Rebalancing the Visual System of People with Amblyopia "Lazy Eye" by Using HMD and Image Enhancement

Sina Fateh[1] and Claude Speeg[2]

[1] Sina Fateh, Vision Performance Lab, Neuroptical Inc.
1931 Old Middlefield way, 94043 Mountain View, CA, USA
[2] Department of Ophthalmology, University of Strasbourg, France
SinaFateh,sfateh@neuroptical.com

Abstract. Amblyopia or "lazy eye" occurs when during early childhood visual information from one eye is absent or poorly transmitted to the brain. This visual deprivation causes poor vision and the eye gradually becomes weaker (amblyope) relative to the other eye which becomes stronger. The visual imbalance is caused by the brain's preference for the strong eye. To restore vision, conventional treatments use occlusion and vision penalization of the strong eye to force the brain to use the amblyope eye. Conventional treatments are regarded as effective in young children but impractical in older subjects and patient compliance remains the main cause of treatment failure. This presentation describes our preliminary efforts to develop a convenient and viable binocular head mounted display (HMD) interface. The goal is to rebalance the vision by using a simultaneous enhancing/attenuation image adjustment. The image presented to the normal eye will be attenuated while the image presented to the amblyope eye will be enhanced. During this operation the user will be engage in recreational activities such as watching movies, using internet or playing video games.

Keywords: Binocular HMD, amblyopia, vision restoration, enhancement/ attenuation, visual rebalance, compliance.

1 Introduction

Amblyopia or "lazy eye" is a visual imbalance that occurs in early childhood by either absence or poor image transmission from one eye to the brain and affects approximately 2% of the population (Figure 1). The treatment of amblyopia has two main objectives: 1) to restore and attain a normal level of vision in the amblyope eye, and 2) to maintain the visual gains and avoid regression.

The oldest treatment method for ambyopia is occlusion of the good eye. Occlusion was introduced in the 18th century [1] and is still the most common form of treatment today. Based on the subject's age and degree of amblyopia there are various forms and regimens tailored to fit the individual patient's needs.

Complete occlusion results in the most rapid visual improvement but has disadvantages such as poor compliance [2,3], risks of reversing the amblyopia, and disruption of an existing binocularity [4]. Partial occlusion, a modified form of treatment, promotes the use of the weak eye by using adhesive filters to attenuate the vision of

R. Shumaker (Ed.): Virtual and Mixed Reality, LNCS 5622, pp. 560–565, 2009.

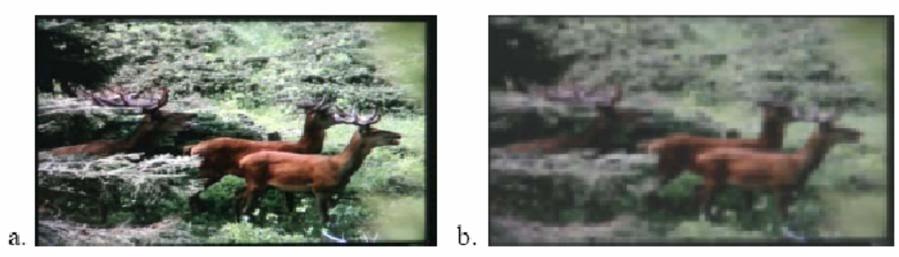

Fig. 1. Simulation of an image seen by a normal eye (a) and image seen by an amblyopic eye (b)

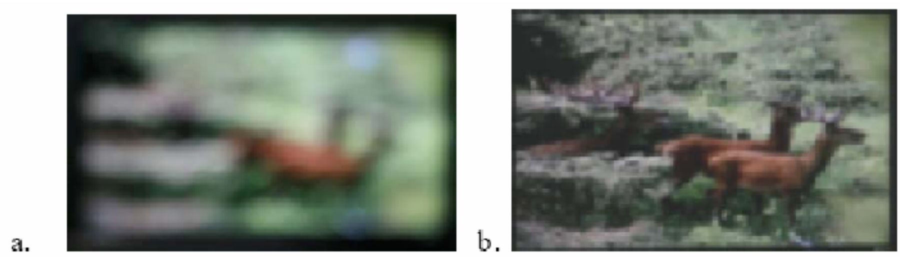

Fig. 2. Simulation of a penalization of the good eye (a) using pharmaceutically induced blur to force the brain to use the amblyope eye (b)

the good eye [5]. Another variation of the occlusion method is penalization, [6] where intentional visual blurring and distorting is used to reduce the vision of the good eye (Figure 2). The blurring is obtained optically using an over corrective lens or pharmaceutically by using atropine. Even after successful treatment visual regression is not uncommon. Approximately 25% of successfully treated cases lose some of their visual gain [8]. To prevent visual regression and preserve visual improvement eye care practitioners recommend continued part-time occlusion, optical overcorrection and pharmaceutical blur.

