TRAINING OF NYSTAGMUS:
A Multi-Sensory Approach

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Abstract
Several training programs have been attempted with varying degrees of success in patients with congenital nystagmus. A new comprehensive, multi-sensory, scientifically-based, integrated approach to training oculomotor control in these patients is discussed. Training involves the use of auditory, visual, and tactile feedback in conjunction with higher-level control aspects including visual attention, visual imagery, and relaxation paradigms.

Key Words
nystagmus, multi-sensory training, biofeedback, eye movements, vision training

Over the past several years, numerous methods have been devised to aid in the control and treatment of nystagmus, but none have had wide appeal.1-5 With both extraocular muscle surgery6-7 and composite prism spectacles, the goal is to "shift" the null zone into primary position, thus attaining maximum visual acuity with minimum head turn. Surgery may have good initial short-term results; however, transient or even permanent post-surgical diplopia is a possibility, and long-term results (i.e., five years post-surgery) are frequently disappointing. With the composite prism spectacles2,10,12,13 which reduce nystagmus by stimulating convergence may also be helpful, but they force the patient to overdrive convergence at all viewing distances, hence placing extra stress on the vergence system which may cause fatigue effects. After-image training9 allows the patient to use visual feedback to monitor changes in eye position and relative movement directly. Thus, the patient visualizes the fixational stability. This method has met with moderate success. Vision therapy/orthoptics,12-14 has improved vision function in selected cases. The technique of instructing patients to "hold the eyes steady" rather than to "fixate accurately" (i.e., the "fixate" versus "hold" paradigm) while looking at a target has resulted in reduced nystagmus in some patients.15 Use of drugs has only demonstrated transient improvements.16,17 And, the use of RGP contact lenses has provided tactile feedback for some patients.18,19 Many have reported reduction of nystagmus and improvement of sensory function with oculomotor auditory biofeedback training,20-26 in isolation as well as in conjunction with an integrated, multi-sensory training approach in these patients3,27 (See Figures 1 and 2.) This last method will be the focus of the present discussion.

Multi-Sensory Training Protocol
Our comprehensive, multi-sensory, two-phase oculomotor biofeedback training protocol is listed in Table 1. It is used by our patients with nystagmus for training in the clinic and at home. The approximate timetable and integration of each training component is described below.

Phase One
In phase one, patients receive approximately ten 45-minute sessions of oculomotor auditory biofeedback training in the clinic. Horizontal eye movements are monitored objectively using the infrared limbal reflection technique,2 with a tone generated that is related to horizontal eye position. We use both custom-made and commercially-available eye movement recording systems3 (Figure 3). Sessions typically occur on a weekly basis, although two or three clinic sessions per week facilitates the learning-conditioning process. In fact, patients who do not live nearby but still desire treatment attend the clinic for several consecutive days (e.g., three-five days) in which the biofeedback is performed twice a day in 60-90 minute sessions, with excellent results.
The emphasis at the initial sessions is on binocular fixation ability, first along the midline and then in slight horizontal eccentric gaze, i.e., five to ten degrees to the left and right of the midline, with the head straight. The patient’s goal is to reduce the nystagmus by 50% or more at least 25% of the time, within one minute (preferably within five-ten seconds) of attempting volitional control of the nystagmus. Patients are instructed to gaze at the target and relax, but at the same time to learn to “do something” to reduce the wavering quality of the tone which reflects the unsteadiness of their eyes. Visual imagery (e.g., imagine looking far) and related split visual attention aspects, as well as overall relaxation and reduced attention to the fixation effort or attempt per se during the task, has positive effects on initial training success. Once the patient has exhibited reasonably consistent control of the nystagmus, the biofeedback is withdrawn for brief (i.e., about ten seconds) and then relatively long (i.e., about one minute) periods. The patient is instructed to maintain the reduced nystagmus solely by invoking the higher-level control strategy he or she has previously developed and adopted with the auditory feedback. However, this is now done with the doctor’s verbal feedback, based on concurrent oculomotor performance as assessed objectively with the recording system. At this time, the patient is loaned one of the commercially available auditory biofeedback training devices for home reinforcement.

