Crossing the Body Midline in Learning-Disabled and Normal Children

(hand dominance, laterality, sensory integration)

Sharon A. Cermak

The SVCU scores of 179 learning-disabled children, ages 5 to 8, were compared with the scores of 120 normal children, using both the actual Space Visualization Contralateral Use (SVCU) score, and the SVCU category of "normal, suspect, or possible deficit," in order to evaluate whether using guidelines to interpret the SVCU as a function of age enabled differentiation between normal children and children with learning disabilities. The SVCU measure clearly differentiated between groups at the younger ages, although the difference was not as clear for the older age groups. It was suggested that the SVCU score be used in conjunction with other observations of midline crossing. Alternative interpretations of the SVCU score are discussed.

Sharon A. Cermak, Ed.D., OTR, FAOTA, is Associate Professor of Occupational Therapy, Sargent College, Boston University, Boston, Massachusetts 02215, and is a faculty member, Center for the Study of Sensory Integrative Dysfunction, Pasadena, California 91102-1065.

A. Jean Ayres, Ph.D., OTR, FAOTA, is Adjunct Associate Professor of Occupational Therapy, University of Southern California, Downey, California; a board member, Center for the study of Sensory Integrative Dysfunction, Pasadena, California 91102-1065; and in private practice, Torrance, California

Midline crossing, that is, the ability to use one hand in the contralateral side of space, has been described in terms of the development of body scheme, spatial orientation, laterality, directional, and bilateral integration (1-4). It has also been stated that the development of the ability to guide the hand to targets in front of the midline is an important step in the emergence of bilateral coordination and complementarity; that is, the ability to manipulate objects with both hands together. The ability to reach across the midline expands the child's capabilities in that it enables the child to grasp objects in contralateral space, even when the ipsilateral hand is occupied (5). Ayres(6) has emphasized the impor-
tance of crossing the midline for the development of hand preference for skilled manipulation.

A tendency to avoid crossing the body midline has been observed in a number of different clinical populations (7, 8) including children with learning disabilities (1, 3, 9). To document this clinical observation more fully, Ayres (10) developed the Crossing the Midline test of the Southern California Sensory Integration Tests. The test has been found to successfully identify children with moderate to severe dysfunction in midline crossing. However, Ayres (6) noted that children with mild dysfunction who tended to avoid crossing the midline spontaneously, did cross when faced with the necessity—as in the testing situation where the actual task was to imitate a crossed response. Thus, another measure was developed to observe midline crossing in spontaneous situations. The second method involved observing whether or not the child used the ipsilateral or contralateral hand to select forms during the Space Visualization Test of the Southern California Sensory Integration Tests (SCSIT). The measure, called the Space Visualization Contralateral Use score (SVCU), is the ratio between ipsilateral responses and contralateral responses subtracted from 30 (6).

Since 1976, therapists have been using the SVCU to assess the child’s hand usage and ability to cross the midline. Original guidelines were based on performance of learning-disabled children (6), and were modified by Cermak, Quintero, and Cohen (11) based on the data from 150 normal children, ages 4 to 8 years. A preliminary reinterpretation of the SVCU as a function of age was suggested. These guidelines were based on normal children and needed to be validated with a learning-disabled sample. The purpose of the present research was to evaluate whether using these guidelines did discriminate between normal children and children with learning disabilities.

### Method

**Subjects.** The normal subjects consisted of 120 children, half male and half female. There were 30 children in each of four age groups: 5, 6, 7, 8. Eighty to 90 percent of the children in each group preferred the right hand for writing or drawing. The sample is described more fully in an article by Cermak, et al. (11).

The learning-disabled (LD) subjects included 179 children, ages 5 through 8 years. A heterogeneous sample of LD children was obtained from three sources. Data for approximately 30 percent of the subjects were gathered by Ayres (6); approximately 15 percent of the data were gathered by Stilwell (9); the remainder were gathered by Cermak and colleagues. All children were identified by school personnel as being of normal intelligence (IQ ≥ 85) and of having no history of hard neurological signs, orthopedic problems, or primary emotional disturbances.

The older LD children (viz, older 6, 7, and 8 year olds) were diagnosed as learning disabled through the use of school diagnostic procedures (test measures included the Peabody Individual Achievement Tests, Wide Range Achievement Test, Carrow Test of Receptive and Expressive Language, Illinois Test for Psycholinguistic Abilities, etc.), and were receiving learning-disability services at the time of data collection. The younger LD children (5 year olds and younger 6 year olds) had either been diagnosed as learning disabled through the use of psychological testing and were attending special preschool or kindergarten classes for children with learning disabilities, or they were performing significantly more poorly than their peers in their classrooms, were considered "at risk" for learning disabilities by their classroom teachers, and had been referred for evaluation of their learning disabilities.

