The Relationship Between Form and Space Perception, Constructional Abilities, and Clumsiness in Children

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Key Words: learning disorders • sensory integration • visual perception

The Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989) were administered to 21 children with learning disabilities and 18 children without learning disabilities, aged 5 to 8 years. The children with learning disabilities were divided into two groups, clumsy and nonclumsy, on the basis of their scores on the Test of Motor Impairment (Stott, Moyes, & Henderson, 1984). It was hypothesized that the learning-disabled children in the clumsy group would score significantly lower than the learning-disabled children in the nonclumsy group on the six SIPT subtests that measure form and space perception and visual construction and that the nonclumsy learning-disabled children, in turn, would score significantly lower than the non-learning-disabled children. It was further hypothesized that there would be a significant correlation between the degree of clumsiness and the degree of visual-perceptual and constructional deficits. An analysis of the data indicated that both groups of learning-disabled children scored lower than the non-learning-disabled children on four of the six SIPT subtests. The clumsy and nonclumsy children with learning disabilities, however, differed from each other on only two subtests. The degree of clumsiness correlated significantly with three of the six subtests. The results are discussed in terms of variations in perceptual and motor skills related to subtypes of learning disabilities.

Controversy exists in the literature regarding whether or not children with learning disabilities exhibit visual-perceptual deficits. Some researchers have identified visual-perceptual deficits as concomitants of learning disabilities (Bush & Waugh, 1982; Savich, 1984), whereas other researchers have found no difference between children without learning disabilities and children with learning disabilities on tests of visual perception (Kershner, 1979; O’Donnell, 1985). Still others have suggested that visual-perceptual abilities are an area of strength for persons with learning disabilities (Bannatyne, 1978; Geschwind & Galaburda, 1985; Gordon, 1980).

One explanation for these discrepant findings is that children with learning disabilities do not form a homogeneous group. Several researchers (Bannatyne, 1978; Fletcher, 1985; Hartlage & Telzrow, 1983; Rourke, 1985; Rourke & Strang, 1983), using a variety of measures, have found different patterns of strengths and weaknesses in children with learning disabilities. Although average abilities in visual perception are common, there is a group of children with learning disabilities in which the outstanding deficit is in the area of visual perception (Strang & Rourke, 1983).

Another reason for the discrepancy is that visual perception is not unitary and cannot be assessed...
through one measure. Visual perception involves a number of skills, including form perception, spatial relations, and constructional abilities. A person may be deficient in one area of visual perception but show average ability in another area (McGee, 1979). Further, some of the tests used to make inferences about visual perception require drawing. Although tests that require the copying of two-dimensional figures are considered measures of visual constructional abilities (Lezak, 1983), performance may also be affected by poor fine motor skills.

Another frequently identified characteristic of children with learning disabilities is difficulty in motor coordination (Ayres, 1979, 1989; Brenner, Gilman, Zangwill, & Farell, 1967; Cermak, 1985; Cermak & Headerson, 1990; Gubbay, 1978; Henderson & Hall, 1982; Kephart, 1960; Levine, 1987; Orton, 1937). The terms clumsy and developmental dyspraxia have been used to identify children who have difficulty with skilled, purposive movement in the absence of general intellectual impairment, limited physical strength, or gross sensory defects (Ayres, 1972, 1985; Gubbay, 1985; Hulme, Biggerstaff, Moran, & McKinley, 1982).

Some researchers who have studied clumsy children have identified deficits in visual-perceptual and visuomotor performance (Gubbay, 1985; Gubbay, Ellis, Walton, & Court, 1965; Hulme & Lord, 1986; Hulme, Smart, & Moran, 1982; O'Brien, Cermak, & Murray, 1988; Waiton, Ellis, & Court, 1963). In an earlier analysis, we (O'Brien et al., 1988) assessed non-learning-disabled and learning-disabled children on a series of tests of visual perception and visual construction, including the Raven Progressive Matrices (Raven, 1960), the Developmental Test of Visual-Motor Integration (Beery, 1980), the Rey-Osterrieth Complex Figure (Waber & Holmes, 1985), the Primary Visual Motor Test (Haworth, 1970), and the Block Design subtest of the Wechsler Intelligence Scale for Children—Revised (Wechsler, 1974). We further classified the children with learning disabilities as clumsy or nonclumsy, on the basis of their scores on the Test of Motor Impairment (Scott, Moyes, & Henderson, 1984). The non-learning-disabled children had significantly higher scores than the clumsy learning-disabled children on all measures of visual perception and visual construction. The differences on these tests between the control group and the nonclumsy learning-disabled children and between the two groups of learning-disabled children were not significant. Four of the five tests were found to correlate significantly with the score on the Test of Motor Impairment.