Finally, in the latter sessions, saccade, pursuit, and vergence tracking, as well as simulated reading, are implemented to increase the oculomotor challenge and to add some diversity to the training sessions. This also provides a more dynamic visual environment, as found in one’s natural surrounds. The protocol for phase one is outlined in the Appendix.

**Table 1**

<table>
<thead>
<tr>
<th>Nystagmus Biofeedback Clinical Training Protocol</th>
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<tbody>
<tr>
<td>Auditory feedback (phases 1 and 2)</td>
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<tr>
<td>fixation</td>
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<tr>
<td>version (saccades and pursuit)</td>
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<tr>
<td>reading (simulated)</td>
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<tr>
<td>vergence</td>
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<tr>
<td>Visual feedback (phase 2)</td>
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<tr>
<td>version and vergence eye movement training</td>
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<tr>
<td>sustained afterimages</td>
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<tr>
<td>very low contrast target discrimination</td>
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<td>fine line separation discrimination</td>
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<tr>
<td>Tactile feedback (phase 2)</td>
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<tr>
<td>digital assessment</td>
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<td>rigid contact lenses</td>
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**Phase Two**

This phase is also approximately 10 weeks in duration, and training involving other sensory modalities is integrated with the auditory modality. This includes both visual and tactile feedback related to eye position and its relative movement.

The visual feedback primarily involves the oculomotor system directly, including both isolated versional and vergence aspects, as well as integrated sensory-motor activities. We use both conventional vision training paradigms, such as Marsden ball and rotating pegboard tracking, maze tracing, vectographic fusion, etc., as well as computer-based training in which the eye movement stimuli can be more carefully controlled and specified. Eye movement performance is grossly quantified. In ad-
dition, we employ sustained afterimages to visualize direct control of the nystagmus movement. Low contrast target identification and discrimination, and densely packed fine-line and letter search and counting tasks are used. These tasks require at least transient reduction of the nystagmus. Furthermore, auditory biofeedback may be incorporated concurrently with the visual feedback to enhance the overall training effect.

Lastly, either concurrent or soon after the implementation of visual feedback training, the tactile feedback aspect is introduced. This is done in two ways. First, patients are taught to appreciate and sense their own eye position changes by gently placing their index finger onto the upper eyelid. Using this digital assessment, they are instructed to monitor eye movement, while attempting to invoke their learned, higher-level control strategy as they gaze at far and near objects at various positions in the visual field. Second, they are prescribed rigid contact lenses. These provide additional and continuous tactile information regarding eye position and its relative movement. The patient is taught to appreciate and sense the lenses' shift against the palpebral conjunctiva. In addition, contact lenses frequently improve visual acuity and the binocular field-of-view, both of which can result in enhanced overall sensory and oculomotor performance.

Discussion

The patient benefits derived from our multi-sensory treatment paradigm have been multifaceted. Visual acuity and related measures of vision function (such as accommodation) improved noticeably. And perhaps as important for some patients, the overall cosmetic aspect has been positively impacted. Now, at least for specific periods of time (up to two minutes), the nystagmus can be reduced voluntarily. This is especially critical in a variety of interactive social and business situations in which direct eye contact is paramount. Lastly, and related to the above, is the accrued psychological benefit. In addition to the more obvious positive psychological effects resulting from improved cosmesis, the knowledge that he or she has some degree of control over the nystagmus frequently gives the patient a better sense of self-worth and confidence. Thus, while each of the three components might only have relatively minor to moderate effects, the overall integrated effect is often greater than the sum of its parts.

The topic of proprioception in the contemporary clinical treatment of nystagmus remains an open and potentially important area. Various forms of proprioceptive stimulation (e.g., acupuncture and high-frequency vibration) of selected neck muscles have resulted in reduced nystagmus. Pro proprioceptive stimulation also has a small (i.e., a few degrees) and consistent biasing effect on steady-state eye position in normals and strabismics, and perhaps should be investigated in nystagmus with respect to the overall therapeutic regimen. This notion might be best exploited with regard to the training of fixational control, especially in conjunction with imposed null position bias effects. If successful, one can envision a small vibratory collar worn by the individual, which when activated would result in reduced nystagmus.

