

# SUCCESSFUL OCULOMOTOR AUDITORY FEEDBACK THERAPY IN AN EXOTROPE WITH ACQUIRED BRAIN INJURY

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## Abstract

*We report the case of a 36-year-old Caucasian male who was referred to the State University of New York, State College of Optometry, for vision rehabilitation. The patient had undergone surgery to remove a presumed brain tumor three years earlier; however, during surgery, it was found to be a brain abscess. As a result, uncontrolled swelling of the brain tissue led to multiple postoperative complications including: coma; neurological, cognitive, speech and memory deficits; physical and sensory visual system defects. The patient reported an outward left eye turn of increasing magnitude and frequency of deviation. He sought to gain better control of his left eye's position. Due to the presence of central scotomas and an inability to obtain sensory fusion, oculomotor auditory feedback therapy was indicated rather than conventional vision therapy. The patient's ability to control his eye position improved with each session. After seven clinical sessions, and related home therapy, he was able to obtain motor control of his eye position. He was capable of achieving and sustaining ocular alignment in different directions of gaze, and his convergence amplitude improved*

*markedly. Although oculomotor feedback therapy is not commonly used in the treatment of oculomotor disorders, it can be a powerful conditioning technique in training voluntary motor control of eye position in patients lacking sensory fusion.*

## Key Words

*binocular sensory fusion, brain injury, exotropia, eye movements, optic atrophy, oculomotor auditory feedback therapy, visual field defects*

## INTRODUCTION

**B**iofeedback refers to the process whereby a person gains voluntary control over some bodily function by immediate use of information regarding its physiological state.<sup>1</sup> The general biofeedback therapeutic paradigm is three-fold: (1) to provide information related to system state variation that the individual learns to control, (2) to withdraw this information gradually, once control is well-learned, and (3) to provide occasional reinforcement using the prior auxiliary feedback information to maintain the newly-learned ability.<sup>2</sup> It has been used to treat a wide range of general medical conditions such as musculoskeletal and neuroskeletal disorders,<sup>3</sup> cardiac arrhythmias, and hypertension.<sup>2</sup>

The clinical application of biofeedback therapy for vision disorders has also received considerable attention. For example, it has been used in the training and control of accommodation, blepharospasm, and glaucoma.<sup>1,4</sup> Auditory feedback has been used in the treatment of a

range of oculomotor conditions including nystagmus,<sup>5</sup> eccentric viewing,<sup>6</sup> and eccentric fixation.<sup>7</sup> Its use in strabismus has met with good success,<sup>8-12</sup> either alone or in conjunction with conventional optometric vision therapy (VT).

In the present case study, we report the therapy results for an adult whose nearly constant exotropia was secondary to brain surgery. Oculomotor auditory feedback was the primary treatment, since the prognosis with conventional VT was deemed poor due to the lack of sensory fusion.

## SUBJECT

TD was a 36-year-old Caucasian male. In March of 2002, the patient underwent surgery to remove what was thought to be a brain tumor, but in reality was a brain abscess; this was determined during the actual course of surgery. As a result, uncontrolled swelling of the brain tissue led to multiple postoperative complications including: a month-long coma; neurological and cognitive dysfunctions; speech and memory deficits; bilateral optic atrophy with resulting large central visual field defects in both eyes; decreased visual acuity. In addition, the patient reported an outward turn of his left eye, which had increased both in magnitude and frequency of deviation. TD felt that this caused discomfort while reading. He closed his left eye during reading or when he was fatigued, and perceived that this improved his clarity of vision. TD was receiving an intensive course of multiple rehabilitative therapies, including cognitive, speech, occupational, and

physical. He had been advised not to consider VT as it could induce diplopia. He was also instructed by his neuro-ophthalmologist to patch his left eye while reading to alleviate the symptoms. In February of 2005, the patient presented to the primary care clinic at the State University of New York, State College of Optometry (SUNY), for a second opinion. His goal was to gain better control of his left eye's position. TD was then referred to the Eye Movement Laboratory for further evaluation and treatment. The referring optometrist did not recommend conventional VT due to the presence of apparent constant suppression in the left eye and lack of stereopsis.

**EXAMINATION FINDINGS**

The following is a summary of the pertinent findings of two previous neuro-ophthalmological evaluations and one optometric evaluation.

**Ocular Health**

There was an afferent pupillary defect of 1+ in the OS.

There was diffuse optic nerve pallor in each eye. C/D ratios were: OD 0.85, OS 0.80.

Interocular pressures were: OD 17mm Hg; OS 17mm Hg.

Color vision was significantly reduced in each eye; only two of the eight Ishihara test plates were identified correctly.

**Refractive Status**

Distance unaided visual acuities were: OD 20/70+, OS 20/300, OU 20/200.

