We tested the following groups for visual pursuit abilities: 54 mentally retarded, 46 cerebral-palsied, and 131 learning-disabled children, 3 to 10 years of age. The resulting five behavioral scores, six directions, and total scores were analyzed for age trends. Comparisons were made between the handicapped groups and between the handicapped and normative samples. The scores were also correlated with other visual and postural abilities. All three handicapped groups scored lower than the normative group and also showed patterns different from the normative group and different from each other. The learning-disabled group most closely approximated the normative group's development patterns. Educational data were not able to be used, and we suggest that future research examine the correlations (both in handicapped and nonhandicapped children) of ocular pursuits and educational achievement, and also obtain more complete data on cerebral-palsied children. Therapists may find the visual pursuits test useful particularly when they want to evaluate a number of aspects of ocular pursuit functioning or when they desire more precision than what is usually available by simple observation.

Evaluation of ocular tracking is used by many occupational therapists to help assess neurologic dysfunction. A previous study (1) addressed the need for a standardized measuring instrument and normative data, but it lacked information about specific diagnostic groups.

The purpose of this study was twofold: a) to examine the validity of the Ocular Pursuit Test (1) as a diagnostic tool and b) to examine the ocular pursuit abilities in learning-disabled (LD), cerebral-palsied (CP), and mentally retarded (MR) children. The study posed the following questions. Do the handicapped groups differ significantly from the normative population a) on the five behavioral observations (pursuits in general, crossing the midline, bilateral use of the eyes, head movements, range) or b) in their ability to follow an object visually in different directions? Are there profiles of abilities/disabilities in ocular pursuits characteristic of particular diagnostic groups? Are there significant correlations between the scores on the visual pursuit tests and other measures of neurologic integration and/or achievement?

Literature Review

A thorough review of the literature on neuroanatomic basis, types, and normal development of eye movements; general problems in ocular pursuit; test methodology; and previous studies of ocular pursuit testing may be found in the normative study (1). A thorough review of the literature on neuroanatomic basis, types, and normal development of eye movements; general problems in ocular pursuit; test methodology; and previous studies of ocular pursuit testing may be found in the normative study (1).

Ocular Abilities in the Learning Disabled

Ayres (2) described the importance of evaluating extraocular muscle control in LD children by observing eye tracking. She considered the smoothness of eye tracking to be an important indicator of overall central nervous system (CNS) integration and also cerebral interhemispheric communication. In a 1977 study, Ayres (3) identified LD children who had abnormally increased or decreased post-torsional nystagmus. She demonstrated that differences in response
to sensory integrative therapy could be correlated with the duration of nystagmus.

Ottenbacher and Short (4) supported Ayres’ findings in a study of 43 LD children, who were categorized according to their pretherapeutic durations of postrotary nystagmus. Children with initial decreased nystagmic functioning responded to therapy with increased duration, whereas children with initial prolonged nystagmus demonstrated decreases. The effects were greater after relatively long periods of therapy. Thus, the researchers concluded that nystagmic responses of LD children were of clinical importance in treatment.

Frank and Levinson (5) randomly selected 30 of 115 dyslexic children for ear, nose, and throat examinations, audiological examinations, and electroneystagmography. Twenty-six of the children had abnormal or positive findings of the vestibular apparatus, which included spontaneous nystagmus and also dysmetric ocular pursuit. The researchers theorized that in the presence of cerebellovestibular dysfunction and subclinical nystagmus, ocular fixation and sequential scanning of words and letters were disturbed.

Conners and Delamater (6) examined visual-motor tracking skills of 14 hyperkinetic children on a task that required controlling a moving spot of light with a joy stick. The children performed more poorly than did the comparison groups of normal controls and psychiatric subjects. They were also more susceptible to increased stress in the tasks, but their difficulty was reduced by practice, age, and stimulant medication. The researchers proposed that hyperactive children are not deficient in visual motor control per se but have difficulty with a task that requires processing high loads of information.

Ocular Abilities in the Cerebral Palsied

Abercrombie (7) discussed the importance of eye movements in the development of visual perceptual skills and in interpersonal communication in CP children. He also noted that pursuit eye movements of CP children were characterized by irregular head or eye movements, squint (strabismus), unsteady fixation, and/or inattentiveness. In 1963, Abercrombie and others (8) recorded the eye pursuit and saccadic movements of normal, physically handicapped, and CP children (5 to 16 years old) using electro-oculography. Pursuit in horizontal and vertical directions were analyzed. Cerebral-palsied children performed more poorly on all the measures, and performance in all three groups was related to both chronological and mental age.