We have successfully performed our multi-sensory treatment in the clinic and at home on cooperative patients ranging from 10 to 70 years of age. An example is shown in Figure 4. The patient is a 10-year-old with idiopathic congenital nystagmus. At this third session, he could reduce his nystagmus considerably with concurrent improvement in visual acuity. While we have also attempted it in a few children as young as 4 years of age, they did not seem to grasp the relatively difficult phase one concept that the tone was related to their eye movements. This could be related to an insufficient appreciation of their ocular-motor dysfunctions. In the future, test paradigms will be developed in our laboratory to facilitate such a link in children. For example, use of a small-field, video-based cartoon test stimuli in conjunction with remote video-based monitoring of eye movements could be a possible scenario, with appearance of the cartoon contingent on an appropriate level of oculomotor control.

One area that requires more careful attention is that of the long-term efficacy of oculomotor auditory biofeedback training, both in isolation as well as in conjunction with the visual and tactile feedback paradigms. We have informally tested patients who had successfully received primarily the auditory biofeedback treatment up to two years earlier. They reported using the learned strategy during specific situations in their everyday activities. Furthermore, they could invoke it readily during both subjective and objective testing of their eye movements in the clinic. However, formal testing over relatively long (i.e., five years) post-treatment time intervals is required to assess the retention ability more accurately and quantitatively, especially with respect to its multi-sensory component contribution to the overall habitually enhanced oculomotor performance. Clearly, a large-scale clinical trial in both adults and children is essential.

References

Appendix 1
Protocol Oculomotor Auditory Biofeedback Training in Patients With Nystagmus—Phase One

Patient Information
1. The patients are informed that within four sessions (but more typically one or two sessions), they should begin to develop some voluntary control of their nystagmus.
2. And, they are informed that patients generally need about 20 sessions to reduce their nystagmus rapidly and to sustain it for 30 seconds or longer without much conscious effort. The patients are instructed to practice these maneuvers at home as often as possible, perhaps in conjunction with other prescribed conventional home vision training, as well as the multi-sensory biofeedback paradigms described in the present paper.
3. Lastly, the patients are told that long-term follow-up, with periodic “booster” sessions to maintain training effectiveness, is beneficial in most cases.

Training Instructions
1. The patients are told to gaze at the target and relax.
2. Then, they imagine looking at a very far object in a quiet environment, such as a sailboat drifting far from the shoreline at dusk. Visual imagery, as well as overall physical and mental relaxation, can play important roles in the success of initial training.
3. While doing so, the patient attends to the tone.
4. They are informed that the wavering quality of the tone reflects the steadiness of their eyes.
5. The patients are told to try to “do something” to reduce the wavering quality of the tone, which means they are controlling and reducing their nystagmus. The goal is to keep the tone as steady and as constant as possible.
6. They are told that some patients may have been able to reduce their nystagmus by:
   a. relaxing and not exerting any special effort.
   b. imagining looking very far at a soothing scene.
   c. imagining they are looking into their null position.
   d. imagining they are looking through their dominant eye.
   e. imagining they are converging upon a very near target along the midline.
7. The patients are told that when they are able to reduce the tonal unsteadiness, they should try to recall what they did (i.e., recall what higher-level control strategy acted as a “trigger mechanism”), and at the end of the session they should describe this to you. However, some patients can consistently and voluntarily reduce their nystagmus, but yet cannot specifically verbalize what they are doing.
8. Next, they are instructed to try to repeat and sustain the reduced nystagmus as frequently and as long as possible.
9. Once fixation can be reasonably controlled, the saccadic and pursuit training is added. For saccadic training, patients are instructed to produce the tonal change with a single and rapid shift in pitch, which reflects a single and accurate saccade. The same would be true for the simulated reading tracking. For pursuit tracking, patients are instructed to vary the tone in a smooth and continuous manner, which reflects smooth pursuit in the absence of corrective saccades. The same would be true for the vergence tracking along the midline.

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