impaired perception of individual elements of the visual scene and with a defect in the integration of multiple elements and image parameters in space and time (global information processing) [23]. Deficiency of local information processing is often associated with a disturbance in the primary visual cortex V1. Disorders in global visual processing are related with the involvement of exstrastriate areas of the cortex. Neurons in these zones have large receptive fields. They can integrate signals coming from the lower levels of the visual system and play essential role in the segregation of signal and noise [25]. In local information processing, processes of spatial and temporal processing are distinguished.

Psychophysical studies have shown that amblyopia affects many aspects of spatial vision: contrast sensitivity, hyperacuity (vernier acuity is the ability to distinguish deformation of a straight line), crowding effect [26]. That is, the parvocellular pathway is engaged. In contrast to the local spatial regions, the dorsal extrastriate visual regions, the V5 / MT zone sensitive to the movement, are specialized for the perception of the localization and motion of objects and, therefore, provides the basis for visual-motor coordination. This visual processing pathway, called dorsal flow, extends from the occipital lobe to the parietal lobe and represents an extension of the magnocellular pathway. The ventral pathway includes the ventral regions of the occipital and temporal lobes. The connections and the structures of this stream are specialized in shape processing that supports object recognition and represents the continuation of the parvocellular pathway.

There is strong evidence that there is a deficit in global motion perception that does not depend on local processing in addition to abnormal local spatial processing [27-29]. It is exciting from the well-known hypothesis, which suggests that local temporal processes are less affected in amblyopia than local spatial processes. Surprisingly, the patterns of local processing deficit do not correspond to the patterns of global processing deficit in monolateral amblyopia. The deficit of global processing is present only in tasks requiring signal extraction from noise. It turns out that the dorsal extrastriate visual cortex is more susceptible than the ventral region to the influence of abnormal development. Studies have shown that suppression in amblyopia is more pronounced in the dorsal than in the ventral flow [30]; therefore, these authors proposed a method for determining suppression in patients with anisometropic and strabismic amblyopia based on the global motion of with kinematogram points [30]. The method for determining suppression – the so-called coordinated movement test [31] - includes the technique of haploscopic (separate) representation of noise elements (having a random direction of movement) in front of one eye and signal elements (having the same sequential direction of motion) in front of the other eye to determine the possibility of binocular interaction in patients with amblyopia [32,33].

The threshold of motion consistency can only be measured in dichoptic conditions if the signal and noise points are combined in the binocular areas of the visual pathway. Noise presented to


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one eye prevents the other eye from determining the direction of signal points. When points of the same contrast were presented to both eyes, the threshold for coordination of movement was strongly shifted towards the paired, nonambliopic eye. When signal points were presented to the paired eye and noise points were presented to the amblyopic eye, the threshold was very low, and vice versa, it was very high or immeasurable when the noise points were presented to the fellow eye and signal points - to the amblyopic eye. These results indicate the presence of suppression of the amblyopic eye. In people with normal binocular vision, who do not have strong dominance of any eye, it does not matter which eye sees the signal and which eye sees the noise; interactions in haploscopic conditions are balanced. In patients with amblyopia, things work out differently. Due to suppression, tasks are performed better when noise is presented to the amblyopic eye and worse when a signal is presented to the amblyopic eye. B. Mansouri and coauthors [31] reducing the contrast of the points presented to the fellow eye demonstrated normal binocular interaction in patients with strabismic amblyopia. The threshold values of motion coherence remained unchanged regardless of which eye saw the signal or the noise. In other words, binocular mechanisms were present in these patients but were suppressed. The change in contrast required to achieve a "point of balance" between the eyes varies depending on the degree of suppression. J. Li et al. [19] measured suppression using the coordinated eye movement test in 43 patients with strabismic, anisometropic, and mixed amblyopia. They have found that the degree of suppression correlates with amblyopia: the more significant the deficit in visual acuity and stereovision, the stronger the suppression. According to the authors, suppression does not depend on the type of strabismus or the magnitude of the deviation angle. The results showed that severe suppression was also associated with poor outcomes of occlusive therapy. There is strong evidence that even in adult patients there is a binocular interaction, which is under suppression [19-34]. Suppression may occur to avoid visual confusion caused by conflicting input from the two eyes, and it renders a structurally binocular visual system functionally monocular in individuals with amblyopia [31,35,36].

