Vestibular Function in Mildly Mentally Retarded Adults

(sensory integration, developmental disabilities, clinical assessment of vestibular function)

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The purpose of this study was to compare the duration of nystagmus in mildly mentally retarded and normal adults as measured by the Southern California Postrotary Nystagmus Test. The results revealed that the retarded males demonstrated attenuated duration of nystagmus. These findings support the need for further investigation of possible sensory integrative deficits in this population so that proper treatment can be provided.

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Vestibular function is a critical area evaluated by occupational therapists because it theoretically underlies sensory integration and academic ability (1). Ayres was the first to stress the importance of sensory integrative processes and has shown that children with certain kinds of learning disabilities presented a clinical picture that was suggestive of underlying vestibular dysfunction (2).

To better define this dysfunction, Ayres developed the Southern California Postrotary Nystagmus Test (SCPNT) (1). Standardized administration procedures involved the observation of duration of postrotary nystagmus following rotation. While Ayres acknowledged there were several other more precise measures of vestibular dysfunction, she justified her decision to use this instrument on the basis of its clinical practicality. This test, in conjunction with interpretation of other assessments and clinical observation, proved useful in detecting which learning-disabled children would benefit most from therapy emphasizing vestibular stimulation. Thus, there was evidence to support the use of this test diagnostically in determining whether or not a client has a vestibular disorder, and prescriptively in developing an appropriate therapeutic program.

The research tools that Ayres developed may have important applications for other than learning-
disabled populations. No studies have used the SCPNT to determine if mentally retarded persons have vestibular abnormalities, but a number of studies have reported therapeutic gains resulting from programs incorporating vestibular stimulation with this population (3-5). Mentally retarded persons demonstrate specific problems in the areas of postural balance and eye-hand coordination, clinical signs which suggest vestibular dysfunction; however, the presence of a vestibular disorder has not been conclusively demonstrated.

The purpose of this investigation was to evaluate the status of vestibular function as measured by the SCPNT in mildly mentally retarded adults. Specifically, postrotary nystagmus scores of mildly mentally retarded and normal males were compared. Finally, duration of nystagmus of adult normal males was compared with that of normal boys in order to determine whether or not a developmental trend was detectable on the SCPNT.

Review of the Literature
The Neurobiological Basis of Nystagmus. The vestibular system comprises the vestibular apparatus located in the inner ear and its connections to the central nervous system. Three structures—the semicircular canals, the utricle, and the saccule—constitute the vestibular apparatus. Principal vestibular pathways originate with the vestibular division of the eighth cranial nerve, the peripheral endings of which are located bilaterally on the hair cells of the maculae of the utricle and saccule, and on the cristae in the ampullae of the semicircular canals.

The semicircular canals are the chief receptors for angular acceleration and deceleration; they function in pairs with stimulation through angular acceleration interpreted as excitation in one member of a pair of bilateral canals, and as inhibition in the other (6,7). For example, the onset of rotation of the body to the left about a vertical axis with the head tilted at 30 degrees toward the vertical will cause a perrotary nystagmus to appear (7,8). Nystagmus is made up of two components. In this example the slow component will be to the right and the quick component will be to the left. There will be no movement of the eyeballs during rotation. Upon cessation of rotation the eyeballs will exhibit the slow component of nystagmus to the left and the quick component to the right. This is labeled postrotary nystagmus.

The maculae, composed of supporting cells, hair cells, and the oto-lith organs, are the sense organs of the utricle and saccule (9). The oto-liths of the utricular maculae are sensitive to both the magnitude and direction of linear acceleration as well as stimulation produced by gravity (10). Saccular function is less well defined. Wilentz (11) suggests that the oto-lith organs of the saccular maculae may be a sensor for vibratory stimuli and also an influence on eye movements; however, these areas are difficult to evaluate in man (12).

