

Efficacy of neural vision therapy to enhance visual acuity and contrast sensitivity function in amblyopia



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INTRODUCTION

Computer based cortical vision training (RevitalVision, Lawrence, KS USA) involves the use of server based software utilizing Gabor patch stimuli to enhance neuronal processing in the visual cortex. The purpose of this study was to evaluate the efficacy of the RevitalVision cortical vision training in enhancing Best Corrected Visual Acuity (BCVA) and Contrast Sensitivity Function (CSF) in amblyopic patients.

BACKGROUND

Visual processing involves the integrated activity of neurons in the visual cortex. Neuronal responses and visual perception is determined by the signal to noise ratio of neuronal activity, whereby the visual cortex collects responses across many neurons to average out noisy activity of single cells to improve the signal to noise ratio, leading to improved visual interpretation and acuity (Geisler and Albrecht 1997). Studies have shown noise of individual neurons can be influenced so that the contrast sensitivity at low levels can be dramatically increased when appropriate stimulus parameters are used (Polat and Sagi 1993; Polat and Sagi 1994; Polat, Mizobe et al. 1998; Kasamatsu, Polat et al. 2001). The use of such stimulus to increase neuronal efficiency causes modifications in the visual cortex, which is the basis for 'brain plasticity' (Doshier and Lu 1998; Doshier and Lu 1999), whereby the brain adapts to change and acquires a new skill. In addition, repetitive performance of many basic tasks has demonstrated physical modifications in the adult cortex (Sagi and Tanne 1994; Gilbert 1998).

RevitalVision cortical vision training is a server-based, interactive system tailored and continuously adaptive to the individuals visual abilities. In the first stage, the subject is exposed to a set of visual perception tasks, aimed to analyze and identify each subject's neural inefficiencies. The building block of these visual stimulations is the Gabor patch (Figure 1), which efficiently activates and matches the shape of receptive field in the visual cortex. The fundamental stimulation-control technique is called "Lateral Masking", where collinearly oriented flanking Gabor's are displayed in addition to the target Gabor image (Figure 2). The patient is exposed to two short displays in succession, in a random order; then the patient identifies which display contains the target Gabor image. The task is repeated and a staircase is applied until the patient reaches their visual threshold level. Based on this analysis, a treatment plan is initialized, and subject specificity is achieved by administering patient-specific stimuli in a controlled environment.

RevitalVision technology has been shown to improve visual acuity and CSF in low myopes (Tan 2004; Tan 2005), early presbyopes (Tan 2006), post refractive surgical patients (Lim and Fam, 2006; Tan 2005a) and amblyopes (Polat, Ma-Naim et al. 2004). Amblyopia is a spatial vision disorder that affects about 3% of the population (McKee, Levi et al. 2003; Simmers, Ledgeway et al. 2003). It is characterized by a cortical impairment resulting from abnormal visual experience in early childhood, such as strabismus, anisometropia or both, however, the neural basis of amblyopia is not entirely clear (Kiorpes and McKee 1999; Barnes, Hess et al. 2001). Conventionally it was thought that visual development became hard-wired after the critical period of approximately 6 to 8 years of age. Recent studies suggest that perceptual learning might be a potential treatment for adult amblyopia (Chung, Levi, & Tan, 2005; Huang, Zhou, & Lu, 2008; Levi & Li, 2009a, 2009b; Levi & Polat, 1996; Levi, Polat, & Hu, 1997; Li & Levi, 2004; Polat, 2009; Polat, Ma-Naim, Belkin, & Sagi, 2004; Zhou et al., 2006).

In this study, we investigated the effect of the RevitalVision Treatment System on BCVA and contrast sensitivity in children and adult patients with amblyopia.