It has been assumed that suppression of the amblyopic eye is absolute and visual information from the suppressed eye does not contribute to visual processing. But recent studies showed that visual information seen by the amblyopic eye, which is under suppression, can be binocularly integrated and influence the overall visual percept. According to the authors, visual information subjected to interocular suppression can still contribute to binocular vision and suggest an appropriate optical correction for the amblyopic eye to improve image quality for the binocular combination [37]. It means that suppressed visual information continues to be represented within the brain even when it is blocked by chronic pathological suppression. Moreover, exercises based on reducing the suppression of the amblyopic eye using RDK (random dot with kinematograms) in dichoptic conditions showed the development of stereopsis and an increase in monocular visual acuity of the amblyopic eye in both children and adults with amblyopia. J. Black J. and co-authors [Black J. M 2011, 2012] developed a version of the test specifically for patients with high-grade anisometropic amblyopia/ In this test the point's sizes were randomized to exclude the effect of aniseikonia in the process of signal and noise segregation.

Moreover, exercises based on reducing the suppression of the amblyopic eye using RDK (random dot with kinematograms) in dichoptic conditions showed not only the development of stereopsis, but also an increase in monocular visual acuity of the amblyopic eye in both children and adults with amblyopia. J. Black J. and co-authors [24] developed a version of the test specifically for patients with high-grade anisometropic amblyopia, in which point sizes were randomized to exclude the effect of aniseikonia in the process of signal and noise segregation.

## Conclusion

To date, objective evidence has been accumulated that suppression plays a vital role in the pathogenesis of amblyopia, transforming the structurally binocular system functionally into a monocular one. The first and most necessary step in the treatment of amblyopia should be considered the elimination of suppression. Quantification of suppression is an essential step for the development of new treatments for amblyopia based on the perception of global movement associated with the function of the extrastriate dorsal visual cortex.

## References

1. Wong AMF (2012) New concepts concerning the neural mechanisms of amblyopia and their clinical implications. Can J Ophthalmol 47(5): 399-409.
2. Birch EE (2013) Amblyopia and binocular vision Prog Retin Eye Res 33: 67-84.
3. Asper L, Crewther D, Crewther SG (2000) Strabismic amblyopia Part 1 Psychophysics. Clinical and Experimental Optometry 83(2): 49-58.
4. Hatt S, Antonio-Santos A, Powell C, Vedula SS (2009) Interventions for stimulus deprivation amblyopia. Cochrane Database of Systematic Reviews. (Online) 3.
5. Harrad R, Sengpiel F, Blakemore C (1996) Physiology of suppression in strabismic amblyopia. Br J Ophthalmol 80(4): 373-377.
6. Kiorpes L, Kiper DC, O'keefe LP, Cavanaugh JR, Movshon JA (1998) Neuronal correlates of amblyopia in the visual cortex of macaque monkeys with experimental strabismus and anisometropia. J Neurosci 18: 6411-6424.
7. Imamura K, Richter H, Fischer H, G Lennerstrand, O Franzén, et al. (1997) Reduced activity in the extrastriate visual cortex of individuals with strabismic amblyopia. Neuroscience Letters 225(3): 173-176.
8. Demer JL, Von Noorden GK, Volkow ND, Gould KL (1988) Imaging of cerebral blood flow and metabolism in amblyopia by positron emission tomography. Am J Ophthalmol 105(4): 337-347.
9. Kabasakal L, Devranoglu K, Arslan, Tanju Yusuf Erdil, Kerim Sönmezoğlu O, et al. (1995) Brain SPECT evaluation of the visual cortex in amblyopia. J Nuclear Medicine 36(7): 1170-1174.