The basic function of the vestibular system is to stabilize body and eye positions to ensure precise, goal-directed movements and clear vision (13). The many connections of the vestibular system influence spinal motor centers for movements of the head, trunk and limbs; oculomotor centers for movement of the eyes; the flocculonodular lobe of the cerebellum for balance (14,15), and autonomic centers of the medulla, midbrain, thalamus, and cerebral cortex affecting vascular changes, perspiration, salivation, gastrointestinal effects, yawning, and sleepiness (16).

Clinical Assessment of Nystagmus. Scientists have been investigating vestibular function for the past 150 years (17). There are several techniques for measuring vestibular function. The two most common and practical techniques available to the clinician are the caloric test and the rotation test. In all three tests, observation of the duration or excursion of nystagmus has served as an indicator of the integrity of the vestibular system's functional state.

The Use of the Southern California Postrotary Nystagmus Test in Occupational Therapy Practice. It was not until 1975 that Ayres began to hypothesize that depressed postrotary nystagmus and went on to hypothesize that depressed postrotary nystagmus in these learning-disabled children was caused by overinhibition of the lateral vestibular nuclei.

Other researchers working independently have found evidence of vestibular disorders in similar populations. According to de Quiros, working in Argentina (18-20), and Frank and Levinson (21,22) in New York, problems in vestibular processing are reflected by difficulties in performing functions such as...
reading and writing and thereby interfere with academic achievement and also contribute to the emotional and behavioral problems often found in learning-disabled children.

By incorporating the SCPNT in her research, Ayres more precisely defined several syndromes of dysfunction that had been detected in earlier factor analytic studies. These are: 1. problems in vestibular and bilateral integration; 2. apraxia; 3. tactile defensiveness; 4. left hemisphere dysfunction; and 5. right hemisphere dysfunction. Some children are found to have more generalized sensory dysfunction and are diagnosed on the basis of sensory systems. Commonly, one child will demonstrate the presence of more than one syndrome.

Research investigating the effects of sensory integrative therapy on specific patterns of neural dysfunction demonstrated that children with the vestibular and bilateral integration syndrome, one parameter of which is hyporeactive nystagmus, appeared to benefit more from sensory integrative therapy than from the more traditional educational programming (2).

Evidence Suggestive of the Presence of Vestibular Deficits in the Mentally Retarded. There have been a number of studies that have investigated the effects of sensorimotor and modified sensory integrative treatment programs on developmental gains in the mentally retarded. Movement through space, a primary stimulus for activation of the vestibular system, has provided the basis for these types of therapeutic interventions. Professionals in the fields of special education, physical education, and occupational therapy have emphasized vestibular activities in sensorimotor and sensory integrative treatment programs (23, 24, 2), although the latter approach uses far more potent means of inducing vestibular stimulation and therefore requires the judgment of highly skilled therapists.

Using a modified version of Kephart’s sensorimotor training methods, Edgar, Ball, McIntyre, and Shotwell (25) found improvements on the motor, language and personal-social scales of the Gesell Developmental Schedule in moderately and severely retarded children. A similar treatment approach used with moderately and severely retarded adolescents demonstrated gains in motor skills and body image in a study reported by Maloney, Ball, and Edgar (26). Also looking for change in body image, Chasey, Swartz, and Chasey (27) reported significant gains made by trainable mentally retarded children as a result of a physical development program.

The effects of a modified sensory integrative treatment program, directly extracting procedures employed by Ayres, Kephart, and others, were studied by Morrison and Pothier (28). Mentally retarded preschoolers participating in the sensorimotor program made greater gains in the areas of overall development, gross-motor and language development than those subjects who participated in gross-motor or social attention groups. The authors concluded that sensorimotor treatment, based on a developmental assessment and an individually prescribed and administered treatment program, was a powerful effector in eliciting developmental gains in this population.

Montgomery and Richter (3) found that mentally retarded children participating in sensory integrative treatment made greater gains in reflex integration and gross and fine motor skills than children who received either an adaptive physical education program or a program that combined physical education with arts and crafts. The authors stressed that the noncognitive sensory integrative activities facilitated neuromotor development more effectively than the more traditional approach of practicing specific motor skills.