METHODOLOGY

A total of 53 individuals with unilateral naturally occurring strabismic, anisometropic, mixed (strabismic and anisometropic) and iatrogenic amblyopia (20.3 ± 11.5 years, range 8 to 50 years; 62% male), with a BCVA of between 1.06 logMar to 0.20 logMar (approximately 6/60 to 6/9.5 Snellen equivalent) were included in this study. All amblyopic visits constituted; cover test, prism cover test, logMar visual acuity (using EDTRS letters), stereovision (Random Dot stereopsis), worths four dot test, CSF (Stereo Optical Company, Functional Vision Analyser) and manifest cycloplegic refraction. If necessary, corrective glasses were prescribed and subject were instructed to wear them at waking hours, especially during the cortical vision training.

The treatment is applied in successive 30-minute sessions, administered 2-3 times a week, a total of approximately 60 sessions. Approximately every 15-20 sessions individuals are recalled for monitoring of their visual status. Visits generally comprise a total of 4 visits; including baseline, 1st visit, 2nd visit and treatment end. In the case where progress continued still at treatment end visit individuals were instructed to continue until progress in both visual acuity and/or CSF plateaued. In this case their treatment end data was used and the 3rd visit or 4th visit was not analyzed.

TREATMENT RESULTS

All 53 individuals completed the study and analysis showed there were statistical significant improvements in both BCVA and CSF post-treatment when compared to pre-treatment data.

Visual Acuity

BCVA in the amblyopic eyes increased an average of 50.8%, equivalent to a mean improvement of 2.6 EDTRS lines. 37.7% improved between 3.3 to 6.6 lines, 39.6% improved between 2.0 to 2.9 lines, 20.8% improved between 1.0 to 1.8 lines and one individual had no improvement or regression of BCVA in the amblyopic eye. Individual improvement of each individual is given in Figure 1. Total improvement of BCVA was not influenced by initial BCVA.

One-way Analysis of Variance (ANOVA) comparing baseline measures with the baseline data, 1st Visit, 2nd Visit and treatment end, showed a significant effect of time, $F(3,156) = 173.38, p < .001$ ($\eta^2 = .77$), indicating all four time points are significantly different from each other (Figure 2). A t-test was used to compare the level of improvement in BCVA in males and females, showing level of improvement not to be effected by gender ($t(54) = -.72, p = .48$).

Our population of 53 amblyopes, with an age range between 8 and 50 years, was separated into four age groups (8 - 11yrs, N=14; 12-17yrs N=18; 18 - 30yrs, N=12 and 30yrs and above, N=12) to assess if efficiency of the treatment was effected by age. A one-way factorial ANOVA showed total improvement in BCVA with treatment was not significantly different across age groups.

Mean treatment time was 4 months. Mean number of treatment sessions was 58 ±14 (range 42 to 87). After baseline assessment, patients revisited approximately every 15 to 20 sessions. The total number of treatments significantly correlated with total improvement of BCVA $p < .028$ level, indicating more therapy sessions equaled larger overall gain in BCVA. The different forms of amblyopia, strabismic (N=7), anisometropic (N=6), mixed (N=40) and iatrogenic (N=3) were also compared to understand if the therapy works better in a particular type of amblyopia. There were only 3 individuals with iatrogenic amblyopia; therefore it was excluded from this analysis. The remaining amblyopia groups were analyzed using a one-way factorial ANOVA, showing that the difference was not significant amongst the groups.

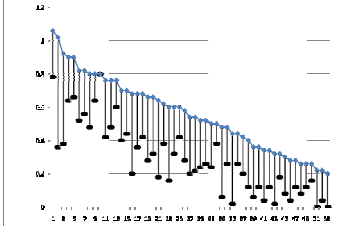


Figure 1: Distribution of BCVA gain from baseline to treatment end (x-amblyopic individual, y-axis logMar BCVA, black line equals total visual gain)

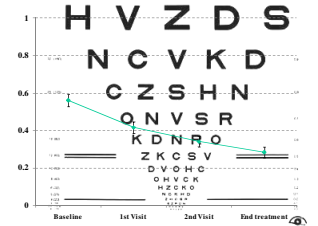


Figure 2: LogMar BCVA from baseline, 1st visit, 2nd visit and treatment end with standard error bars.