In a pilot factor-analytic study using preliminary versions of the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989), Ayres, Mailloux, and Wendler (1987) found that tests of visual perception loaded with measures of praxis and hypothesized a common conceptual system underlying both visual perception and motor planning. More recently, through factor analysis of the normative data from the SIPT, Ayres (1989) defined a group of tests that measure an ability that she labeled visuoparaxis. This group of tests includes tests of form and space perception as well as tests of visual construction (constructional praxis) and visuomotor control. A cluster analysis indicated that children with low scores on these tests also tended to have low scores on other praxis tests, although factor analyses suggested two separate factors of visuoparaxis and somatoparaxis (Ayres, 1989).

Because occupational therapists frequently treat children with learning disabilities both for clumsiness and for visual-perceptual problems, it is important to ascertain to what extent these two areas are related. The purpose of the present study was to assess the relationship between clumsiness and both visual perception and visual construction, as measured by subtests of the SIPT, in children with learning disabilities. We hypothesized that clumsy children with learning disabilities would score significantly lower on tests of form and space perception and visual construction than nonclumsy children with learning disabilities and that both groups of children with learning disabilities would score significantly lower than the control group of non-learning-disabled children. We further hypothesized that there would be a significant correlation between the degree of clumsiness and the degree of visual-perceptual and constructional deficits in children with learning disabilities.

Method

Subjects

Thirty-nine children participated in this study: 21 of these children had learning disabilities (age range: 5 years 4 months to 8 years 7 months) and 18 (the control group) did not have learning disabilities (age range: 5 years 1 month to 8 years 10 months). The means and standard deviations for age and test scores for each group are presented in Table 1.

The children participating in the study attended public and private schools within the greater Boston area. Each child in the control group was in an age-appropriate grade and had no special education requirements and no history of receiving remedial help. Each child in the learning-disabled group had a diagnosed learning disability and was receiving special education for his or her specific disability. The children with learning disabilities were divided into two groups, clumsy and nonclumsy, on the basis of their scores on the Test of Motor Impairment. With this criterion, 12 of the children in the learning-disabled
Table 1
Ages and Test Scores of Children With and Without Learning Disabilities (N = 39)

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Age (in months)</th>
<th>Test of Motor Impairment Score a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n = 18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Disabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonclumsy (n = 9)</td>
<td></td>
<td></td>
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<tr>
<td>Clumsy (n = 12)</td>
<td></td>
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</table>

82.8 14.9 1.94 1.52
82.4 13.7 2.28 1.12
80.7 11.2 8.04 2.31

a (Stott, Moyes, & Henderson, 1984).

group were classified as clumsy and 9 as nonclumsy. It should be noted that 3 subjects in the control group scored in the mildly clumsy range and the rest scored in the nonclumsy range. There was no difference in age among the three groups [F(2, 36) < 1, p = .91].

Procedure
Each child was seen individually for three sessions in his or her home or at the Boston University Occupational Therapy Clinic. In the first two sessions, the first and second authors administered the Sensory Integration and Praxis Tests according to standardized instructions. The SIPT subtests considered relevant to the present study were the form and space subtests (Space Visualization, Figure-Ground Perception, Motor Accuracy, Manual Form Perception) and the constructional subtests (Design Copying, Constructional Praxis).

In the third session, the third author administered the Test of Motor Impairment, which measures the degree of motor impairment. In this test, the child is given a series of eight age-appropriate tasks that evaluate manual dexterity, static balance, dynamic balance, and ball skills. The scores are interpreted as follows: 0 to 3.5, no impairment; 4.0 to 5.5, mild to moderate impairment; and above 6.0, definite impairment. For the purposes of this study, scores of 0 to 3.5 were considered normal and scores of 4.0 and above were considered clumsy. The test was administered in the standardized manner according to the directions in the test manual (Stott et al., 1984).