In the only study investigating the effects of modulated vestibular stimulation in infants, Kantner, Clark, Allen, and Chase (4) found vestibular habituation and increased motor performance in both normal subjects and those with Down’s Syndrome, but the subjects with Down’s Syndrome exhibited a greater degree of change. Similarly, Norton (29) found that a combined sensory integrative and neurodevelopmental approach facilitated reflex integration, development of eye contact and vocalization, as well as a decrease in self-mutilating behaviors in severely retarded multiply handicapped infants. It should be noted that sensory stimulation techniques, similar to those described by Ayres, were employed in both of these investigations.

Techniques of rocking, bouncing, and swinging, all of which provide considerable vestibular stimulation, were described by Webb (30) as producing improvement in the areas of movement, awareness, manipulation of the environment, and posture and locomotion in profoundly retarded persons. Although those results were not statistically significant, Webb argues for further investigation of such treatment procedures. Finally, a provocative study, conducted by Clark, Miller, Thomas, Kucherawy, and Azen (5), was made on the comparative effects of sensory integrative therapy, operant conditioning, and a combined therapeutic approach on vo-
ocalization in profoundly retarded adults. Although significant differences were not found among the treatment programs, an analysis comparing pre- and post-treatment scores indicated significant improvements in the areas of postural adaptation, frequencies of eye contact, and vocalization. Conclusions were drawn indicating that profoundly retarded, minimally vocal adults benefited from the three types of therapies with gains made in vocalization and the vestibularly influenced areas of eye control and postural adaptation. The authors proposed that the lack of significant differences among the programs may have been due to methodological limitations that did not allow for the use of suspended equipment so necessary for the provision of intense angular and linear vestibular stimulation.

**Hypotheses.** The following two hypotheses were considered: there would be a difference in duration of postrotary nystagmus between normal males and mildly mentally retarded males of the same age group; there would be a difference in duration of postrotary nystagmus between normal adult males and normal boys.

**Methods**

**Subjects.** Sixteen mildly mentally retarded males ranging in age from 18 to 33 years and 16 normal males of the same age span were compared for duration of postrotary nystagmus. The mentally retarded subjects met the criteria for inclusion in the mildly mentally retarded category established by the American Association of Mental Deficiency (31). The normal males were participants in a physical education class at a local YMCA serving various ethnic and socioeconomic groups. The population was considered to be representative of male adults living in metropolitan Los Angeles. No subjects with a history of convulsive disorders or hearing or severe visual deficits participated in the study. The normative sample of 111 boys ages 5 to 9 are those described by Ayres (1).

**Procedures.** Testing was conducted in a quiet, slightly darkened room with minimal visual distraction. The nystagmus board was placed in the middle of the room. One examiner tested all subjects in accordance with the standardized procedures of the SCPNT. After each subject was seated on the nystagmus board and his head positioned in 30 degrees of flexion, the standardized instructions for the SCPNT (1) were given. The subject was then rotated 10 times in 20 seconds and abruptly stopped. The examiner observed the movement of the subject's eyeballs simultaneously timing the duration of nystagmus with a stopwatch. Each subject was spun first to the left and then to the right with an interval of no less than 10 seconds between rotations.

The normal subjects were tested between 8:00 a.m. and 9:00 a.m. after participating in a one-hour moderately strenuous physical education class consisting of stretching, physical exercises, and jogging. The mildly mentally retarded subjects were tested in the early evening after a day of activity.

**Results**

Table 1 presents the means ± SD for duration of postrotary nystagmus after rotation to the left and right as well as the total duration for normal and mildly mentally retarded adults. Two sample t-tests revealed significant differences in mean duration of nystagmus after rotation to the left and right, as well as for the total scores (p < 0.001). On the average, the mentally retarded males had significantly lower left, right, and total duration of postrotary nystagmus.

