Developmental Age Trends in Crossing the Body Midline in Normal Children

The ability to cross the body midline was assessed in 150 normal children, ages 4 through 8, by observing hand usage during the Space Visualization Test of the Southern California Sensory Integration Tests. A Space Visualization Contralateral Use score (SVCU) was computed for each subject and was regarded as a measure of the tendency to spontaneously cross the body midline. This score is based on a ratio of ipsilateral (uncrossed) to contralateral (crossed) responses. The percentage of time a child used the preferred hand to pick up a block was also recorded. Results indicated that spontaneous midline crossing increased with age. Although the percent of preferred hand responses increased with age, there was enough variability at each age that there were no significant differences among age groups. Perceptual, motor, and psychosocial factors that could influence midline behavior were discussed. Based on the data from this study, a preliminary reinterpretation of the SVCU score is offered.

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The body midline, or the central longitudinal axis, is described as an extension of the mid-sagittal plane of the face that essentially divides the body into two equal halves (1). Man has sensory apparatus—ears, eyes, arms and legs—symmetrically arranged around the body midline. Crossing the midline involves the ability to use one body part, such as an arm, in the contralateral side of space.

**Importance of the Body Midline in Normal Development**

The role of the body midline has been cited in the development of body scheme, spatial orientation, bilateral integration, laterality, and directionality (1-6). In addition, it has been suggested that midline behavior has a significant role in the emerging sense of self and ego skills (7).

Goody and Reinhold (3) postulated that people orient themselves in a manner directly related to their symmetrical structure and that all movements in space are likewise related to this symmetry around the midline. Gross movements or postures of the body such as standing upright, walking, turning, sitting, or lying involve both halves of the body, moving parallel to, in the opposite direction from, or in a rotary manner about the central axis.

Kephart (4) stated that movement about the midline contributes to the development of body scheme necessary for interpretations of outside relationships. Luria (5) stated that spatial orientation consists of differentiating objects in external space that lie on the right from those that lie on the left. Right and left, above and below, in front of and behind may be perceived by means of basic geometric coordinates (5). The reference point, or the ordinate, for the coordinates of space is the line of gravity through the body or the body midline (4).

One element of body scheme is the ability to differentiate one side of the body from the other, that is, right/left discrimination. An individual is able to project a mental image of himself into space by means of abstract thought processes. The image of the body projected into space is of the same pattern as the perceived body; that is, it is formed by two symmetrical halves linked along a central axis (3). In the young child this mental projection of the body is performed directly forward, the right side of the body into the right field of space, and the left half into the left field of space. Children later learn to rotate their projected image and their movements around the central axis so that they are able to imagine themselves facing themselves. They then become aware that the right side of a person who faces them is opposite to their left side and vice versa. It is not until children are 5 years old that they can consistently verbally label right and left to objects (8). The ability to rotate a projected image in space has an important bearing in such functions as reading, writing, recognition of directions, and skilled movements (2).

Ayres (9) states that the ability to cross the midline is an indication of how well both sides of the body have become integrated. She believes that the ability to cross the midline is necessary in order for one hand to develop preference for manipulatory work. When the cerebral hemispheres are specialized and communicating effectively, the individual’s capacity to interpret perceptually complex material is maximized. If one considers hand dominance to be an indication of hemispheric specialization and normal bilateral motor coordination to indicate effective hemispheric communication, then the ability to cross the body midline may be considered to play an important role in perceptual development.