Ocular Abilities in the Mentally Retarded

The relationship between the visual motor, visual memory, and reading abilities of MR persons was explored by Song and Song (9). They suggested that reading achievement in this population was related more to the population’s ability to remember what is perceived than to the perceptual ability itself.

Horgan (10) used an electronic rotary pursuit task with supplementary visual, auditory, or tactile feedback with 119 mildly retarded subjects. In general, supplementary sensory feedback associated with correct response behavior facilitated learning.

In summary, the few studies that examined ocular pursuit abilities of LD, CP, and MR children found deficiencies in all three of the diagnostic groups. Most investigators studied the relationship between some aspect of ocular ability or pursuit and specific learning task, behavior, or response to therapy.

Methodology

The sample consisted of 230 children (140 boys, 90 girls), 3 to 10 years of age. These children were located in the 10 states where the trained testers worked. The following operational definitions were used to classify subjects into one of the three diagnostic groups: MR denoted a child who had a recorded intelligence quotient (IQ) between 36 and 86 and a recorded diagnosis of educable/trainable mental retardation or mild/moderate mental retardation; CP denoted a child determined by a physician to have spastic, athetoid, or rigidity type of cerebral palsy as a primary diagnosis and who had an IQ ability above 70; LD denoted a child who had learning disabilities as a primary diagnosis (designated through an interdisciplinary staffing team consensus professional with or by a PhD or a physician). Furthermore, all subjects had to be able to understand test directions and could not be legally blind.

The Ocular Pursuit Test was used to measure ocular tracking abilities (1). Items (scored on a 3, 2, 1, 0 scale, according to preset criteria) tested the areas of slow pursuit in vertical, horizontal, diagonal, and circular directions; quick localization (a type of saccadic movement); and convergence. The following five aspects (behaviors) of eye pursuit were measured: a) smoothness of pursuits in general, b) smoothness
across midline, c) bilateral use of the eyes, d) extraneous head movements, and e) range.

Correlational data were obtained in the following five categories: a) mental age, as determined by IQ scores; b) educational data, as measured by the Wide Range Achievement Test (WRAT) (11) or Peabody Individual Achievement Test (PIAT) (12); c) visual perception data, as measured by the Developmental Test of Visual Motor Integration (13), visual perception tests of the Southern California Sensory Integration Tests (SCSIT) (14), Purdue Perceptual Motor Survey (15), and the Illinois Test of Psycholinguistic Abilities (ITPA) (16); d) vestibular information, as measured by the Southern California Postrotary Nystagmus Test (17), and e) postural responses (presence or absence of asymmetrical tonic neck reflex (ATNR) in supine or quadruped positions, standing balance with eyes open and closed).

Sixteen occupational therapists from ten states who were part of a group of 20 trained in a two-day workshop, participated as testers. One tester did not achieve adequate interrater reliability, but with her scores removed, the reliability coefficients (standardized alpha) ranged from .73 to .97 for four behaviors of the test and for total scores. One behavior, bilateral use of the eyes, had insufficient variance to obtain reliability coefficients. Besides administering the Ocular Pursuit Test to each subject, the testers obtained as much requested correlational data as possible from patient records and other sources. In general, subjects were children who were readily available to the therapists because they were current occupational therapy patients. No children were being treated for visual or ocular pursuit problems.

Means, standard deviations, and standard errors of measurement were determined for boys and girls at six-month intervals. Because of insufficient numbers in some cells, these data were then collapsed to one-year intervals in each diagnostic category for comparison to the normal sample. Age, diagnostic category, and behaviors were intercorrelated. Analyses of variance between diagnoses on each behavior were computed. Correlations between the total ocular pursuit scores along with individual behaviors were made with IQ, the Beery test, the SCSIT visual perception tests, postrotary nystagmus, ATNR responses, and standing balance scores. Correlations could not be made with school achievement measures because few of the subjects had been given the WRAT or PIAT. Neither the Purdue test nor the ITPA were used in correlation for the same reasons. A variety of educational and perceptual evaluations were reported, but no instruments were used consistently enough to allow analysis.

From the 272 protocols received, we determined that all children were testable. However, 15 protocols were rejected, because of incorrect or missing data. Two additional CP subjects were dropped because they totally determined an age cell that was extremely different from the rest of the data. Finally, the subjects who did not achieve adequate interrater reliability were dropped. Therefore, the final sample consisted of 230 subjects—54 MR, 45 CP, and 131 LD children (see Table 1).