The conventional methods are regarded as effective in treating amblyopia before the age of 7, but their success is limited in older subjects. The high rate of failure in older subjects results from their lack of compliance and a reluctance to wear an eye patch due to cosmetic concerns. More importantly, it is inconvenient and onerous to rely solely on the amblyope eye for daily activities [9].

We propose to address the compliance issue and the risk of disrupting an existing binocular vision by using a combination of binocular head mounted display (HMD) and a monocular image alteration technique that could be used daily during recreational activities such as watching movies, using the internet, or playing video games.

2 Method and Implementation

The goal of our first phase is to develop a fully functional prototype which provides a flexible and convenient way to promote the vision of the amblyope eye without the unpleasant effect of impairing the good eye. The proposed system consists of a commercial binocular HMD, the Solo model from Myvu Corporation, a monocular image adjustment control and an Ipod video for providing the images. The HMD resolution of 320x240 was not ideal for our application; however, its modest weight of 90 grams and the possibility of adding optical correction by using a clip-on connector made it the best choice. Solo is compatible with the IPod video and DVD player and has two transmissive LCD micro displays. Having a separate image control for each eye is key to our application. We modified the commercial version by adding a separate image adjustment control to each LCD. The new configuration could host a second source of image for binocularity and anti suppression control.

For our experiment we displayed a series of five different video clips, a Power Point presentation, and two trivia games preloaded on the IPod video for a total of 25 minutes of viewing content. We randomly preset the contrast of the image presented to the left eye to a low level and the contrast of the image presented to the right eye to a high level (Figure 3).

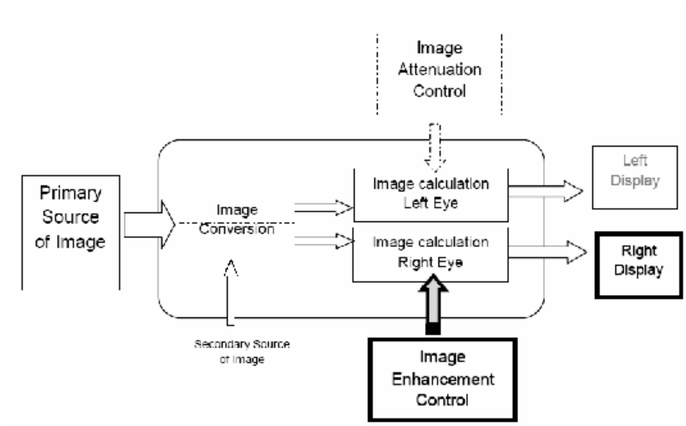

Fig. 3. The system configuration shows a separate image adjustment control for each LCD

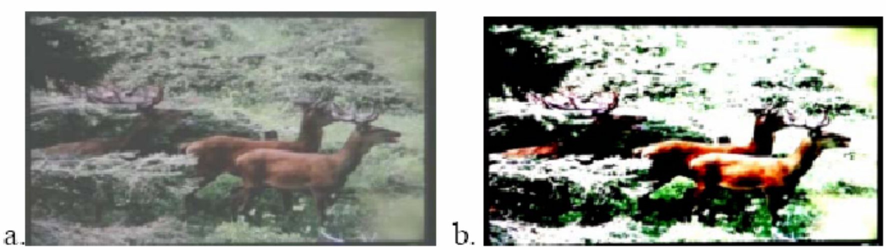

Fig. 4. Simulation of images perceived by each eye the low contrast image (a) and the high contrast image merged into one image

3 Results

Our subjective results show that the two images can reconcile into one perceived image. A similar device with a higher level of image enhancement/attenuation capability coffers a unique opportunity to treat moderate amblyopia by offering monocular image adjustment in a controlled binocular environment.

4 Discussion

Active stimulation techniques such as viewing high contrast targets as a supplement to conventional occlusion treatment have been proposed since late 1970s [10]. For example, the CAM vision simulator used rotating black and white strips to enhance the vision of the amblyope eye. While some studies reported some success [11], others found no significant difference compared to older forms of treatment [12].

However, recent studies on neuronal processes at the visual cortex [13,14] have enhanced our understanding of vision recovery and the maintenance mechanisms of some visual function.

Visual improvement demonstrated by perceptual learning in adults [15-18] confirms the possibility of restoring important visual function thought untreatable after age of 7. Extensive studies have shown the benefit of real time contrast enhancement [19,20] and its effect on improving vision [21,22].
Other studies have emphasized the role of the binocular interaction [23] in the vision recovery process [24].

Despite the encouraging results of these discoveries, the main obstacle to a successful vision recovery in amblyopia remains the compliance. Since compliance is a key issue, treatment methods that enable the subject to have enjoyment and recreation while simultaneously improving vision have the greatest chance for success. By combining the latest findings in neuroscience with technological advances in image processing, graphics technology, and the newest generation of HMD, we envision the development of a viable, convenient system that is effective for patients of any age.

