Representational and Nonrepresentational Gestures in Boys with Learning Disabilities

(apraxia, learning disabilities, gestural representation, motor planning, imitation)

Sharon A. Cermak  Wendy Coster  Charles Drake

This study was designed to investigate the gestural abilities of boys with learning disabilities. Eighteen boys with learning disabilities (who had a low verbal-high performance WISC profile) and 24 normal boys between the ages of 9 and 13 were given a gestural test that consisted of two sets of tasks, one requiring the symbolic representation of implement usage—on command and on imitation (representational items) and the other requiring the imitation of hand positions (nonrepresentational items). The items were classified according to place of action as either on-self or away-from-self. The results indicated that the learning-disabled subjects performed at a significantly lower level than the normal control group on the gestural representation tasks. Results are discussed in terms of the need to investigate the various parameters of praxis.

Piaget (1) has proposed that gestural representation has its origin in the sensorimotor period of development (i.e., the first two years of life). This development begins with the infant repeating familiar movements made by a model (object or person) in front of him, and ending in the VIth stage of sensorimotor intelligence when the child can perform imitation of a "no longer present" model. According to Piaget, the development of imitative skills reflects the child's increasing ability to differentiate between an actual object and a representation of that object. Both the child's internal representation (mental image) and external representation (motor act) of a model become more elaborate as the child develops the ability to differentiate.

Werner and Kaplan (2) extended Piaget's theory by proposing that the development of "deferred" imitation is the next step in the development of gestural representation. This step is important largely because it is the stage in which gesture emerges as a symbolic vehicle.

Sharon A. Cermak, M.S., OTR, is an Assistant Professor in Occupational Therapy at Sargent College, Boston University, and a doctoral candidate in Special Education at Boston University.

Wendy Coster, M.S.O.T., OTR, works with emotionally disturbed children with sensory-integrative dysfunction at The Norfolk Clinical Children's Center and in private practice.

Charles Drake, Ed.D., is founder and headmaster of Landmark School for Children with Learning Disabilities. He is also an Associate Professor at Sargent College.
Werner and Kaplan feel that further development involves increasing differentiation, that is, by increasing distance between symbol and referent.

Using this developmental framework, Kaplan (3) investigated the development of gestural representation that conveys symbolic information in the absence of a model or implement. Toward this end, she developed a "Gestural Representation Test" and administered it to 4-, 8-, and 12-year-old boys. She found a distinct developmental progression in which the gestural representation reflected increasing differentiation of the components of the symbolic situation. This developmental sequence was supported by research by Overton and Jackson (4) with three- to six-year-olds. The levels of differentiation, or modes of gestural representation identified by Kaplan (3), were based on the degree of differentiation they reflected. Ordered hierarchically they were:

1. **Deictic behavior**—pointing to either the implement or the object of action, i.e., locating where the action would take place (e.g., pointing to mouth for "brushing teeth").

2. **Manipulation of the object of action**—direct manipulation of the actual object of the action without representing the stimulus implement in any way (e.g., tapping teeth).

3. **Body part as object**—part of the body is recognizably positioned in such a way as to ideally represent the perceptual, formal, physiognomic properties of the stimulus implement, and the movement performed is the characteristic movement that the implement makes when it is manipulated by an agent (e.g., using extended forefinger, making brushing movements against teeth).
4. **Holding plus body part (as object)**—initially the hand is positioned for holding the absent implement. However, in the course of manipulation there is a tendency for part of the hand to slip into representation of the implement as body part as object (e.g., hand initially positioned as if holding toothbrush, but gradually forefinger is extended and used).

5. **Holding without extent**—the hand is postured for holding the absent implement; however, there is lack of extent between the implement and the object of action, reflecting a neglect of the extent of the implement (e.g., hand is too close to mouth).

6. **Holding with extent**—the extent between the implement and object of action (the length or size of the implement) is indicated by the distance of the hand holding the implement from the object of action.

In Kaplan's study, body-part-as-object (BPO) responses predominated among the 4-year-olds, decreased to less than 25 percent frequency among the 8-year-olds, and appeared less than 10 percent of the time, in the 12-year-old group with the predominant response at that age being holding with extent. Also, Kaplan found that for her 8-year-olds, implements that could be used on the self, such as a comb, yielded less differentiated responses, and thus lower levels of gestural representation, than implements used away from the self, such as a saw.