Near unaided visual acuities at 16" were: OD 20/40, OS <20/200, OU 20/40.

His current Rx and distance refraction was: OD -1.50-0.75X70, 20/40+, OS -1.75, 20/70.

However, the patient reported that he rarely wore his glasses.

**Oculomotor Status.**

Versional testing indicated comitancy. However, both pursuit and saccades were of a unstable, jerky nature, especially in the oblique meridians, OD, OS and OU.

**Binocular Status**

Distance and near cover testing revealed a left, nearly constant, exotropia (LXT) that varied from 10 to 30 prism diopters (pd).

Nearpoint of convergence (NPC) with a large bright light target was more than

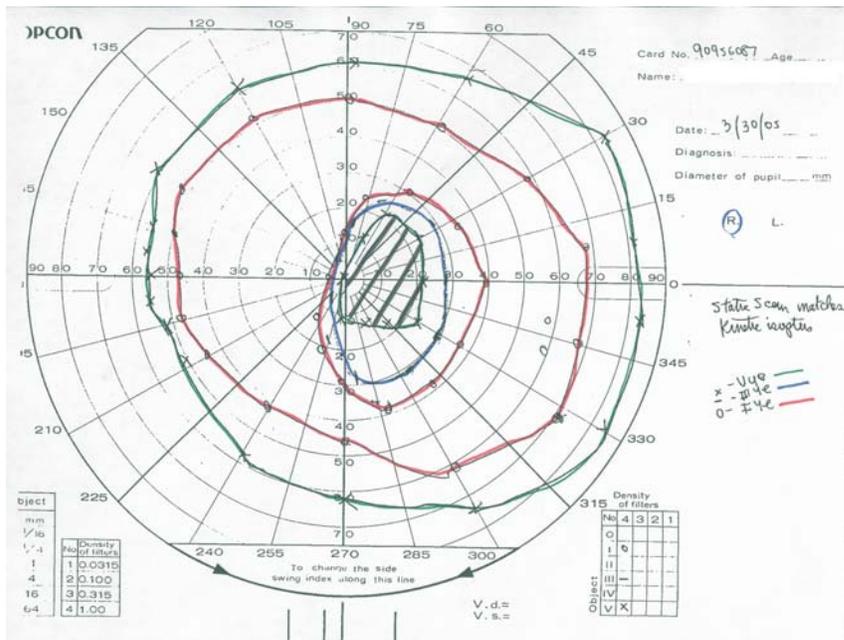


Figure 1. Goldmann visual field of right eye.

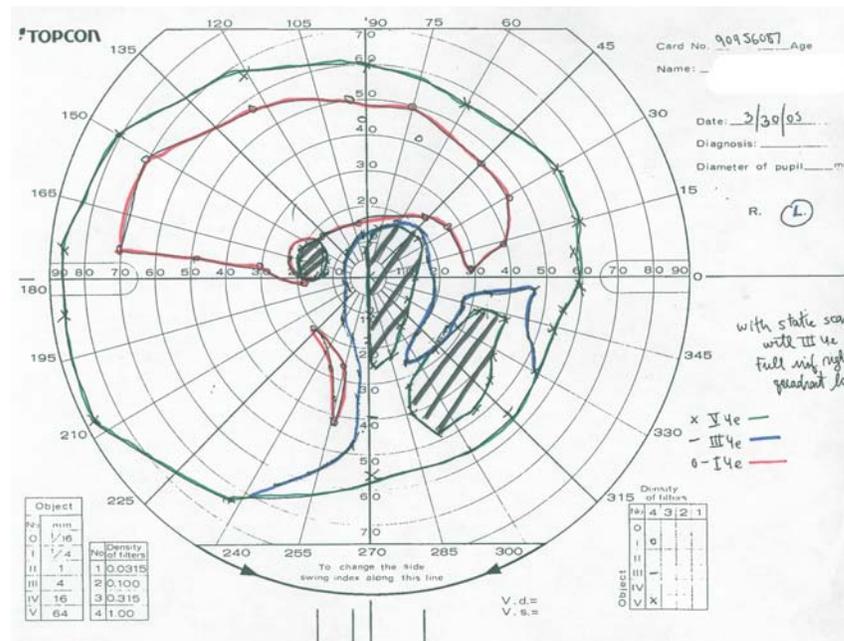


Figure 2. Goldmann visual field of left eye.

18", and receded further with repeated testing.

Suppression testing revealed an apparent constant left suppression at all distance, which we felt really was a reflection of the central field defects. See Visual Fields section.

When viewing a large bright light target through red/green glasses, the patient did not report diplopia or luster.

Stereopsis testing with the Random Dot E Sterogram<sup>a</sup> device indicated an absence of central stereopsis for all targets.