Some subjects had identified sensory integration dysfunction. Of these, some were receiving sensory integration procedures, whereas others had just been diagnosed and were therefore not receiving sensory integration procedures. Data on the

| Age | X Age  
<table>
<thead>
<tr>
<th>N</th>
<th>(Mo)</th>
<th>%R</th>
<th>%L</th>
<th>%M</th>
<th>%F</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>21</td>
<td>64</td>
<td>67</td>
<td>33</td>
<td>81</td>
</tr>
<tr>
<td>6</td>
<td>48</td>
<td>77</td>
<td>69</td>
<td>31</td>
<td>67</td>
</tr>
<tr>
<td>7</td>
<td>62</td>
<td>91</td>
<td>85</td>
<td>15</td>
<td>73</td>
</tr>
<tr>
<td>8</td>
<td>46</td>
<td>101</td>
<td>81</td>
<td>19</td>
<td>87</td>
</tr>
</tbody>
</table>

---

Table I

Characteristics of the Sample of Learning-Disabled Subjects Tested on the SCVU
degree and type of sensory integrative dysfunction were not available for the majority of these subjects. The numbers, age, writing hand, and sex distribution of the learning-disabled subjects are presented in Table 1.

There was an unequal number of subjects at each age with fewest subjects at the 5-year-old level, probably because a learning disability is not usually diagnosed until children are of school age. Because of the unequal number of subjects in each age group, data are presented in percentages.

When examining Writing Hand, there was no significant difference between age groups in the percentage of right when compared to left handers, Chi Square (df 3) = 6.20. There were certain handedness and sex distribution differences between the normal control and learning-disabled samples, since, for the normal controls, an equal number of boys and girls were recruited, whereas all possible learning-disabled children were tested. Generally, there was a higher percentage of left handers in the learning-disabled sample when compared to the children in the normal sample. Also, there were more boys than girls: approximately 2 to 4 boys per girl. These sample characteristics are consistent with the characteristics of the learning-disabled population (12).

Procedure. The children were individually administered the Space Visualization Test of the SCSIT according to the standardized procedure (10). During the test, the examiner recorded which hand the child used to select each choice. The number of ipsilateral responses and the number of contralateral responses were recorded by noting agreement between the hand used and the side on which a chosen block lay. If both hands were used to pick up the block, the response was not included in the scoring. The SVCU score was computed according to the standardized method (6). In addition, each child’s score was categorized as being in the possible deficit range, suspect range, or normal range, using the guidelines suggested by Cermak, et al. (11).

Results
Because the data for the learning-disabled children were gathered from three separate sources, the SVCU scores of the three sources were analyzed to determine whether performance across the three learning-disabled sources was equivalent. Since the composition of subjects from the three sources varied as a function of age, separate analyses were done for each age. Analysis of variance revealed no significant between-source difference at age 5, $F(1,19) = 0.41$, at age 6, $F(2,45) = 1.49$, at age 7, $F(2,59) = 0.43$, or at age 8, $F(1,46) = 0.71$. Thus, data were collapsed across the three sources.

Table 2 presents a comparison of the mean, standard deviation, and range of the SVCU scores for the normal and learning-disabled children at each age. A 2 (group) X 4 (age) analysis of variance revealed a significant group effect, $F(1,291) = 24.84$, $p < .001$, with learning-disabled children scoring lower than normal controls, and a significant age effect, $F(3,291) = 9.730$, $p < .001$, with younger children scoring lower than older children. There was also a group by age interaction, $F(3,291) = 3.78$, $p < .05$. Multiple comparisons revealed a significant between-group difference, with learning-disabled children scoring lower than normal controls, and a significant age effect, $F(3,291) = 9.730$, $p < .001$, with younger children scoring lower than older children. There was also a group by age interaction, $F(3,291) = 3.78$, $p < .05$. Multiple comparisons revealed a significant between-group difference, with learning-disabled subjects scoring more poorly than the normal subjects at ages 5 ($F = 8.03, p < .001$), 6 ($F = 3.92, p < .001$), and 8 ($F = 2.76, p < .01$), but not at age 7 ($F = 1.53, p = .21$).

