

# Research progress of treatment for amblyopia

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## Abstract

• The most common forms of treatment for amblyopia are occlusion therapy and pharmacologic penalization. But these methods can not recover all the visual deficits of amblyopes and there are some disadvantages of the treatment which need to be considered, including adverse effects, compliance and social stigma. Recently, some novel approaches are investigated for improving the effectiveness and compliance of treatment for amblyopia.

• **KEYWORDS:** amblyopia; perceptual learning; virtual reality; effectiveness; compliance

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## INTRODUCTION

Amblyopia is a developmental disorder of spatial vision caused by abnormal visual stimulation during sensitive period<sup>[1]</sup>, which is characterized by reduced visual functions in the absence of any detectable structural abnormalities. Most of the cases are due to squint or refractive error<sup>[2]</sup>. It is the most common ocular disorder in children, affecting approximately 3% of the population worldwide<sup>[3,4]</sup>. So it is critical for us to treat amblyopia effectively and safely.

## CONVENTIONAL TREATMENT FOR AMBLYOPIA

Occlusion therapy and pharmacologic penalization are the most common forms of treatment for amblyopia. But these methods can not recover all the deficits that caused by amblyopia even long after the visual acuity had become normal, and there is no convincing evidence that they are clinically effective for patients >12 years old up to now<sup>[5,6]</sup>. Furthermore there are some disadvantages which need to be considered before they are prescribed.

Except for the side-effects, several studies indicated that both occlusion and penalization in amblyopia treatment might have an impact on the child's behavior or family life recently<sup>[7]</sup>.

Occlusion therapy is not always effective in treating pediatric patients, about one third of the children gain little or no visual benefit despite prolonged treatment<sup>[8,9]</sup>. Perhaps compliance is the critical factor which has an influence on the effect of occlusion therapy. But full concordance with patching is very difficult because of restriction of visual field and the adverse effects such as skin irritation, allergy and so on<sup>[10,11]</sup>. Moreover patching is difficult to implement for the reason that patching may interfere with social activities or have an impact on educational development<sup>[9,12]</sup>. Pharmacologic penalization is an alternative to patching for amblyopia therapy when the child is intolerant of patching. But atropine works less quickly than occlusion initially, and there are some side-effects from atropine use, including light sensitivity, allergy, dry mouth, hyperactivity and tachycardia, which need to be considered<sup>[5,10,11]</sup>. So it is reasonable to explore safer method for improving the effectiveness and compliance of treatment which can fully recover visual functions for amblyopes.

## NOVEL APPROACHES TO TREAT AMBLYOPIA

Recently, perceptual learning (practice-induced improvement in performance on specific task) and the Interactive Binocular Treatment<sup>[12]</sup> (I-BITM, a computer-based virtual reality treatment) system are investigated as novel approaches for improving the effectiveness and compliance of treatment for amblyopia. Many studies have delivered encouraging results in recent years. Perceptual learning can improve performance on many visual tasks and learning can generalize to other tasks following some degree of inter-ocular transfer to the untrained fellow eyes<sup>[13,14]</sup>. The Interactive Binocular Treatment system<sup>[12]</sup> encourages the two eyes to work together, which can avoid disrupting fusion during treatment<sup>[15]</sup>. Furthermore there is no evidence that they have the negative effects mentioned above as yet.

**Perceptual Learning** Amblyopes show abnormal performance in many visual functions except for reduced visual acuity, which include hyperacuity<sup>[16,17]</sup>, and contrast-sensitivity function *et al*. But the traditional methods could not recover all the abnormalities<sup>[6]</sup>. Recently, a lot of studies showed that perceptual learning could improve performance on many visual tasks in amblyopic eyes, which had more benefits than traditional methods. Perceptual learning is more active and intensive than passive patching<sup>[18]</sup>, so it is more acceptable.