Results
To test the hypothesis that the clumsy learning-disabled children would score significantly more poorly than the nonclumsy learning-disabled children on the form and space and constructional subtests of the SIPT and that both learning-disabled groups would score significantly more poorly than the control group, one-way between-group analyses of variance (ANOVAs) on each dependent measure were performed (see Table 2). Between-group differences did exist on each of the form and space and constructional tests. Newman-Keuls multiple comparisons (Ferguson, 1981) were performed to find the difference (see Table 3). Both of the learning disabled groups scored

Table 2
Children's Test Scores on the SIPT (N = 39)

<table>
<thead>
<tr>
<th>SIPT Measure</th>
<th>Control Group (n = 18)</th>
<th>Learning-Disabled Group</th>
<th></th>
<th></th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nonclumsy (n = 9)</td>
<td>Clumsy (n = 12)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Form and Space Tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Visualization</td>
<td></td>
<td>0.39</td>
<td>0.73</td>
<td>-0.53</td>
<td>0.65</td>
<td>0.85</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>0.69</td>
<td>1.15</td>
<td>-0.16</td>
<td>1.35</td>
<td>0.98</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>0.00</td>
<td>0.48</td>
<td>-0.66</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td>Figure-Ground Perception</td>
<td></td>
<td>0.30</td>
<td>0.85</td>
<td>-1.32</td>
<td>1.22</td>
<td>0.72</td>
</tr>
<tr>
<td>Motor Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>0.48</td>
<td>1.10</td>
<td>-0.64</td>
<td>0.98</td>
<td>0.91</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>0.43</td>
<td>0.45</td>
<td>-0.82</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>Manual Form Perception</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Copying</td>
<td></td>
<td>0.48</td>
<td>1.10</td>
<td>-0.64</td>
<td>0.98</td>
<td>0.91</td>
</tr>
<tr>
<td>SD</td>
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<td>0.45</td>
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<td>0.96</td>
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<tr>
<td>Constructional Tests</td>
<td></td>
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</table>
| Note. SIPT = Sensory Integration and Praxis Tests (Ayres, 1989).
more poorly than the control group on four of the six SIPT subtests. Within the learning-disabled group, however, the clumsy and nonclumsy groups differed from each other only on the Motor Accuracy and Design Copying subtests.

To test the hypothesis that there would be a significant correlation between the degree of clumsiness and performance on the form and space and constructional praxis tests of the SIPT in children with learning disabilities, we computed Pearson correlation coefficients for the learning disabled group as a whole. The correlations were significant on three of the six subtests: Space Visualization ($-0.47$, $p < 0.05$), Motor Accuracy ($-0.50$, $p < 0.01$), and Design Copying ($-0.50$, $p < 0.05$).

**Discussion**

The hypothesis that the clumsy learning-disabled children would score significantly lower than the nonclumsy learning-disabled children on tests of form and space and visual construction and that both groups would score significantly lower than the non-learning-disabled group was partially supported. A comparison of the performance of the clumsy and nonclumsy learning disabled groups indicated that the clumsy learning-disabled children performed significantly more poorly than the nonclumsy learning-disabled children on two of the six SIPT measures: Motor Accuracy and Design Copying. Interestingly, Ayres (1989) found that “Motor Accuracy was the best single measure in the SIPT for discriminating between normal and dysfunctional children” (p. 156). She believed that the Motor Accuracy subtest was an indicator of overall sensory integration in younger children (aged 4 to 6 years). The Design Copying subtest was described by Ayres (1989) as “the best single indicator of visuopractic ability” (p. 158) and was thought to be a better discriminator in older children. These two subtests, which in the present study best discriminated between the clumsy and nonclumsy learning-disabled children, loaded most highly on the visuopraxis factor in the factor analysis of SIPT scores of 125 children with learning or sensory integrative deficits (Ayres, 1989). The Motor Accuracy and Design Copying subtests, therefore, may be more sensitive to differences within certain subgroups of learning-disabled children. Alternatively, one must consider the possibility that clumsy children are poorer in all aspects of motor execution, including the fine motor skills measured by the Motor Accuracy and Design Copying subtests. In our previous study (O'Brien et al., 1988), however, we found no differences between clumsy and nonclumsy learning-disabled children, even on the Rey-Osterrieth Complex Figure and the Primary Visual Motor Test, both of which require some degree of motor execution skill.