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10. Anderson SJ, Holliday IE, Harding GFA (1999) Assessment of cortical dysfunction in human strabismic amblyopia using magnetoencephalography (MEG). Vision Res 39(9): 1723-1738.
11. Levi DM, Nanny RE (1982) The pathophysiology of amblyopia: Electrophysiological studies. Annals of the New York Academy of Sciences 388: 243-263.
12. Kubova Z, Kuba M, Juran J, Blakemore C (1996) Is the motion system relatively spared in amblyopia? Evidence from cortical evoked potentials. Vision Research 36(1): 181-190.
13. Joly O, Frankó E (2014) Neuroimaging of amblyopia and binocular vision: a review. Front Integr Neurosci 8: 62.
14. Kiorpes L, Kiper DC, O'keefe LP, Cavanaugh JR, Movshon JA (1998) Neuronal correlates of amblyopia in the visual cortex of macaque monkeys with experimental strabismus and anisometropia J Neurosci 18(16): 6411-6424.
15. Smith EL, Chino YM, Ni J, Cheng H, Crawford ML, et al. (1997) Residual binocular interactions in the striate cortex of monkeys reared with abnormal binocular vision. J Neurophysiol 78(3): 1353-1362.
16. Zhang B, Bi H, Sakai E, Ichiro Maruko, Jianghe Zheng, et al. (2005) Rapid plasticity of binocular connections in developing monkey visual cortex (V1). Proc. Natl Acad Sci USA 102(25): 9026-9031.
17. Duffy FH, Burchfiel JL, Conway JL (1976) Bicuculline reversal of deprivation amblyopia in the cat. Nature 260(5548): 256-257.
18. Hamm L, Chen Z, Black J, Dai Sh, Yu M (2017) Thompson B. Interocular suppression in children with deprivation amblyopia. Vision Research 133: 112-120.
19. Li J, Thompson B, Lam CS, Deng D, Daming Deng, Lily Y, et al. (2011) The role of suppression in amblyopia. Invest Ophthalmol Vis Sci 52(7): 4169-4176.
20. Travers TA (1938) Suppression of vision in squint and its association with retinal correspondence and amblyopia. Br J Ophthalmol 22(10): 577-604.
21. Pratt-Johnson JA, Tillson G (1984) Suppression in strabismus--an update. Br J Ophthalmol 68(3): 174-178.
22. Jampolsky A (1955) Characteristics of suppression in strabismus. AMA Arch. Ophthalmol Nov 54(5):683-696.
23. Dakin SC (2009) Current Biology 19(18).
24. Black JM, Hess RF, Cooperstock JR, To L, Thompson B (2012) The Measurement and Treatment of Suppression in Amblyopia. J Vis Exp 40(70): e3927.
25. Born RT, Bradley DC (2005) Structure and function of visual area Annu Rev Neurosci 28: 157-189.
26. Hamm L, Chen Z, Black J, Dai Sh, Yu M (2014) Thompson B. Global processing in amblyopia: a review Front. Psychol 17
27. Simmers AJ, Ledgeway T, Hess RF, McGraw PV (2003) Deficits to global motion processing in human amblyopia. Vision Research 43(6): 729-738.
28. Simmers AJ, Ledgeway T, Hess RF, McGraw PV (2005) The influences of visibility and anomalous integration processes on the perception of global spatial form versus motion in human amblyopia. Vision Research 45(4): 449-460.
29. Husk JS, Hess RF (2013) Global processing of orientation in amblyopia. Vision Research 82(19): 22-30.
30. Zhou J, Thompson B, Hess RF (2013) A new form of rapid binocular plasticity in adult with amblyopia. Scientific Reports 3: 2638.
31. Mansouri B, Thompson B, Hess RF (2008) Measurement of suprathreshold binocular interactions in amblyopia. Vision Research 48(28): 2775-2784.
32. Li X, Mullen KT, Thompson B, Hess RF (2011) Effective connectivity anomalies in human amblyopia NeuroImage 54(1): 505-516.
33. Li J, Hess RF, Lily YL, Chan BA, Yang X, et al. (2013) Quantitative Measurement of Interocular Suppression in Anisometropic Amblyopia: A Case-Control Study. Ophthalmology 120(8): 1672-1680.
34. Narasimhan S, Harrison ER, Giaschi DE (2012) Quantitative measurement of interocular suppression in children with amblyopia Vision research 66(1): 1-10.
35. Hallum LE, Shooner C, Kumbhani RD, Kelly JG, Marín VG, et al. (2017) Altered Balance of Receptive Field Excitation and Suppression in Visual Cortex of Amblyopic Macaque Monkeys J Neurosci 37(34): 8216-8226.
36. Shooner C, Hallum LE, Kumbhani RD, Marín VG, Kelly JG, et al. (2017) Anthony Movshon and Lynne Kiorpes. Asymmetric Dichoptic Masking in Visual Cortex of Amblyopic Macaque Monkeys. Journal of Neuroscience 6 September 37(36): 8734-8741.
37. Chow AHY, Silva A, Tsang K, Thompson B (2021) Binocular Integration of Perceptually Suppressed Visual Information in Amblyopia. Investigative Ophthalmology & Visual Science 62(12):11.