**Disorders of Crossing the Midline**

According to Schilder (6), the body midline has special significance to the body scheme in many disorders. A number of investigators found
that patients in certain clinical populations gave ipsilateral responses to crossed stimuli. More than 50 years ago, Head (10, 11) reported that certain types of brain injury (which manifested themselves in aphasia) resulted in a tendency on the part of patients to avoid crossing the midline of their body with their hand. Pearson, Alpers, and Weisenburg (12) compared normals with aphasic adults and found that, when the subject imitated the examiner, the errors made by aphasic persons consisted most frequently of an uncrossed response to a crossed stimulus. Gordon (13) compared retarded persons with normals and found that retarded persons more frequently gave ipsilateral responses to crossed stimuli. Gordon concluded that “the noncrossing of the face was generally found among the very unintelligent; it was certainly far more prevalent among the mental defectives” (13, p 297). Benton (2), after studying the frequency with which brain-damaged patients gave uncrossed responses to crossed commands, agreed with Quadfasel’s hypothesis that “the ipsilateral response to a crossed command can be conceived to be an expression of a biologically grounded primitive reaction tendency” (2, p 34).

In discussing problems with crossing the midline, Goody and Reinhold (3) suggested that the inability to cross the midline was but one symptom in an array of other perceptual and motor disorders. Ayres (1, 9, 14) also believed that the tendency to avoid crossing the midline was frequently accompanied by other symptoms. Ayres studied the learning-disabled population and found that the tendency to avoid crossing the midline was frequently accompanied by impaired ability to discriminate between the right and left sides of the body. Ayres (1) suggested that these two behavioral dimensions reflected a syndrome identified by diminished integration of function of the two sides of the body (bilateral integration). This syndrome is further characterized by difficulty in moving the two arms together in a coordinated manner. Crossing the midline has also been found to be associated with other parameters such as inadequate lateralization, poorly integrated postural reflexes, including the asymmetrical tonic neck reflex, and poor ocular control including eye jerks when crossing the midline (1).

Although researchers have not identified the exact neurological locus related to problems in crossing the midline, Ayres (1) considers the brain stem to be the primary site involved. Ayres suggested that the midbrain mechanisms responsible for postural integration are associated with an interhemispheral integrating mechanism, and a deficit in the functioning of the mechanism may underlie symptoms of poor bilateral integration in learning disorders. Ayres suggests that the interhemispheric integrating mechanism is the area that Penfield (15) describes as the centrencephalic system. This system, which is responsible for integrating cortical with subcortical information for final analysis, is located in the general region of the brain stem-midbrain.

**Assessing the Ability to Cross the Midline**

A number of ways have been designed to assess crossing the midline. Head (11), one of the first to assess this function, asked the subject to touch the right ear with the left hand, a typical test item. Kephart (4) assessed crossing the midline primarily through informal clinical observations such as ocular tracking and arm usage. Ayres (14) was the first to assess crossing the midline with a standardized test, the Crossing the Midline Test of the Southern California Sensory Integration Tests (14). The Crossing the Midline Test is based on Head’s method, but the test has been simplified and modified to eliminate the verbal element. In the Crossing the Midline Test, the child is asked to imitate the examiner (mirror image response) as the latter used either the right or left hand to point to either the right or left eye or ear. Half of the items require pointing to the ipsilateral eye or ear and half to the contralateral eye or ear. According to Ayres (14), this test assesses the degree to which the two sides of the body integrate their sensorimotor function. However, although children with mild dysfunction tend not to cross the body midline spontaneously, when faced with the necessity of crossing (such as in the testing situation), they do so. As a result, children may score within normal limits on this test, for the purpose of the test appears to be a little too obvious for the perceptive or test-sophisticated child (1). These children appear to perform the test cognitively, rather than perceptually, and thus receive a score more indicative of intellectual rather than sensory integrative status (9, 14).

Since Ayres (1) thought it was essential to evaluate crossing the midline without the child’s awareness, she devised a quantitative measure of the child’s tendency to spontaneously cross the body midline (9). This measure, which is derived from observation of hand usage during the Space Visualization Test, is called the Space Visualization Contralateral Use Score. Space Visualization, a test in the Southern California Sensory Integration Tests, is used to assess the child’s...
visual perception of form and space. The test is composed of a series of "puzzles," each consisting of one formboard and two blocks. The formboard is placed at the child's midline. One block lies slightly to the left and the other lies slightly to the right of the midline. The child chooses one of the two blocks and then places it in the formboard.