**Visual Fields**

Testing with the Goldmann device revealed:

OD- A large central scotoma to the right of fixation which respected the vertical meridian. There was a full periphery. (Figure 1.)

OS- A large central scotoma to the right of fixation which respected the vertical midline. Further, a sizeable paracentral scotoma was present in the right inferior quadrant. There was a full periphery to a V4e stimulus, a right inferior quadrant

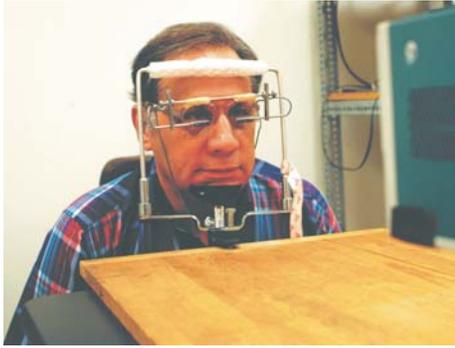


Figure 3.

constriction to III4e, and total inferior hemianopia to I4e. (Figure 2.)

### DIAGNOSIS AND MANAGEMENT

We made the following diagnoses: bilateral optic neuropathy, central visual field defects, severe convergence insufficiency, and a nearly constant LXT. Since the patient's ability for sensory fusion was severely compromised secondary to the central scotomas in both eyes, traditional VT was determined to have limited potential for success. TD was referred for oculomotor auditory feedback therapy to enhance voluntary motor control of the ocular alignment, with the potential of then employing conventional VT, particularly peripheral sensory fusion training.

The goal of the therapy was to develop reflexive vergence control to overcome his nearly constant LXT. All therapy was performed at near (57cm) with binocular viewing. Binocular recording of horizontal eye position was performed using a custom-designed infrared recording eye movement system connected to a differential amplifier and speakers, thus allowing the patient to "hear" when his eyes were not aligned.<sup>5</sup> The auditory component was set in a discrete "on/off" manner. When the eyes were misaligned, a tone was present; when they were aligned within a criterion level of approximately  $\pm 1$  degree, the tone was extinguished. The target consisted of a small (10 min arc), bright spot of light on a display monitor placed along the midline. The task was two-fold: to develop an "internal control strategy" to align the eyes motorically at near, so that the tone was extinguished for as long as possible; and, to recover accurate alignment immediately following binocular disruption with an occluder. See Figure 3.

At the introduction to the feedback training, TD was able to develop a sense of

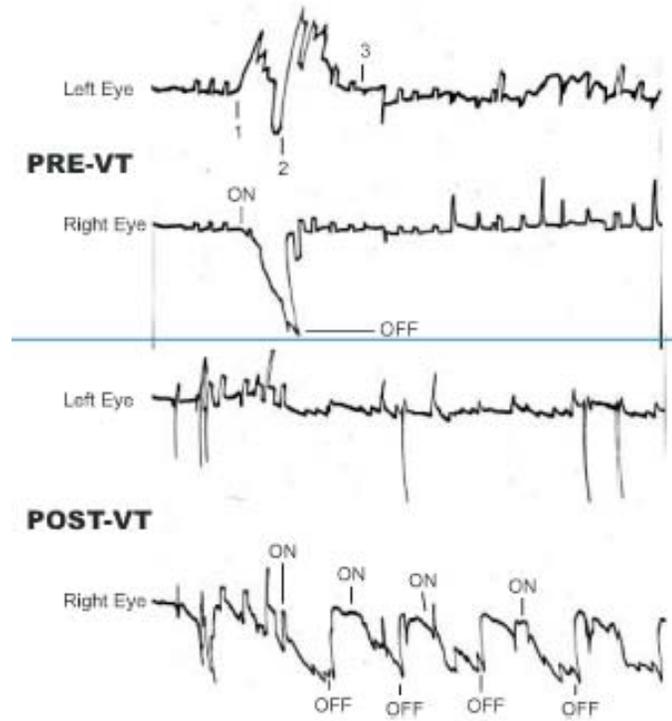


Figure 4. Eye movement recordings pre- and post-VT. See text.

his eyes' positions while either converging or diverging. His frustration grew as he was unable to extinguish the sound for more than 2 seconds by aligning his eyes. Therapy consisted of 45-minute weekly sessions which initially involved learning how to extinguish the tone by aligning his eyes, keeping the tone off for as long as possible, and finally, momentarily occluding either eye and then extinguishing the sound by recovering alignment as soon as possible (cover-uncover technique). Also, out-of-instrument procedures were incorporated such as sustaining ocular alignment while following a large bright target in various directions of gaze, as well as recovering alignment after occlusion of either eye, using verbal feedback. The patient was instructed to continue practicing sustaining motor alignment at home via verbal feedback using the large bright target for 5-10 minutes each day.