<table>
<thead>
<tr>
<th>Age</th>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Normal</td>
<td>30</td>
<td>25.5</td>
<td>3.4</td>
<td>9 to 29</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>21</td>
<td>18.4</td>
<td>9.7</td>
<td>1 to 29</td>
</tr>
<tr>
<td>6</td>
<td>Normal</td>
<td>30</td>
<td>26.1</td>
<td>3.0</td>
<td>14 to 29</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>48</td>
<td>23.4</td>
<td>5.9</td>
<td>1 to 29</td>
</tr>
<tr>
<td>7</td>
<td>Normal</td>
<td>30</td>
<td>26.9</td>
<td>3.8</td>
<td>8 to 29</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>62</td>
<td>24.9</td>
<td>4.7</td>
<td>1 to 29</td>
</tr>
<tr>
<td>8</td>
<td>Normal</td>
<td>30</td>
<td>27.4</td>
<td>2.7</td>
<td>16 to 29</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>48</td>
<td>25.9</td>
<td>4.4</td>
<td>1 to 29</td>
</tr>
</tbody>
</table>
In order to analyze whether there was a significant difference between learning-disabled and normal subjects according to the suggested reinterpretation of the SVCU score, Chi Square analyses were performed on the number of children scoring within each of the three categories. Different “cut-offs,” as suggested by Cermak, et al. (11) (see Table 3), were used for the different age groups. Results are presented in Table 4 where the percentage of learning-disabled children in the Possible Deficit category progressively decreases with increasing age.

Discussion

Between-group analyses of the SVCU data, using raw SVCU scores and SVCU categories, yielded somewhat different findings. Both measures discriminated between groups at ages 5 and 6. Using the raw SVCU score, there was a significant difference between groups at age 8 but not at age 7. Analyses using the SVCU categories yielded a significant difference between groups at age 7 but not at age 8. Overall, it seems as though the measures clearly differentiate between groups at the younger ages, although the difference is not clear cut for the older age groups.

When using the SVCU categories, it appears that the suggested reinterpretation of the SVCU score discriminates between normal and learning-disabled children at the 5-, 6-, and 7-year-old ages, but does not discriminate between groups at age 8. Although, in the 8-year-old group, twice as many learning-disabled children scored in the deficit range than did the normal children (Table 4), the majority of LD children still scored within the normal range.

Since crossing the midline is a developmental skill, perhaps by age 8 many learning-disabled children have sufficiently matured so that the deficit may not be evident. Support for this hypothesis can be seen in Table 4 where the percentage of learning-disabled children in the Possible Deficit category progressively decreases with increasing age.

Another possibility is that some of the learning-disabled children may have received perceptual motor or sensory integrative procedures before the time of this testing and thus had improved in their ability to cross the midline. If this is so, it is more likely that the older children would have had therapy than the younger children. It is also possible that the 8-year-old learning-disabled children may not have been as severe a learning-disabled group as the younger children. For this reason, they may not have been identified and tested until they were older.

An alternative explanation concerns the sensitivity of the SVCU measure in differentiating children with mild impairments. In the Space Visualization Test, the child has only to cross the midline slightly in order to choose the block in the opposite side of space. If there is a trend in crossing the midline (as there is in the child’s drawing of a cross), such that, initially, each hand works on its own side of space without crossing, then the hand comes to midline, then crosses slightly, and finally crosses completely, it is possible that different placement of the blocks (or a test that demands further crossing) would yield different results. It may be that more stringent criteria are needed to detect deficits in midline crossing at the older ages. The possibility that some children may use lateral trunk flexion and thus select a “contralateral” block without ever having crossed the midline must also be considered.

A limitation of the study that might affect the generalizability of the results and confound interpretation is the heterogeneous nature of the sample of learning-disabled subjects. The data for the learning-disabled children were gathered from three separate sources and, although the legal definition of a diagnosed learning disability (or at risk for learning disability) was a criterion in all instances, there still may have been a variance created within the learning-disabled sample by possibly discrepant interpretive criteria. Although inspection of the sample characteristics and scores among the three samples (e.g., scores as they related to age) did not reveal any notable differences, nevertheless, there was a lack of a priori operational detail for subject selection.