The Space Visualization Contralateral Use (SVCU) score is the ratio between ipsilateral responses (picking up the left-side block with the left hand or picking up the right-side block with the right hand) and contralateral responses (picking up the left-side block with the right hand or picking up the right-side block with the left hand) subtracted from 30. Since the child's attention is focused on the mental manipulation of forms in space, contralateral responses are considered as spontaneous midline crossings.

Norms for the SVCU score have not been established. Ayres (9) suggested, based on observation of 128 learning-disabled children, that 28 was an optimum score. She proposed that a score of 27 was suspect and scores of 26 or below were probably indicative of a lack of an establishment of adequate dominance for skilled motor tasks. The use of one hand exclusively results in a score of 29. Ayres (9) suggested that this may be, but is not necessarily, indicative of a lack of adequate functioning of one side of the body.

Since 1976, therapists have been using the SVCU score as an aid to identifying children with bilateral integration deficits. However, observation of normal children suggests that there appears to be a developmental trend in the SVCU score. Furthermore, a large number of young normal children appear to score below 26. If there is a developmental trend in the ability to cross the midline, this needs to be considered when interpreting the SVCU score.

The present investigation was designed to examine whether or not there is a developmental age trend in the tendency to cross the body midline in normal 4- to 8-year-old children and to gather preliminary normative data on SVCU scores of normal children. Support for a developmental age trend would be established by substantiating the following hypotheses: 1. There will be significant differences in the number of children at each age obtaining a particular score on the SVCU test, and 2. Young normal children will tend to obtain SVCU scores less than 28, whereas older children will tend to obtain scores greater than or equal to 28. Since an increased ability to cross the body midline would appear to allow for increased hand dominance, it was also hypothesized that, with increasing age, the child will use the preferred hand more than the nonpreferred hand to select blocks, and the percentage of preferred hand responses will increase.

Methods
Subjects. The subjects consisted of 150 children, 72 males and 78 females, who ranged in age from 4 years 0 months to 8 years 11 months. The children were divided, by age, into five groups (4, 5, 6, 7, and 8 year olds). There were 30 children in each group. Eighty to 90 percent of the children in each group preferred the right hand for writing or drawing, and each group had an approximately equal number of boys and girls. Chi-square analysis of the number of right- versus left-handed children and the number of males versus females between groups was not significant—p = .68 and p = .73, respectively.

According to their teachers, the children were normal academic achievers and were performing successfully at an age-appropriate grade level. All subjects were without diagnosed visual, motor, or auditory handicaps that could interfere with academic learning. The children came from a variety of socioeconomic backgrounds. Each child included in the study scored within normal limits on the Space Visualization Test (standard score above -1.0 SD). Analysis of variance indicated no significant difference between standard score means of the age groups on the Space Visualization Test, p = .13.

Procedure. The children were administered individually the Space Visualization Test of the Southern California Sensory Integration Tests. The test was administered according to the standardized procedure described in the Southern California Sensory Integration Tests Manual (14). During the test, the examiner recorded which hand the child used to select each choice. (Inter-rater reliability was not examined nor was test-retest assessed.) 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 method described in Interpreting the Southern California Sensory Integration Tests (9).

\[
\text{SVCU} = 3s - u\text{ipsilateral responses} - l\text{contralateral responses}
\]

The hand the child used to write or draw was considered the preferred hand. Percentage of preferred hand usage was obtained by using the following formula:

\[
\text{Percent of preferred hand use} = \frac{\text{No. of preferred hand responses}}{\text{No. of preferred and nonpreferred responses}} \times 100
\]

### Results

Mean, standard deviation, and range of the SVCU score for each age are shown in Table 1. Since chi-square analysis revealed no sex differences on the SVCU scores within and between groups, male and female data were combined. The data for left-handed and right-handed subjects were also combined since there were an insufficient number of left-handed subjects to compute differences between right- and left-handed subjects; and the right/left distribution within groups was reflective of the normal population—that is, 80-90 percent of the children in each group were right handed. In addition, inspection of Table 2, which indicates the distribution of scores for all subjects, does not suggest a difference in performance between right- and left-handed subjects.