While Kaplan's test investigated representational gestures (gestures that convey symbolic meaning), most tests of praxis in children assess nonrepresentational gestures (5-7). In fact, the use of the term apraxia, when applied to children, has generally been used to describe impairment in imitation of nonrepresentational gestures involving a visuo-spatio-motor component (5-8), and there has not been an investigation of disturbance in representational gestures. In contrast, when the term apraxia is applied to adults, it usually refers to an inability to perform representational movements to verbal command, a deficit frequently associated with damage to the left hemisphere (9-11).

Since learning-disabled children have been identified as a group having both spatial disorders (4, 6, 12) and disorders involving the processing of symbolic material (12, 13), this group seemed an appropriate one in which to study both representational and nonrepresentational gesture disabilities. Thus, the purpose of this study was to investigate the quality of the gestural response used by boys with learning disabilities. It was decided to use learning-disabled subjects with Wechsler Intelligence Scale for Children Verbal Intelligence Quotient scores lower than Performance Intelligence Quotient scores, because children with this profile would more likely represent the type of learning-disabled child with a left hemisphere problem (14) and would be likely to demonstrate a lag in representational gesture.

### Method

**Subjects.** The subjects were 38 right-handed boys who ranged in age from 9 to 13. There were 18 learning-disabled boys from a private school for children with learning disabilities and 20 normal boys from a public school in an area of comparable (middle to upper middle income) socioeconomic level to that of the private school.

The learning-disabled subjects were selected to meet the following criteria: 1. Verbal IQ at least 15 points lower than Performance IQ on The Wechsler Intelligence Scale for Children (WISC); 2. A full scale WISC score of at least 85; 3. A reading score of at least two grades below age as measured by the Slosson Oral Reading Test. The normal subjects were selected to meet the following criteria: 1. An intelligence quotient of at least 85 as measured by the Thorndike Intelligence Test; 2. Achieving passing grades in all academic subjects with no history of receiving remedial or special education.

The mean and standard deviation of age and IQ scores for normal and learning-disabled boys is presented in Table 1. There were no significant differences between groups in terms of age or full scale IQ scores.

### Table 1

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Age (months)</th>
<th>Full Scale IQ</th>
<th>Verbal IQ</th>
<th>Performance IQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning-Disabled</td>
<td>139.5</td>
<td>105.0</td>
<td>95.2</td>
<td>114.7</td>
</tr>
<tr>
<td>Normal</td>
<td>132.6</td>
<td>108.8</td>
<td>9.5</td>
<td>10.9</td>
</tr>
</tbody>
</table>

*S.D. = Standard deviation.*
Table 2
Representational and Nonrepresentational Items on the Gestural Test
Divided According to Place of Action

<table>
<thead>
<tr>
<th>Items to-Self</th>
<th>Representational Task</th>
<th>Items Away-from-Self</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Show me how you would brush your teeth with a toothbrush</td>
<td>1. Show me how you would hit a nail with a hammer</td>
<td></td>
</tr>
<tr>
<td>2. Show me how you would comb your hair with a comb</td>
<td>2. Show me how you would turn a screw with a screwdriver</td>
<td></td>
</tr>
<tr>
<td>3. Show me how you would eat with a spoon</td>
<td>3. Show me how you would cut wood with a saw</td>
<td></td>
</tr>
<tr>
<td>4. Show me how a man would shave with a razor</td>
<td>4. Show me how you would cut paper with scissors</td>
<td></td>
</tr>
<tr>
<td>5. Show me how a man would smoke with a pipe</td>
<td>5. Show me how you would make a hole in wood with a drill</td>
<td></td>
</tr>
</tbody>
</table>

Nonrepresentational Task

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dorsal side of hand covering ear, fingers extended and adducted (forearm supinated)</td>
</tr>
<tr>
<td>2.</td>
<td>Thumb abducted to 90° and placed ½ inch from nose (fingers extended and adducted). Thumb maintains this position while hand is moved forward and backward over forehead three times in a rocking motion in the sagittal plane.</td>
</tr>
<tr>
<td>3.</td>
<td>Dorsal side of hand under chin, fingers extended and adducted</td>
</tr>
<tr>
<td>4.</td>
<td>Hand to side of nose (fingers extended and adducted), palmar side medial</td>
</tr>
<tr>
<td>5.</td>
<td>Arm out sideways, with arm externally rotated and abducted to 90°, forearm pronated and elbow flexed to 90°, wrist fully flexed and ulnar deviated</td>
</tr>
<tr>
<td>1.</td>
<td>Arm out sideways internally rotated and abducted to 90°; thumb abducted and pointing down with fingers extended and adducted, back of hand facing subject</td>
</tr>
<tr>
<td>2.</td>
<td>Fingers 1 and 4 touching (palm down); other fingers extended and oriented to subject</td>
</tr>
<tr>
<td>3.</td>
<td>Fingers 2 through 5 are flexed to 90° at metacarpal joint and held extended and abducted. Thumb is flexed at metacarpal joint and held extended ½ inch from finger 2. Hand positioned so extended fingers are horizontal, parallel to, and held about 1 foot from mouth. Hand is moved from right to left and back 3 times with an 18-inch excursion</td>
</tr>
<tr>
<td>4.</td>
<td>Beginning with hand held with palm toward self, arm makes 3 counter clockwise circles away from body ending with arm extended and forearm supinated</td>
</tr>
<tr>
<td>5.</td>
<td>Fingers 1 and 2 touching to form a circle (forearm neutral). Rest of fingers slightly flexed. Hand is moved outward towards subject to and from nose (without touching nose) three times</td>
</tr>
</tbody>
</table>