Table 3

Preliminary Reinterpretation of the Space Visual Contralateral Use Score as a Function of Age

<table>
<thead>
<tr>
<th>Possible Deficit Range</th>
<th>Suspect Range</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Range</td>
<td>Range</td>
</tr>
<tr>
<td>5</td>
<td>1-21</td>
<td>22-24; 29</td>
</tr>
<tr>
<td>6</td>
<td>1-22</td>
<td>23-24; 29</td>
</tr>
<tr>
<td>7</td>
<td>1-23</td>
<td>24-25</td>
</tr>
<tr>
<td>8</td>
<td>1-23</td>
<td>24-26</td>
</tr>
</tbody>
</table>

In Table 3, the possible deficit range (1-21) is defined as that which can be fully accommodated by a hand crossing the midline. The suspect range (22-24; 29) is defined as that which can be accommodated by a hand crossing the midline slightly, but not crossing it completely. The normal range (25-28) is defined as that which can accommodate a hand crossing the midline with no difficulty. The table indicates that the possible deficit range is less at age 5, more likely that the older children would have had therapy than the younger children. It is also possible that the 8-year-old learning-disabled children may not have been as severe a learning-disabled group as the younger children. For this reason, they may not have been identified and tested until they were older.

An alternative explanation concerns the sensitivity of the SVCU measure in differentiating children with mild impairments. In the Space Visualization Test, the child has only to cross the midline slightly in order to choose the block in the opposite side of space. If there is a trend in crossing the midline (as there is in the child’s drawing of a cross), such that, initially, each hand works on its own side of space without crossing, then the hand comes to midline, then crosses slightly, and finally crosses completely, it is possible that different placement of the blocks (or a test that demands further crossing) would yield different results. It may be that more stringent criteria are needed to detect deficits in midline crossing at the older ages. The possibility that some children may use lateral trunk flexion and thus select a “contralateral” block without ever having crossed the midline must also be considered.

A limitation of the study that might affect the generalizability of the results and confound interpretation is the heterogeneous nature of the sample of learning-disabled subjects. The data for the learning-disabled children were gathered from three separate sources and, although the legal definition of a diagnosed learning disability (or at risk for learning disability) was a criterion in all instances, there still may have been a variance created within the learning-disabled sample by possibly discrepant interpretive criteria. Although inspection of the sample characteristics and scores among the three samples (e.g., scores as they related to age) did not reveal any notable differences, nevertheless, there was a lack of a priori operational detail for subject selection.
Summary and Conclusions

The proposed reinterpretation of the SVCU by using cut-off scores that varied as a function of the child's age did differentiate between learning-disabled and normal subjects in the 5-, 6-, and 7-year-old groups. However, there was no difference between groups at the 8-year-old level. A number of explanations were proposed. In addition, until data are gathered on the test-retest reliability of the SVCU, caution must be used in interpreting individual scores. As with other assessments of sensory integrative dysfunction, it is necessary to depend upon several observations, any one of which would not have much statistical weight, but, as a group, would seem meaningful enough to enable a therapist to make a judgment.

A variable that has not been addressed in this study but which needs to be considered is the interpretation of the SVCU score. The score has been interpreted as reflecting a tendency to avoid crossing the midline (11), and/or inadequate bilateral integration that results in a lack of established hand dominance (6). It could be speculated that, because the child avoids crossing the midline, he or she is "forced" to use each hand on its ipsilateral side and therefore is unable to develop a skilled hand. Alternately, it could be argued that, because the child has not developed a skilled hand, and each hand works equally well, it is easier to use each hand on its own side (viz, shorter distance to target) and therefore the child does not cross the midline. This latter explanation is more consistent with the hypothesis underlying vestibular and bilateral integration in which it is suggested that, since there is poor communication between the cerebral hemispheres, each cerebral hemisphere has tended to develop a capacity for direction of the contralateral hand (13). Thus the control for the two hands are more equal in quality than in the average person. Being equal, the nondominant hand is more apt to be used; the person does not make the inefficient response of using one hand in the contralateral side of space. This latter interpretation is consistent with the factor analytic studies of Ayres (6) in which performance on the SVCU was associated with the eye pursuit-contraction-postural response domain.

It may be that there are two different neural mechanisms: one that, when interrupted, results in avoidance of midline crossing; and the second, less an avoidance of crossing than an inclination to use the hands ipsilaterally because each works equally well. Ultimately, it may be important to ferret out this distinction because the treatment focus might be quite different depending on whether the midline crossing deficit interfered with the development of a skilled hand, or whether what appeared to be a crossing deficit was primarily caused by a lack of established hand preference.

Acknowledgment

Appreciation is extended to Janet Stilwell for sharing the SVCU data obtained as part of another study (9), and for her review of this manuscript.

REFERENCES

1. Ayres AJ: Sensory Integration and Learning Disorders, Los Angeles: Western Psychological Services, 1971