To evaluate Ayres’ interpretation of the SVCU score, the scores were divided into four SVCU categories, 1, \( \leq 20 \); 2, 21; 3, 22-28; 4, 29. The number of children in each age group scoring within each category was analyzed. Resulting data appear in Table 3. The frequency distribution of the number of children obtaining each SVCU score confirmed Ayres’ findings that most children will score between 27 to 29. Sixty percent of the total sample scored in the 27 to 29 range. As predicted, chi-square analysis revealed a significant difference between age groups, \( p \leq .001 \).

The relationship between age and...
been shown to correlate with SVCU category at each age. The hypothesis that younger children will obtain SVCU scores lower than 28, whereas older children obtain SVCU scores greater than or equal to 28, was demonstrated. Since age has been shown to correlate with SVCU scores in the normal population, the percentage of preferred hand use was also examined and is shown in Table 4. The mean percentage of preferred hand use for the total population was 73 percent. An analysis of variance between the percent of preferred hand responses and age groups was computed and showed a difference significant at the $p < .05$ level; however, a Scheffe multiple comparison yielded no significant differences.

### Discussion

Data analysis indicated that there is a developmental age trend in a child's tendency to spontaneously cross the body midline. There were significant differences in the number of children scoring in each SVCU category at each age. The hypothesis that younger children will obtain SVCU scores lower than 28, whereas older children obtain SVCU scores greater than or equal to 28, was demonstrated. Since age has been shown to correlate with SVCU scores in the normal population, age needs to be considered when interpreting the SVCU score in children being assessed for sensory integrative dysfunction.

Since only 13 percent of the 4-year-old sample obtained the "optimum" score of 28, one must question the appropriateness of a score of 28 for a 4-year-old. Instead, it appears that most 4-year-olds scored $\leq 26$. One possible explanation for lower SVCU scores among younger children is that they may not have established hand dominance as strongly as older children; thus, a lesser ability to spontaneously cross the body midline might result. However, the hypothesized age trend of increasing frequency of use of preferred hand responses was not found. Research has suggested that skilled hand dominance develops with age. Perhaps the amount of skill needed to pick up a particular block is not developmentally related. If a more valid assessment of skilled hand preference were used, the hypothesized age trend might have emerged.

Another possible explanation for lower SVCU scores in the younger children is that body scheme, right/left discrimination, and spatial perception may not be as well developed in 4-year-olds as in older children. The degree of development of these skills has been linked with a child's ability to spontaneously cross the body midline. Studies (16, 17) indicate that increased sensorimotor training, specifically designed to develop laterality and body image, increased the number of correct crossed responses on a modified version of Head's test in both a sample of normal kindergarten children and a sample of retarded institutionalized teenage males. This suggests that there is a relationship between the ability to cross the midline and the perception of the body. One would expect that, as body scheme, right/left discrimination, and spatial perception continue to develop during the 4- to 8-year-range, the ability to spontaneously cross the midline also continues to develop.

Ayers (9) has suggested that a score of 29 may indicate a lack of adequate functioning of one side of the body. The interpretation of a score of 29 as a possible indication of unilateral disregard may be valid for 4-, 5-, and 6-year-olds since only 5 percent of the children in these age groups scored 29. However, this interpretation appears unlikely for 7- and 8-year-olds since 20 percent and 33 percent of the samples, respectively, obtained a SVCU score of 29. A score of 29 for a 7- or 8-year-old may be indicative of a higher degree of use of the dominant hand in a positive sense as opposed to unilateral neglect of the nondominant side. In any case, an interpretation of unilateral disregard must always be supported by other clinical observations and not based on the SVCU score alone (9).