The gestural test consisted of two components, one requiring the representation of implement usage (representational task), and the other requiring the performance of nonrepresentational motor acts (nonrepresentational task). On the representational task, there were 20 items. Of these, 10 items were performed to verbal commands in which the subject was told to represent the use of a specific implement (i.e., “Show me how you brush your teeth with a toothbrush”), and 10 items were performed to imitation, in which the subject was asked to imitate the examiner who represented the use of each of the implements. The experimental stimulus items were drawn from the implements used in the Kaplan (3) Gestural Representation Test. On the nonrepresentational task, there were 10 items in which the subject was required to imitate hand and arm positions demonstrated by the examiner. Items on both the representational and nonrepresentational tasks were divided according to place of action such that for each task there were five items to-the-self and five items away-from-the-self. The specific items for the representational and nonrepresentational tasks are presented in Table 2.

Procedure. The testing was administered in the following sequence: representational and nonrepresentational components were counterbalanced as was place of action. For the representational component, the items “to verbal command” always
preceded the items "to imitation." All testing was done on an individual basis in a small room where distractions were minimal. The subject sat facing the examiner with a table in between on which implement usage away-from-self could be demonstrated. The entire test procedure required about one half hour per child.

The examiner introduced the test by saying: "This is not a school test; it is part of a study to learn more about children. What I want to see is how well you can pretend to use some tools and some other things. For each thing I ask you about, I want you really to pretend that you are holding that thing in your hand and using it, so that if someone were watching you, they'd have a pretty good idea of what it is you're trying to do.""

The examiner then asked the subject to demonstrate how he would use a pencil. If the subject made a body-part-as-object response, the examiner re-emphasized that the subject should pretend to hold the implement, and then demonstrated such holding. During the administration of the test, the actual implement was always first shown to the subject to ensure that the subject understood what he was to represent. The implement was then removed from sight before the subject demonstrated its usage.

Directions for the imitation tasks were as follows:

"Now what we're going to do will be a little different. I'm going to use my hands to do some things, and I want you to do exactly what I do, using the same hand. If I use my right hand, I want you to use your right hand; if I use my left hand, I want you to use your left hand. Watch me very carefully so you'll be able to imitate me exactly."

Scoring and Statistical Treatment. Before testing the subjects, four non-test children were videotaped and reviewed by two raters to determine inter-rater reliability. This was established to be .95. In testing each child in the study, a description of the child's responses was recorded in sufficient detail to permit an accurate reconstruction at any later reading of the protocol. For the representational task, items were scored according to the developmental level of gesture as well as for the number and type of spatial errors.

The level of response for representational items was determined using Kaplan's (3) categories as follows:

1 point—The response focuses entirely on the object of the action, manifested by either deictic behavior or direct manipulation of the object of action. The implement is in no way depicted.

2 points—The implement and the characteristic action of the implement are represented by part of the body—i.e., body-part-as-object.

3 points—The agent and the implement are differentiated. The child positions his hand in some way to indicate that an implement is being held. However, the hand holding the implement is too close to the object of action; i.e., holding without extant.

4 points—The agent, implement, and the object of action are fully differentiated. The child holds the implement at a distance sufficient to indicate the formal extent of the implement; i.e., holding with extent.

A change from one level of response to another (i.e., if, in the course of responding, the child modified his response), resulted in a half point being either added or subtracted from the response score depending on whether the change was to a higher or lower level. There were 20 representational items in all, with 1-to-4 points given per item; thus a possible gestural score could range from 20 to 80 points on the total test.

