

Newly developed binocular treatment of Amblyopia using head-mounted display

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Introduction

Amblyopia is defined as decrease of visual acuity in one eye when caused by abnormal binocular interaction or occurring in one or both eyes as a result of pattern vision deprivation during visual immaturity, for which no cause can be detected during the physical examination of the eye(s) and which in appropriate cases is reversible by therapeutic measures [1]. There are 2~5% of patients in population and the most common cause of visual impairment in children and monocular low vision in adults.

The treatment of amblyopia is monocular patching or penalization. However, there are some limitations of monocular amblyopia therapy. First, there is incomplete recovery resulting in the final vision of 20/30 in 25~60%, or 2 lines worse than sound eye [2,3]. Second, there is a possibility of recurrence after withdrawal of the treatment, reported as about 25% in patients [4,5]. Third, the compliance is poor, especially in children [6].

Recent studies have reported that abnormal binocular interactions play a key role in amblyopia. Based on this theory, the binocularity-stimulating therapies on amblyopia using perceptual learning or dichoptic stimulus presentation have been introduced [7-11]. The mechanism of dichoptic presentation is presenting the strong stimulus to the amblyopic eye and another weak stimulus to the normal fellow eye. Many types of devices are used for dichoptic presentation: Head-mounted video display [12], LCD shutter glasses [13], combination of the images [14, 15], and iPad [16-19]. Based on this mechanism, we developed the new system using Head-mounted display.

Material and methods

We developed the new software program which directly targets the binocular function using dichoptic presentation. It separates the 3D images and controls the visual inputs into the both eyes using Head-mounted display. The genre of developed software program is the game. The game presents a split screen view, allowing independent control of the contrast and intensity of the 3D images using the 16 level of Gaussian blur method; the contrast and intensity of the 3D images increases to the amblyopic eye and decreases those to the normal fellow eye (Figure 1).

The name of game is “Ice Cream Truck”, a casual shooting game throwing ice creams to the kids running towards the player. There are three levels including normal, expert and hardest level that can be selected according to the player’s ability (Figure 2). This separation of 3D images is expected to improve the monocular visual acuity of the amblyopic eye with the reduction of suppression and strengthen the binocular fusion including stereopsis.

Conclusion

The binocular therapy using Head-mounted display seems breakthrough in amblyopia therapy. This is based on the new concept of action mechanism like stimulation of the binocular interaction and stereopsis. It is free control of parameters (contrast, brightness, resolution, etc) using Head-mounted display and dedicated application and possible to control the personalized level at beginning and during the treatment.

In addition, the newly developed binocular therapy using head-mounted display is hand-held and convenient. Further investigation



Figure 1. The developed software program separate the 3D images and control the visual inputs into the both eyes by increasing the contrast and intensity of the 3D target to the amblyopic eye and decreases those to the normal fellow eye. (A) Example of blur-applied screenshot of the game. (B) 16 level of Gaussian blur method used in this software program.



Figure 2. The software program named “Ice Cream Truck” game which is a casual shooting game throwing ice creams to the kids running towards the player.

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is under way to prove the effectiveness in improvement of both monocular and binocular vision in children and adults with amblyopia. Furthermore, other various contents such as game, movie, or animation to improve the compliance of patients could be used in the next generation system.

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