### Results

#### Total Score Comparisons

Unlike the normative group (1), all three handicapped groups had total scores that covered a very wide range from 22 to 198. The mean total score for each diagnosis at each age level was at least one standard deviation (1 SD) below the mean for the normative group, except for those a) 3 years old, where all three handicapped groups fell within 1 SD of the mean of the normative group, and b) 5 years old, where the LD group was within 1 SD of the normative mean (see Table 1). Also, the LD group, unlike the normative group (1) that showed a definite age progression of total scores and a tendency for the curve to flatten out at the older ages, showed only a linear age progression, the other two groups (MR and CP) showed no tendency to improve with age. In fact, the CP group tended to show a downward trend (see Figure 1).

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Table 1: Total Means, Standard Deviations, and Sample Size by Age and Diagnosis (N = 230)

<table>
<thead>
<tr>
<th>Age, yr</th>
<th>Mentally Retarded</th>
<th>Cerebral Palsied</th>
<th>Learning Disabled</th>
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<td></td>
<td>n</td>
<td>Mean</td>
<td>SD</td>
</tr>
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<tr>
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</tr>
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</tr>
<tr>
<td>10</td>
<td>6</td>
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</tr>
</tbody>
</table>

SD, standard deviation.
groups had neither an age progression nor a component of linearity to the distribution of scores (see Figure 3).

Bilateral use of eyes. The graph for bilateral use of eyes was almost flat in the normative study, and many of the children achieved perfect scores. However, in our study, there was an age progression (or perhaps "regression," because the slope was negative) ($df = 7, F = 2.869, p < .016$) for the CP group. It was also significantly linear ($F = 8.67, p < .005$). The MR and LD groups showed no age progression or linearity (see Figure 4).

Extraneous Head Movements. Eye movement separated from head movements had an earlier linear and later quadratic trend in the normative group (1). In this study, the LD groups showed significant age trend ($df = 7, F = 10.084, p < .0000$) and linearity ($F = 66.592, p < .0000$), but neither the CP or MR groups showed anything similar (see Figure 5).

Range of pursuit. In the normative study (1), the ability to follow through the range also showed an earlier linear and later quadratic trend, although it was less pronounced than for head movements. In our study, however, there was no age trend for any of the groups and only the LD group showed a tendency towards linear-

Behavioral Comparisons

The five behaviors (smoothness in general, midline crossing, bilateral use of eyes, extraneous eye movements, and range of movement) were examined for age-related progression.

Smoothness in general. Smoothness, in the normative study (1), showed a linear, age-related progression. However, in this study, age-related improvement and linearity were not significant, except for the MR group ($F = 3.583, p < .06$) (see Figure 2).

Midline crossing. In the normative group (1), midline not only showed a linear age progression in the earlier age range but also showed a significant quadratic component in the older age range, which indicates a tendency to level off. In the current sample, the LD group showed an age-related progression ($df = 7, F = 2.072, p < .05$) that was linear ($F = 5.685, p < .02$) in nature, but it did not flatten out. The MR and CP
Directional Comparisons

No developmental patterns were discerned for the data in the normative study (1). However, in our study, some interesting trends were noted, the greatest being the tendency, in all directional comparisons, for the three groups to score similarly at the three-year age level but to become disparate at the older age levels.

The curves representing the ability to move left and right (including horizontal, diagonal, and beginning movements of circular directions) were similar. The LD group evidenced a linear improvement, but neither of the other two groups showed the same trend.

In the horizontal direction, the LD children showed a gradual improvement with age; both the MR and CP groups remained essentially the same or, in the case of the CP children, showed slight negativity. In the vertical direction, the MR and LD groups showed somewhat similar curves, with little or no improvement noted. The CP group, on the other hand, became worse in the older age ranges. The LD children improved with age in their ability to follow in a diagonal direction, but neither the MR nor CP groups showed positive change. None of the groups showed appreciable change in the ability to follow circular movements. The ability to converge tended to remain stable in the LD group and became slightly worse in the other two groups.

Correlational Data

No analyses were made of scholastic ability because there were not enough subjects with any comparable scholastic scores. Also insufficient data were collected on the subparts of the Purdue Perceptual Motor Survey (15) and the Illinois Test of Psycholinguistic Abilities (16) to allow analysis of those ability areas.

Postrotary nystagmus. Using only those subjects for which standardized scores could be reasonably used, there were no significant correlations within the CP group and very few in the MR and LD groups. None of the correlations accounted for more than 25% of the variance between the particular variables.

Space visualization. Both raw scores and standard scores were computed, but only correlations using standard scores are reported here. The correlations with most visual pursuit functions in the CP group ranged from $r = .53$ to $r = .71$. The LD group showed significant correlations with all ocular pursuit behaviors except bilateral use of eyes and quick localization. There were no significant correlations in the MR group.

