Introduction

NeuroVision™ NVC vision correction technology is a non-invasive, patient-specific treatment based on visual stimulation and facilitation of neural connections responsible for vision. The technology involves the use of an internet-based computer-generated visual training exercise regime using sets of patient specific stimuli based on Gabor patches, to sharpen contrast sensitivity and visual acuity. Children with highly progressive Myopia often use under-corrected eyeglasses, due to: improper prescription, intentional under-correction or simply due to the high progression of their Myopia.

We evaluated the efficacy of NVC treatment in the enhancement of under-corrected visual acuity and contrast sensitivity function in Myopic children in Singapore. We also monitored the Myopia progression in these children for a 12 months period after the end of the NVC treatment.

Scientific Background

Cortical neurons in the visual cortex function as highly specialized image analyzers or filters, responding only to specific parameters of a visual image, such as orientation and spatial frequency, and visual processing involves the integrated activity of many neurons, with inter-neural interactions affecting both excitation and inhibition. Visual contrast activates neurons in visual areas in which interactions determined sensitivity for visual contrast at each spatial frequency, and the combination of neural activities set Contrast Sensitivity Function (CSF). The relationship between neuronal responses and perception is mainly determined by the signal-to-noise ratio (SNR) of neuronal activity, and the brain pools responses across many neurons to average out noisy activity of single cells, thus improving SNR, leading to improved visual performance and acuity.

Studies have shown that the noise of individual neurons can be brought under experimental control by appropriate choice of stimulus conditions, and CSF can be increased dramatically through control of stimulus parameters[3]. This precise control of stimulus conditions leading to increased neuronal efficiency is fundamental in initiating the neural modifications that are the basis for brain plasticity[4]. Brain plasticity (the ability to adapt to changed conditions in acquiring new skills) has been demonstrated in many basic tasks, with some pointing to physical modifications in the adult cortex during repetitive performance[5-6].

NeuroVision's technology probes specific neural interactions, using a set of patient-specific stimuli that have improved neuronal efficiency[7-8] and induce improvement of CSF due to a reduction of noise and increase in signal strength. As visual perception quality depends both on the input received through the eye and the processing in the visual cortex, NeuroVision's technology compensates for blurred (myopic) inputs, coming from the retina, by enhancing neural processing.

Technology Implementation

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-flickering Gabor are displayed in addition to the target Gabor image. The patient is exposed to two short displays in succession, in a random order; the patient identifies which display contains the target Gabor Image (Figure 2). Audio feedback is provided with an incorrect response, which is an acoustic signal, and the staircase is applied until the patient reaches their visual threshold level.

The NeuroVision System

The NeuroVision System is a software-based, interactive system tailored and continuously adaptive to the individual visual abilities. In the first stage, the system is exposed to a set of visual perception tasks, aimed to analyze and identify each subject's neural inefficiencies or deficiencies. Based on this analysis, a treatment plan is initialized, and subject specificity is achieved by administering patient-specific stimuli in a controlled environment.

Each session is designed to train, directly and selectively, those functions in the visual cortex, which were diagnosed to be further enhanced. At each session an algorithm analyzes the patient’s responses and accordingly adjusts the level of visual difficulty to the range most effective for further improvement. Between sessions, the progress of the patient is taken into account by the algorithm for the next session generation. Thus, for each subject a training schedule is designed based on the initial state of visual performance, severity of dysfunction and progress in course of treatment. The treatment is applied in successive 30-minute sessions, administered 2-3 times a week, a total of approximately 30 sessions. Every 5 sessions, subject's visual acuity is tested in to continuously monitor subject's progress. The average entire treatment duration is around 3 months.

Myopic Children In Singapore

The Singapore Cohort Study of the Risk factors for Myopia (SCORM) found that about 50% of Myopic children (age 7-9) do not wear proper eyeglasses prescription, 57% out of these children have a ≥12 or worse VA in both eyes. Out of the 50% Myopic children who do use a proper prescription, 47% have a ≤9 or worse VA in at least one of their eyes.

According to the SCORM study, the Myopia progression in Myopic Children (At least -1.00D in both eyes) age 7 to 9 is 0.94±0.43 logMAR a year. This rapid progression of Myopia means that effectively children in Singapore are most of the time significantly under-corrected even when they are annually prescribed with new corrective eyeglasses. In this pilot study we evaluated:

1) The efficacy of the NeuroVision NVC technology in enhancing quality of vision i.e. under-corrected visual acuity (UC-VA) and contrast sensitivity function (UC-CSF) in myopic children when they use an under-corrected prescription.

2) The progression rate of Myopia of children who use daily a significantly under-corrected prescription (by approximately 1D) after completion of the NeuroVision NVC treatment.

Methods

33 children aged 7 to 9 having a myopic refraction of at least -1.00D in both eyes (mean cycloplegic SE of -2.64D, range -1.00D to -6.00D) completed NVC treatment over a period of 3-4 months. During the course of treatment, subjects were prescribed with eyeglasses that are 0.50D under their full manifest refraction.

Investigations included: manifest and cycloplegic refraction, axial length measurements and under-corrected (-1.00D) VA and CSF.

Investigation were done pre- and post- NeuroVision treatment and every 3 months for the period of 12 months following the end of treatment.

After the end of the NVC treatment, children were prescribed with the highest possible under-correction that allows them a ≥6/12 binocular VA. 27 Children have been followed up for a complete 12 month period while wearing daily the new under-corrected prescription.

Results

- Baseline Under-Corrected (1D Spherical) was 0.47 logMAR, improving by 2.2 lines to 0.24 logMAR at the end of the treatment.
- 83% of the participants achieved the treatment success criteria (2 lines of improvement in all 3 axes of the child’s eyes).
- Contrast Sensitivity improved in all spatial frequencies as shown in Figure 3. Areas

<table>
<thead>
<tr>
<th>Spatial Frequency</th>
<th>Baseline</th>
<th>End of Treatment</th>
</tr>
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<tbody>
<tr>
<td>Low</td>
<td>0.47</td>
<td>0.24</td>
</tr>
<tr>
<td>Medium</td>
<td>0.47</td>
<td>0.24</td>
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<tr>
<td>High</td>
<td>0.47</td>
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<table>
<thead>
<tr>
<th>Age Group</th>
<th>Average change in S/N</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td>2-4 years</td>
<td>0.12</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>5-7 years</td>
<td>0.12</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>8-10 years</td>
<td>0.12</td>
<td>&lt;0.05</td>
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Conclusions

Results of the NVC treatment suggest that this technology is able to improve under-corrected eyes without the use of external aids. Myopic children, it appears to allow functional quality of vision even when the children use a significantly under-corrected prescription.

It appears that using NeuroVision treatment followed by prescription of significantly under-corrected eyewear may slow down the progression of Myopia. We are in the planning stage of a large randomized controlled trial involving myopic Singaporean school children to validate these findings.

References