An examination of the learning-disabled and control groups indicated that both of the learning-disabled groups performed more poorly than the control group on four of the six SIPT subtests. The only subtest that did not discriminate between any of the groups was Figure-Ground Perception. Further, the only significant difference on the Manual Form Perception subtest was between the control group and the nonclumsy learning-disabled group. Although Ayres has used the term form and space perception to describe a group of subtests that includes Space Visualization, Figure-Ground Perception, Manual Form Perception, and Motor Accuracy, the psychological literature indicates that visual (and haptic) perception consists of several aspects, including form perception and space perception, and that these aspects may require different abilities (Lezak, 1983). The Figure-Ground Perception subtest assesses perception of form, as does the Manual Form Perception subtest. Tests of constructional abilities (i.e., Design Copying and Constructional Praxis) are considered measures of spatial abilities. Space Visualization involves both form perception (in the earlier items) and space perception (in the later items involving mental rotation). Ayres (1989) indicated that the Motor Accuracy subtest requires control of movement of the hand in space. Children with learning disabilities, therefore, may be poorer in the spatial aspects of visual perception.
The findings of this study indicate that learning-disabled children perform more poorly than non-learning-disabled children on some but not all tests of visual perception and that only some perceptual tests discriminate between clumsy and nonclumsy learning-disabled children. For example, Space Visualization and Constructional Praxis differentiated between the learning-disabled versus non-learning-disabled children but not between the clumsy and nonclumsy learning-disabled children. The results of this study can be interpreted in two ways. One can merely state that clumsy children may emerge primarily when motor precision is required.

The relationship between clumsiness and perception and visual construction in children with learning disabilities was also partially supported. Motor Accuracy, Design Copying, and Space Visualization all showed significant correlations with the Test of Motor Impairment. The lack of significant correlation between the Test of Motor Impairment and the SIPT subtests of Figure-Ground Perception and Manual Form Perception may indicate that these subtests make greater demands on form perception, whereas the Motor Accuracy, Design Copying, and Space Visualization subtests more closely tap spatial abilities. If this is so, however, it is unclear why the correlation between the Test of Motor Impairment and the SIPT subtest of Constructional Praxis is so low. Constructional Praxis involves aspects of both visual perception and praxis. Problems arise, however, in the equating of clumsiness, as measured by the Test of Motor Impairment, with dyspraxia, as measured by Constructional Praxis and other subtests of the SIPT. Although the term praxis is often equated with motor planning, the emphasis should be on planning rather than on motor, because praxis includes a conceptual or ideational component. The Constructional Praxis subtest involves complex ideation as well as visual perception. Performance on the Test of Motor Impairment may not be sensitive in differentiating actual practical or planning deficits from other factors, such as coordination, balance, and neuromotor dysfunction. Although Design Copying is often considered a measure of constructional praxis as well, clumsy children may have more difficulty with the fine motor component of this test. Several of the SIPT subtests designed to assess developmental dyspraxia are similar to the type of assessments used with adults. The use of these tests may allow one to differentiate problems in planning from problems in execution.

Summary

The results of this study indicate that clumsiness appears to be related to some aspects of visual-perceptual ability. One should not assume, however, that because a child is poorly coordinated he or she will necessarily have problems in visual perception. Neither motor skill nor visual perception is a unitary ability, and certain aspects of visual perception may more closely relate to coordination and fine motor performance than others. The preliminary results indicate that the spatial aspects may be more important than form perception. Similarly, motor coordination and praxis should not be viewed as synonymous. The relationship between clumsiness, praxis, and visual-perceptual deficits needs further study to more fully define the nature of the relationship. It is important for therapists to keep in mind that correlation does not mean causation. Because a child experiences problems in both motor coordination and visual perception, one cannot assume that the visual-perceptual problems underlie the clumsiness and that the remediation of perceptual deficits will automatically improve coordination. Instead, coordination and perception may both reflect the integration of the central nervous system.

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References