Position in space. Again, using standard score comparisons, the
CP group had some high correlations \( (r = .52 \text{ to } .65) \), but there were very few significant correlations in the LD group and only one significant correlation in the MR group.

**Figure ground.** In this area, there were very few significant correlations within the LD group, only one significant correlation \( (r = .52) \) in the MR group, and no significant correlations in the CP group.

**Beery raw score.** All three groups showed one or two significant correlations, but only two accounted for very much of the variance between the respective variables. These were with midline in the CP group \( (r = .61) \) and range in the MR group \( (r = .46) \).

**Asymmetrical tonic neck reflex.** Although the reflex was tested in both the supine and quadrupedal positions, only the quadrupedal position yielded useful information. There were several significant correlations (particularly with midline, bilateral use of eyes, and head movement), but only in two instances was more than 23% of the variance explained. Interestingly, almost no overlap existed between the items that correlated within the MR group and those that correlated in the CP group.

**Standing balance.** Both standard scores and raw scores were included in the correlation matrix. In general, standing balance with eyes open showed more correlations with ocular pursuit abilities than did standing balance with the eyes closed. The correlations that were significant for the MR group in the eyes-open condition were, again, usually not significant for the CP group and vice versa. The LD group demonstrated significant correlations with nearly every behavioral measure (except bilateral use of eyes and quick localization), but only two of those correlations accounted for more than 25% of the variance shared by the variables represented.

**Discussion**

There were sufficient numbers of children in each cell of the LD group to bolster confidence in the results obtained with that group. Although the sample was small, the MR group seemed homogeneous enough to allow a reasonable amount of confidence in the representativeness of those scores also. The small sample of CPs, coupled with the wide variance found in many of the scores, dictates caution in interpreting results obtained for the CP group; they should be considered exploratory.

Nevertheless, the following observations can be made. First, the Ocular Pursuits Test is usable for three categories of handicapped children. Second, handicapped children showed different results from normative children in a number of ways, which may be significant. Third, there may be impor-
tant differences between the responses of different diagnostic groups. Specific comments related to the above observations follow.

Trends and Abilities

Age trends. In the current study, the CP and MR groups showed little tendency to improve with age. In fact, the CP group worsened in some behaviors. This may be because the subjects were children who were being seen in occupational therapy programs. The more severely impaired children would be expected to remain in treatment programs at older ages and therefore would bias the results. In contrast, a number of the LD children were not in occupational therapy treatment programs and so may have been more representative of the LD population as a whole. The LD group showed trends more nearly like those of the normative group, except they did not show a tendency to "ceiling out" in any of the behaviors. However, this study does not determine whether this represents an immaturity that would correct itself with age or a relatively lowered ability at all ages.

Directional differences. No patterns were discernible in the data of the normative group; however, the handicapped groups did show differences, both with age (in some instances) and in the patterns that each group displayed. Further studies are needed to ascertain the diagnostic or predictive value of the directional designations. At present, however, it seems worthwhile to continue to measure separately smooth pursuit behavior in various directions.

Other ocular abilities. Because the correlations between postrotary nystagmus and smooth pursuit seem limited, it might be assumed that the two functions tap different parts of the visual system, and therefore both should be included in testing. It could be hypothesized that the voluntary component and need for constant monitoring, along with the lack of need for memory, might account for the correlations with the space visualization and lesser correlations with position in space. However, the small correlation with figure ground remains unexplained.

Postural abilities. This study supports the expectation that postural abilities correlate with visual pursuit abilities and serves to differentiate between the ability to stand when being able to monitor with eyes versus the need to rely on proprioception (balance with eyes closed). More interesting, however, the CP group and MR group were quite different in their patterns of correlations. Further work might be directed toward the part that attention, site of pathology, time, and repetition might play in differences seen.

Suggestions for Future Research

The CP data could be strengthened by expanding the sample size, enabling differentiation between athetoid and spastic types of CP, and ensuring that the information is more representative. The entire study could be improved by providing the one area of information that was considered to be of prime importance both for predictive validity and for practical application of the procedure: school performance. Perhaps this could be done by choosing one instrument to administer to all the subjects or by using instruments that yield standard scores so that they could be compared. It is important to undertake a study (with both nonhandicapped and handicapped children) that would allow correlation between ocular pursuit abilities and academic performance.

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Correlational matrices can be requested from W. Mayberry, Occupational Therapy Dept., Colorado State Univ., Ft. Collins, CO 80523.

REFERENCES