Since research has suggested that nystagmus duration increases with age (32-34), the data were further analyzed to determine whether a similar trend would be detectable on the SCPNT. A 2-sample t-test
Table 2
Comparison of Mean (± SD) Duration of Postrotary Nystagmus between Normal Male Adults and Normal Boys

<table>
<thead>
<tr>
<th></th>
<th>Normal Adults (n = 16)</th>
<th>Normal Boys (n = 111)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>19.6 ± 6.0</td>
<td>10.0 ± 4.4</td>
<td>7.77</td>
<td>0.001</td>
</tr>
<tr>
<td>Right</td>
<td>20.2 ± 6.8</td>
<td>10.1 ± 3.7</td>
<td>7.30</td>
<td>0.001</td>
</tr>
<tr>
<td>Total</td>
<td>39.8 ± 11.6</td>
<td>20.0 ± 7.3</td>
<td>7.55</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Statistics on Normal Boys from Ayres (1).

Table 3
Comparison of Mean (± SD) Duration of Postrotary Nystagmus between Normal Boys and Mildly Mentally Retarded Adults

<table>
<thead>
<tr>
<th></th>
<th>Normal Boys (n = 111)</th>
<th>Mildly Retarded Adults (n = 16)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>10.0 ± 4.4</td>
<td>11.6 ± 3.9</td>
<td>1.38</td>
<td>n.s.</td>
</tr>
<tr>
<td>Right</td>
<td>10.1 ± 3.7</td>
<td>11.8 ± 3.3</td>
<td>1.72</td>
<td>n.s.</td>
</tr>
<tr>
<td>Total</td>
<td>20.0 ± 7.55</td>
<td>22.9 ± 6.4</td>
<td>1.49</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

n.s. = not significant

was performed to compare the mean duration of nystagmus of the normal adults with the mean duration of nystagmus of the sample of 111 boys ages 5 to 9 on whom the SCPNT normative data were obtained. Results reported on Table 2 revealed significant differences in duration to the left and right, as well as for total scores (p < 0.001). On the average the boys had significantly lower left, right, and total duration of postrotary nystagmus suggesting a developmental progression with duration of nystagmus increasing as a function of age.

This raised the question of whether the duration of nystagmus of mentally retarded adults was comparable to that of the boys in the normative sample on whom the SCPNT was standardized. Results of a 2-sample t-test presented in Table 3 revealed no significant differences between the groups.

Discussion
The results of this study reveal that mildly mentally retarded adult males demonstrate attenuated nystagmus when compared to normal adult males and corroborate the findings of earlier studies on nystagmus using neurologically impaired subjects of other diagnostic categories. Ayres (1) found that learning-disabled children frequently exhibited depressed postrotary nystagmus. Likewise, de Quiros (18, 19) and Frank and Levinson (21, 22) found attenuation of nystagmus together with other concomitants of poor vestibular functioning in populations comparable to those studied by Ayres.

Furthermore, some of the most consistent findings of depressed postrotary nystagmus have been found in schizophrenic populations (35-37). Fish (38) found decreased duration of nystagmus in her longitudinal studies on childhood schizophrenia. A decreased vestibular response was also noted by Rito, Ornitz, Eviatar, and others (39) in their study on autistic children. Depressed nystagmus, a common denominator among these diagnostic categories for which etiologies are unknown, suggests perhaps underlying vestibular dysfunction may vary its manifestations from the subtle problems of the learning disabled to the more extensive problems of those afflicted with schizophrenia, autism, and mental retardation.

Ayres (1) suggests reduced nystagmus was probably indicative of a dysfunction in the adaptive capacity of the vestibular system and suggests two interpretations of this dysfunction. First, she speculates that cortical or other structures above the level of the vestibular nuclei may inhibit the nystagmus response, which is mediated at the level of the vestibular nuclei. Support for this hypothesis of excessive inhibition over vestibular processing is supported by a study by Wylie and Felden (40). These investigators found that the cerebellum has a tonic inhibitory influence on the lateral vestibular nuclei in cats. While the practice of using results from animal studies to interpret human
responses must be performed cautiously, this study does substantiate the hypothesis that reduced nystagmus may be due to excessive inhibitory influences of the cerebellum via cerebellofugal fibers postulated to influence oculomotor nuclei (15). In contrast, the second interpretation proposed by Ayres suggests that the vestibular nuclei may receive inadequate sensory excitation via peripheral receptors and neurons. It is unclear at this time as to which of these hypotheses would best explain the depressed nystagmus of mental retardates.