The goal of our first phase was to evaluate the convenience of using a binocular HMD with enhanced/attenuated system to view video images. We are working on improved image adjustment control for our next phase.

5 Conclusion

We propose to use a binocular HMD with a monocular image enhancement/ attenuation control to rebalance the vision in mild amblyopia and recurring cases with binocularity.

In our anticipated second phase which includes a prospective clinical trial, we will use an improved HMD implementation with a higher resolution and higher level of image adjustment.

References

1. Buffon, G.L.: Sur la cause du strabisme ou des yeux louches, Memories de l'Academie des Sciences, Paris (1743)
2. Catford, G.V.: Amblyopic occlusion: The results of treatment. Transactions of the Ophthalmological Soc of UK (1987)
3. Oliver, M.: Compliance and results of treatment for amblyopia in children more than 8 years, old. Am. J. Ophthalmol. 102, 340–345 (1986)
4. Fawcett, S.L.: Disruption and reacquisition of binocular vision in childhood and in adulthood. Curr. Opin. Ophthalmol. 16(5), 298–302 (2005)
5. Charman, W.N.: Optical characteristics of Transpaseal as partial occluder. Am. J. Optom. Phys. Opt. 60, 846–850 (1983)
6. Von Norden, G.K., Milam, J.B.: Penalization in the treatment of amblyopia. Am. J. Ophthalmol. 88, 511–518 (1979)
7. Holmes, J.M., Beck, R.W., Kraker, R.T.: Risk of amblyopia recurrence after cessation of treatment. J. AAPOS 8, 420–428 (2004)
8. Flynn, J.T., Shiffman, J., Feyer, W., Corona: Trans. Am. Ophthalmol. Soc. 96, 431–450 (1998)
9. Fateh, S., Mawas, J.L.: Utilisation de telescope pour regarder la television afin d'ameliorer la vision de l'oeil amblyope. Con. An Orthop. Paris (1994)
10. Banks, R.V., Campell, F.W., Hess, R.A.: New treatment for amblyopia. Br. Orthot. J. 35, 1–12 (1978)
11. Watson, P.G., Banks, R.V.: Clinical assessment of a new treatment for amblyopia. Trans. Opthalmolo. Soc. UK 93, 201–208 (1978)
12. Lennerstrand, G., Samuelsson, B.: Amblyopia in 4 year-old children treated with grating stimulation and full time occlusion, A comparative study. Br. J. Ophtahlmol. 67, 181–190 (1983)
13. Hubel, D.H., Wiesel, T.N., Levay, S.: Plasticity of Ocular dominace clumuns in Monkey straite cortex. Phils. Trans. R Soc. Lon. Ser. B 278, 377–409 (1997)
14. Liao, D.S., Krahe, T., Prusky, G.T., Medina, A., Ramoa, A.S.: Recovery of cortical bicocularity and orientation selectivity after the critical period of ocular dominace plasticity. J. Neurophysiol 92, 2113–2121 (2004)
15. Levi, D.M., Polat, U., Hu, Y.S.: Improvement in vernier acuity in adults with amblyopia: practice makes better. Invest Ophthalmol. Vis. Sci. 38, 1493–1510 (1997)
16. Simmers, A.J., Gray, L.S.: Improvement of visual function in an adult amblyope. Optom. Vis. Sci. 76, 82–87 (1999)
17. Levi, D.M.: Perceptual Learning in Adults with Amblyopia: A Reevaluation of the Critical Periods in Human Vision. Dev. Psychobiol. 46, 222–232 (2005)
18. Polat, U., Ma-Naim, T., Belkin, M., Sagi, D.: Improving vision in adult amblyopia by perceptual learning. PNAS 101, 6692–6697 (2004)
19. Hier, R.G., Schmidt, G.W., Miller, R.S., Deforest, S.E.: Realtime locally adaptive Contrats enhancement a Practical Key to Overcoming Display and Human Visual System Limitations. In: SID Symposium Digest of technical Papers, pp. 491–494 (1993)
20. Fine, E., Peli, E., Brady, N.: Video enhancement improves performance of persons with moderate visual loss. In: Proceedings of the International Conference on Low Vision, Vision 1996, Madrid, Spain, pp. 85–92 (1997)

21. Peli, E., Goldstein, R.B., Young, G.M., Trempe, C.M., Buzney, S.M.: Image enhancement for the visually impaired: Simulations and experimental results. Invest. Ophthalmol. Vis. Sci. 32, 2337–2350 (1991)
22. Fullerton, M., Peli, E.: Post-transmission digital video enhancement for people with visual impairments. Journal of the Society for Information Display 14(1), 15–24 (2006)
23. Harrad, R.A., Hess, R.F.: Binocular Integration of Contrast Information in Amblyopia. Vision Res. 32(110), 21–35 (1992)
24. Baker, D.H., Meese, T.S., Mansouri, B., Hess, R.F.: Binocular Summation of Contrast remains intact in Strabismic Amblyopia. IOVS 48(11) (2007)