For the nonrepresentational task, items were scored only according to number and type of spatial errors, since they could not be scored for level of gesture response.

Spatial errors were recorded for both the representational and nonrepresentational tasks. For each item, there were five possible spatial errors.

1. Location—erroneous location either on the body or in extrapersonal space.

2. Plane—any disorientation in plane; either for positioning of fingers, limbs or body, or the orientation of movement through space.

3. Reversal—the reversal of movement in the antero-posterior plane.

4. Right-Left—right-left disorientation, or mirror movements, e.g., using left hand instead of right hand in imitating examiner.

5. Finger position—substitution of incorrect fingers in imitation of examiner's finger position.

The score was the mean number of spatial errors per item. The variables were compared by analysis of variance and multiple
comparisons. First, the level of gestural representation of the two groups was compared on the representational tasks. Second, instruction (command and imitation) and place of action (to-self and away-from-self) were analyzed for the representational task as well as interaction between these factors. Finally, the number of spatial errors on the nonrepresentational task was compared to the number of spatial errors on the imitation instruction of the representational task using groups, and place of action as independent variables.

Results

Gestural Representation Scores. A 2 (Group) x 2 (Instruction) x 2 (Place of Action) repeated measures analysis of variance revealed that the learning-disabled group performed at a significantly lower level than the control group, $F = 16.47, p < .001$ on the gestural representation tasks. There was a significant difference between instruction (command vs. imitation) $F = 28.60, p < .001$, and between place of action (self vs. away), $F = 25.23, p < .001$. The group x place of action interaction achieved significance, $F = 8.16, p < .01$; the two other double interactions and the triple interaction did not. Mean scores for learning-disabled and control subjects on the gestural representation tasks as a function of instruction and place of action are presented in Table 3.

In order to determine which variables were responsible for these results, a series of multiple comparisons was performed. When place of action was collapsed, the learning disabled performed at a significantly lower level than the control group, $t = 3.47, p < .01$ and the imitation to-self, $t = 3.90, p < .001$, but not away-from-self.

Contrasting specific conditions showed that the learning-disabled group performed at a significantly lower level than the control group to-self, $t = 4.39, p < .001$, but not away-from-self.

Table 3

<table>
<thead>
<tr>
<th>Group</th>
<th>Command</th>
<th>Imitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self</td>
<td>Away</td>
</tr>
<tr>
<td>Learning-Disabled</td>
<td>Mean</td>
<td>15.92</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>1.91</td>
</tr>
<tr>
<td>Normal</td>
<td>Mean</td>
<td>17.67</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Within groups, both the learning disabled and the control subjects performed at a lower level on command than on imitation, $t = 2.90, p < .01$ and $t = 5.20, p < .001$, respectively. The learning-disabled group performed at a lower level on the self versus the away place of action, $t = 5.34, p < .001$, but there was no difference between place of action for the normal group.

Spatial Errors on the Representational and Nonrepresentational Tasks. A 2 (Group) x 2 (Task) x 2 (Place of Action) analysis of variance revealed that the learning-disabled group made significantly more spatial errors than the control group, $F = 6.64, p < .05$ on the combined representational (imitation) and nonrepresentational tasks. In addition, there was a significant task difference, $F = 30.42, p < .001$; however, no interactions were significant. The mean number of spatial errors per item for learning-dis-
abled and normal subjects as a function of task and place of action is presented in Table 4.

In order to determine which variables were responsible for these results, a series of multiple comparisons was performed. When place of action was collapsed, there was no significant difference between groups on the number of spatial errors on the representational task. However, the learning-disabled subjects made significantly more spatial errors than the control subjects on the nonrepresentational task, \( t = 2.67, p < .05 \). When task was collapsed, the learning-disabled group made significantly more errors than the control group on both the self and away-from-self orientations, \( t = 2.57, p < .01 \) and \( t = 2.05, p < .05 \), respectively.

Contrasting specific conditions revealed that the learning-disabled subjects made significantly more spatial errors than the control group on both the to-self representational (\( t = 2.13, p < .05 \)) and to-self nonrepresentational (\( t = 2.29, p < .05 \)) tasks. There were no significant differences between groups on the away-from-self representation task, but the learning-disabled group made significantly more errors than the normals on the away-from-self nonrepresentational task, \( t = 2.57, p < .05 \).