At the initial evaluation, pointer-and-straw activity<sup>13</sup> was attempted; however, the patient was unable to perform it due to the presence of his bilateral central scotomas and absence of stereopsis. However, with a large, bright target such as a red cap, TD was able to converge on the target with some degree of facility to about 18". During the course of therapy, several additional activities were at-

tempted such as Brock string, prism jumps, large target anaglyph techniques, and a variety of third-degree fusion targets. However, there was a minimal degree of success with these activities, as initially predicted.

### RESULTS

The patient's ability to control his eyes' horizontal position improved with each session. The outline of oculomotor auditory feedback therapy progress was as follows:

*Session 1:* TD was able to maintain eye alignment up to 5 continuous seconds toward the end of the 45 minute session.

*Session 2:* TD was able to maintain eye position in an increasing manner. We introduced the cover-uncover technique, first in primary position, and then in other positions of gaze. Toward the end of the session, this technique was combined with pursuit movements.

*Sessions 3-5:* We used the same regimen as in session 2 above, but with more demanding tasks for each technique.

*Session 6:* TD was able to recover ocular alignment with repeated unilateral and alternating cover-uncover. We observed that his eyes were aligned about 80% of the time during this visit.

*Session 7:* TD was capable of achieving and sustaining ocular alignment in all directions of gaze at least 80% of the time. He was able to recover motor fusion immediately following cover-uncover. He was dismissed with a plan of home maintenance therapy. TD returned 1 month and 6 months later, with continued excellent reflexive motor fusion and lack of his earlier symptoms.

After seven sessions of audio feedback therapy and compliant home therapy, he was able to obtain voluntary motor control of his horizontal eye position as was evident by direct observation. This was confirmed by the eye movement recordings shown in Figure 4. The "ON" for the right eye recordings indicates occlusion of that eye, while the "OFF" indicates that the occlusion was removed. When this sequence occurred in the pre-auditory feedback therapy recordings (top recordings, Figure 4), the left eye lost fixation (#1), became unstable in an attempt to regain alignment (#2), and then eventually regained alignment. The post-therapy recordings (bottom recording, Figure 4) show that with a series of four ON/OFF occlusions of the right eye, the left was able to maintain fixation virtually all of the time.

His NPC improved significantly; it went from approximately 18" to 2"/5", and this finding remained constant with repetition. He was capable of achieving and sustaining ocular alignment in different directions of gaze, and to immediately recover the aligned position upon cover-uncover. The LXT was still 30 pd, but improved from being nearly constant to being intermittent and present just 10% of the time. Furthermore, TD reported significant improvement in reading comfort without the earlier need for unocular eye closure.

## DISCUSSION

This is the first report using auditory feedback for the treatment of strabismus in a patient with acquired brain injury. Perhaps what is most noteworthy about the case findings is the considerable improvement in horizontal vergence eye movement control obtained with relatively few in-office training sessions and a short training time: total in-office training time across the seven sessions using oculomotor auditory feedback alone was three hours; total in-office training time

using all procedures was five hours. Hence, with our novel primary training strategy and paradigm, very rapid and excellent results were obtained at all distances and directions of gaze. It was maintained as was his entering complaints of difficulty reading, fatigue, and blurred vision during the six month follow-up period with continuance of the simple home therapy. Lastly, according to his spouse's observations, TD's eye now deviated less than 10% of the time. These rapid and positive results are similar to those reported by Goldrich<sup>9</sup> in adult exotropes without brain injury. These individuals lacked sensory fusional ability due to macular disease. Goldrich used a similar training device and paradigm.

The relative lack of central fusional ability resulting from the bilateral scotomas indicated a poor prognosis for traditional VT. Our non-traditional approach allowed us to exploit the patient's ability to incorporate a primary motor-based "voluntary" vergence aspect, presumably involving fusional convergence.<sup>14</sup> However, it is likely that a secondary, peripherally-based sensory fusional component contributed to the overall response. This has been found in functionally-based strabismics having a binocular suppression scotoma when large peripheral stimuli were used.<sup>15</sup> Such a peripheral retinal contribution likely occurred later in the training sequence, as elicitation of this type of sensory fusional response was either absent or highly variable prior to the motor fusion training.

The present findings emphasize the important role that auxiliary forms of feedback play in the VT conditioning paradigm for oculomotor disorders.<sup>2</sup> We have been incorporating auditory and visual feedback, and at times proprioceptive feedback via contact lenses, in the treatment of a variety of oculomotor disorders in both non-brain injured<sup>2</sup> and individuals with brain injury<sup>16</sup> with a high degree of success for over two decades. This multisensory approach may be especially valuable for patients in which normal sensory-based visual feedback related to horizontal retinal disparity is rendered ineffective.<sup>2</sup>

## SOURCE

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