Based on these findings, interpretation of the SVCU score needs to be age related. A revised interpretation of the SVCU score is suggested in Table 5 and is based on the data from 150 normal children presented

### Table 4

Mean, Standard Deviation, and Range of Percent of Times the Child Selected Choice with Writing Hand

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Percent Preferred Hand</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>71</td>
<td>20</td>
<td>32-100</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>68</td>
<td>25</td>
<td>13-100</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>67</td>
<td>22</td>
<td>25-100</td>
<td></td>
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<tr>
<td>7</td>
<td>79</td>
<td>21</td>
<td>34-100</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>81</td>
<td>23</td>
<td>18-100</td>
<td></td>
</tr>
</tbody>
</table>

Analysis of Variance, $F = 2.49, df = 4, p < .05$. *Scheffe Multiple Comparison yielded no significant differences between groups at $p < .05$.

Percent Preferred Hand in Selecting Choice for All Groups Combined

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>73</td>
<td>23</td>
</tr>
</tbody>
</table>

### Table 5

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

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Possible Deficit Range</th>
<th>Suspect Range</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1-17</td>
<td>18-21, 29</td>
<td>22-28</td>
</tr>
<tr>
<td>5</td>
<td>1-21</td>
<td>22-24, 29</td>
<td>25-28</td>
</tr>
<tr>
<td>6</td>
<td>1-22</td>
<td>23-24, 29</td>
<td>25-28</td>
</tr>
<tr>
<td>7</td>
<td>1-23</td>
<td>24-25</td>
<td>26-29</td>
</tr>
<tr>
<td>8</td>
<td>1-23</td>
<td>24-26</td>
<td>27-29</td>
</tr>
</tbody>
</table>
in Table 2. The reader is cautioned to remember that this preliminary reinterpretation is to be used as a guideline and not as strict diagnostic criteria. In arriving at the reinterpretation, the lowest 10 percent of the sample was considered to be in the suspect range, whereas the remaining 80 percent constituted the normal range. A score of 29 was considered to indicate a suspect range for the younger age groups since only 10 percent of the 4-year-olds and 3 percent of the 5- and 6-year-olds obtained a score of 29. In Table 2, white areas designate normal scores, gray areas designate possible suspect ranges, and the dark areas indicate possible deficit ranges. Again, since some of the normal children tested fall into the suspect and deficit ranges, difficulty crossing the midline and/or a diagnosis of bilateral integration deficit must depend not only on the results of the SVCU test, but rather on a cluster of related clinical observations indicating bilateral integration dysfunction.

Development of additional standardized test tasks that would evaluate a child's natural and spontaneous ability to cross the body midline is also needed since diagnosis of a midline disorder needs to be based on a cluster of clinical observations and test results.

Summary

The importance of midline behavior was reviewed and the role of the body midline was discussed in terms of bilateral integration, directionality, laterality, spatial relations, and ego development. Various assessment tools used to assess midline crossing behavior were examined. One method of evaluating the child's spontaneous midline crossing behavior is to calculate a Space Visualization Contralateral Use score by observing hand usage on the Space Visualization Test of the Southern California Sensory Integration Tests. The results of the present study confirmed the hypothesis of a developmental age trend in crossing the body midline as shown in the SVCU score. The original interpretation of the SVCU score, which was suggested by Ayres in 1976, does not take into account the child's age. A preliminary age-related reinterpretation of the SVCU score was presented.

Acknowledgments

Sincere gratitude is extended to Dr. Jean Ayres, whose work in the area of sensory integration inspired the authors in this project; to William Parfitt, Marie Delena, and the staff at John Street School, Franklin Square, New York; Cecily Gully, the Director of the Pound Ridge Nursery School, New York; the director and staff of the Rogers Pierce Children's Center, Arlington, Massachusetts; to Milagros Cordero and staff of the Escuelita Aguaybana, Boston, for allowing testing to be done at their facilities; to the Master of Science Sargent College Occupational Therapy students who participated in gathering data; and above all, to the children who participated in the study. This article was based, in part, on thesis research conducted at Sargent College of Allied Health Professions, Boston University, and was supported in part by an Allied Health Professions Traineeship Grant, US Department of Health, Education and Welfare.

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The American Journal of Occupational Therapy 319