When mean postrotary nystagmus duration of the mentally retarded subjects was compared to that of normal children, ages 5 to 9, there were no statistically significant differences; but when the mean postrotary nystagmic duration of normal male adults and the boys on whom the SCPNT was standardized were compared, the adults demonstrated a statistically significant increase, suggesting a developmental trend—of particular interest in light of the finding that the nystagmic duration of the male retarded adults was compared to that of the boys. Nystagmus has been shown to become more prolonged up to the age of 60, but beyond this age it declines (32-34). It may be that depressed nystagmus in the retarded when compared to normal adults is simply another manifestation of overall developmental delay.

There were also some methodological considerations that have a bearing on interpretation of the results. Certain aspects of the statistical procedures used warrant further discussion. Measures of nystagmic duration provide curvilinear data in which scores in the midrange are considered normal, with those extremely high or low typical of dysfunction. In using statistical procedures in which means are computed, the extent to which scores tend to be excessively high or low is somewhat obscured and the researcher may not detect significant differences. In this study, inspection of the raw data revealed that in general the mean was a valid summary statistic, since neither the male retarded nor normal adults demonstrated a tendency toward scores in the extreme ranges. On the contrary, the retarded adults tended to cluster in the depressed range with 81 percent below 1 SD of the normal adult group. Only two subjects in the normal adult group demonstrated nystagmic duration in this range.

The vestibular system, through its neural connections with the reticular formation, is also influenced by state of arousal. Clark (41) suggested that degree of arousal must be taken into consideration when looking at duration of nystagmus. Fredrickson, Kornhuber, and Goode (42) stated that nystagmus is enhanced by arousal and depressed by fatigue. This effect on nystagmus is especially important to the present study since the normal subjects were tested after participation in an hour of strenuous exercise and jogging early in the morning, whereas the mentally retarded subjects were tested in the early evening after a day of activity. It may be that the nystagmus of the mentally retarded subjects was depressed and conversely that of the normal subjects was prolonged by such arousal factors.

Conclusions
This study provides evidence that mildly mentally retarded adults demonstrated attenuated nystagmus when compared to normal adults, therefore suggesting that they may have a vestibular dysfunction. Depressed nystagmus, also a characteristic of some learning-disabled, schizophrenic, and autistic populations, probably represents a dysfunction in the adaptive capacity of the vestibular system. The duration of nystagmus correlates with age in normal populations so that attenuated nystagmus in the mentally retarded may be a reflection of developmental delay. Finally, duration of nystagmus is related to arousal factors so that the results of this study may have been influenced by the time of day during which normal and mentally retarded subjects were evaluated on the SCPNT.

If the results of the study can be considered valid or are verified in future investigations, there are important clinical implications. The current practice of providing vestibular stimulation as part of therapy programs for retarded populations seems warranted. However, as with other populations, those offering these therapy programs must be knowledgeable of the function of the vestibular system and the precautions thereof. Moreover, depressed postrotary nystagmus has been shown to be one of the best predictors of success of sensory integrative therapy programs (2). Therapists working with the retarded could use this relatively quick assessment to justify inclusion of male adult retarded individuals in programs emphasizing vestibular stimulation.

Acknowledgments
The authors acknowledge Susan Aoki, M.S., OTR, Dottie Ecker, M.A., OTR, Annette Levey, M.S., OTR, and Bart B. Sokolow, D.Env., P.E., for their support and suggestions. This article is based in part upon material submitted in partial fulfillment of the requirements for the Master of Arts Degree, Univer-
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