Several studies indicated that perceptual learning was useful for different age groups to improve visual functions. In 1997, Levi *et al*<sup>[19]</sup> found that training with Vernier task could lead to significant improvements in Vernier acuity in the amblyopic eyes, in some of these observers the improvement was

accompanied by some improvement in Snellen acuity. In addition, their results showed that adults with amblyopia retain some degree of neural plasticity. From then on perceptual learning has received more and more attention as a method for treating amblyopia. Other studies also showed that perceptual learning could induce some degree of recovery of vision in amblyopic eyes. In three recently studies, Li *et al* found that practicing position-discrimination could improve positional and Snellen acuities, and they also found that the improvement transferred to letter acuity<sup>[18, 20, 21]</sup>. In a prospective, randomized, masked, controlled study, Polat *et al*<sup>[22]</sup> used training tasks that emphasized lateral interactions to aim directly at the deficient connectivity in amblyopes. They demonstrated that perceptual learning could improve contrast sensitivity and visual acuity significantly in amblyopes (between 9 and 55 years old). Their results support the use of perceptual learning in amblyopia to improve vision of adults. In order to understand the basis of neural plasticity in amblyopia, Zhou *et al*<sup>[14]</sup> used sine-wave gratings to evaluate effects of perceptual learning in young adults and older children with amblyopia. They found that training could improve visual acuity and contrast-sensitivity functions and the improvement could generalize to the fellow eyes. Focusing on juvenile amblyopia, Li *et al*<sup>[21]</sup> found that perceptual learning may speed up the time of recovery. Compared with the tasks as we have said above, perceptual learning of contrast-defined letters may have limited value in treatment of amblyopia, but adults with amblyopia can also benefit from it<sup>[23]</sup>. These results support the use of perceptual learning to improve vision of amblyopes which target at the specific deficiencies. If we combine different visual-tasks for amblyopia treatment<sup>[18]</sup>, perhaps we could fully recover visual functions of amblyopes. Perceptual learning is usually very specific for the exact task trained, however, it can generalize to other task. This can be explained by the reverse hierarchy theory of perceptual learning, which assumes that learning starts at high-levels of visual system, where it generalizes and progresses backwards towards input levels, where it is specific<sup>[13, 24]</sup>. Now several studies had shown that the improvement with perceptual learning could generalize to untrained eye, and other untrained, higher level visual tasks. Some of them indicated that the improvement can be maintained for a long period. These evidences also support the use of perceptual learning to improve visual functions of amblyopes.

#### **Interactive Binocular Treatment ( I-BiT ) System**

However, nearly in all these studies mentioned above observers were required to covered the fellow eye during training. Therefore they can not avoid the negative impact on children that accompanies occlusion therapy completely<sup>[7]</sup>. The Interactive Binocular Treatment ( I-BiT ) system was developed by Eastgate *et al*<sup>[12]</sup> to treat amblyopia with both eyes stimulated simultaneously. This system incorporates virtual reality ( VR ) technology and specific software which provides interactive games ( 2D or 3D ) and videos to the patient via a stereo ( binocular ) display. Waddingham *et al*<sup>[15]</sup> demonstrated that this system could improve vision in the

amblyopic eyes of children within a short period of time while avoiding occlusion of the nonamblyopic eye. This is an exciting new technique, which is positive and enthusiastic for patients.

#### **CONCLUSION**

The most common forms of treatment for amblyopia are occlusion therapy and pharmacologic penalization. But these methods can not recover all the visual deficits of amblyopes and there are some disadvantages of the treatment which need to be considered, including adverse effects, compliance and social stigma. Perceptual learning and the Interactive Binocular Treatment ( I-BiT ) system can both improve vision in the amblyopic eyes. Ophthalmologists can use these new effective approaches clinically which can avoid the disadvantages of conventional therapy. However, before these approaches is used widely, there are still many questions to be resolved.

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## 弱视治疗方法的研究进展

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### 摘要

遮盖疗法和阿托品压抑疗法是最常用的弱视治疗方法。但是这些传统的方法并不能恢复弱视患者的所有视功能, 而且还有一定的缺点, 包括副作用、依从性和社会影响。近年来, 人们逐渐开始应用一些可以提高弱视治疗的有效性和依从性的新方法治疗弱视患者。

**关键词:**弱视; 知觉学习; 虚拟现实; 有效性; 依从性