CSF Improvement from Baseline to Treatment End

Mean improvements of 75.5%, 68.7%, 52.2%, 42.2% and 27.5% was found in the 5 CSF levels respectively; A(1.5), B(3), C(6), D(12) and E(18) from baseline to treatment end. The 5 CSF levels were analyzed across the 4 time points; baseline, 1st visit, 2nd visit and treatment end, using repeated measures ANOVA. The two way interaction between time and CSF was significant, $F(12,660) = 2.29, p < .007$ ($\eta^2 = .04$). CSF significantly differed at the different time points. However, for most CSF levels the 2nd visit and treatment end did not significantly differ from each other, but baseline and 1st visit do significantly differ. In terms of the number of treatments and CSF, there numbers of treatment sessions were significantly correlated with improvement level; however, improvement of CSF was not influenced by age.

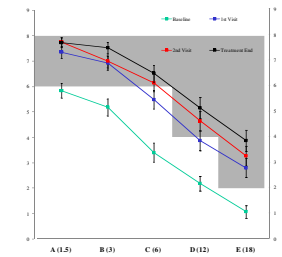


Figure 3: CSF from baseline, 1st visit, 2nd visit and treatment end with standard error bars. Gray area is CSF norms.

CONCLUSION

Cortical vision training in amblyopia may improve BCVA and CSF.

REFERENCES

Chung S, Li L, Serrano A (1998) Amblyopia: clinical aspects. *Statens Beredning for Medicinsk Forskning*.
 Chung S, Li L, Serrano A (2004) Amblyopia: clinical aspects. *Statens Beredning for Medicinsk Forskning*.
 Cooper T, Birch D, Birch J, Birch M, Birch A, Birch C, Birch E, Birch F, Birch G, Birch H, Birch I, Birch J, Birch K, Birch L, Birch M, Birch N, Birch O, Birch P, Birch Q, Birch R, Birch S, Birch T, Birch U, Birch V, Birch W, Birch X, Birch Y, Birch Z, Birch AA, Birch AB, Birch AC, Birch AD, Birch AE, Birch AF, Birch AG, Birch AH, Birch AI, Birch AJ, Birch AK, Birch AL, Birch AM, Birch AN, Birch AO, Birch AP, Birch AQ, Birch AR, Birch AS, Birch AT, Birch AU, Birch AV, Birch AW, Birch AX, Birch AY, Birch AZ, Birch BA, Birch BB, Birch BC, Birch BD, Birch BE, Birch BF, Birch BG, Birch BH, Birch BI, Birch BJ, Birch BK, Birch BL, Birch BM, Birch BN, Birch BO, Birch BP, Birch BQ, Birch BR, Birch BS, Birch BT, Birch BU, Birch BV, Birch BW, Birch BX, Birch BY, Birch BZ, Birch CA, Birch CB, Birch CC, Birch CD, Birch CE, Birch CF, Birch CG, Birch CH, Birch CI, Birch CJ, Birch CK, Birch CL, Birch CM, Birch CN, Birch CO, Birch CP, Birch CQ, Birch CR, Birch CS, Birch CT, Birch CU, Birch CV, Birch 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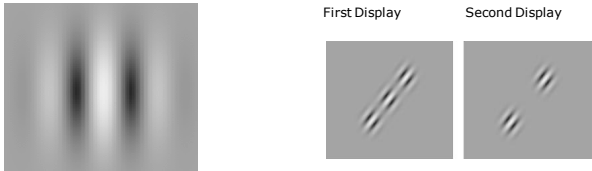


Figure 1: The Gabor Patch

Figure 2: Lateral Masking Images. Two displays showing a target Gabor patch flanked by other Gabor patches.