Within groups, both the learning disabled and the normals made significantly more spatial errors on the nonrepresentational task than on the representational task, \( t = 5.69, p < .001 \), and \( t = 2.68, p < .05 \), respectively. There were no significant differences for either group on performance to-self as compared to away-from-self on either the representational task or the nonrepresentational task. When examining the to-self orientation, the learning-disabled and the control groups made significantly more errors on the nonrepresentational task than on the representational task, \( t = 2.78, p < .05 \) and \( t = 3.06, p < .01 \), respectively. On the away-from-self orientation, the learning-disabled children made significantly more spatial errors on the nonrepresentational task than they did on the representational task, \( t = 2.88, p < .05 \), while there were no significant differences between normals on this condition.

**Discussion**

The boys with learning disabilities were less differentiated in their gestural representation than their normal reading peers. However, the degree of differentiation between the two groups was not found under all conditions, suggesting that the deficit in the learning-disabled group may be specific for certain types of gestural performance. Specifically, the learning-disabled subjects showed significantly less articulated representation of items executed on the self than did the controls, but were not different from the controls on items executed in extrapersonal space. Thus place of action was not a significant variable in the gestural performance of normal readers, but it was for learning-disabled children. Schilder (15), in discussing apraxic disorders, also noted that disturbance in one's own body is usually stronger than in extrapersonal space. The finding that the learning-disabled children showed less articulate representation of items on the self is consistent with the hypothesis that many learning-disabled children are field-dependent and do not have a normal sense of interior body orientation (Drake, unpublished observations).

The performance of learning-disabled subjects in this study was similar to that of the normal eight-year-olds in Kaplan's (3) study who also achieved lower gestural maturity scores for personal space than for extrapersonal space. However, this distinction between personal and extrapersonal space did not hold for Kaplan's 12-year-old children nor did it hold for the normal readers in this study since, in these groups, there was no difference between personal and extrapersonal space scores. Since the mean age of the children in the present study was comparable to Kaplan's 12-year-old group, it seems that the gestural performance of learning-disabled children more closely approximates their level of reading than it does their chronological age. This suggests that factors involved in the reading process may also be related to a child's ability to gesturally represent the use of implements.

On the representational task, both the learning-disabled and the normal control groups scored higher on imitation than on command, a difference that was not found by Overton and Jackson (4). A number of possible reasons may account for this finding of higher imitation than command scores. It is possible that, on imitation, the child uses the visual model to compare his performance and self-correct. It is also possible that improvement was noted in the imitation condition because verbal mediation was not necessary. Another possible explanation is that the imitation condition always followed the command condition, thus the subjects may have had some familiarity with the experimental tasks.

It has been suggested by some researchers that both aphasia and apraxia are symbolic disorders; that aphasia is a disturbance of verbal symbolization and that apraxia is a
defect in nonverbal symbolization (16). The finding that "low verbal" learning-disabled children achieved lower scores than the normal controls on the imitation as well as the command condition, and that they made significantly more spatial errors than the normal controls on both the nonrepresentational as well as representational items, suggests that the low performance of the learning-disabled children is not limited to a symbolic disorder. The learning-disabled subjects evidenced both developmentally less mature modes of gestural representation and deficits in the spatial organization of their movements. Although a dissociation between the symbolic and the spatial components of praxis may occur in adults as a function of specific cortical dysfunction (17), results of this study appear to indicate that, in the acquisition of gesture, the symbolic and spatial components of praxis may not be separable, perhaps because these functions have not yet been focalized in the maturing brain. This finding may account, in part, for the discrepancy in the literature between descriptions of praxic deficits in adults and those found in children.

Implications for Occupational Therapy. Occupational therapists are frequently involved in evaluating and identifying children with motor planning problems. The tests most frequently used are the Southern California Sensory Integration Tests with the best single indicator of apraxia being the score on the Imitation of Postures test, a test of nonrepresentational gestures (4, 7). Research with adult brain-injured patients has shown that gestural representation to verbal command is often impaired. However, this aspect of praxis is rarely evaluated in children. There are many aspects or parameters of praxis that are also addressed in the literature that have not been investigated in children. These include whether the gesture is in response to verbal command or in imitation, whether the material is symbolic or nonsymbolic, familiar or nonfamiliar, whether the place of action is on the self or away-from-the-self, whether the gesture is static or dynamic, and whether the action involves total body or primarily distal musculature. The results of this study found that place of action was indeed a relevant parameter, at least for certain types of learning-disabled children. It will be important to investigate whether or not a similar pattern of gestural performance is seen in learning-disabled children with different profiles, in particular, those with high verbal-low performance Wechsler IQ scores. These factors need to be evaluated to determine their significance so that a comprehensive test of motor planning can be designed. We may then be able to identify different types of motor planning problems and evaluate the most effective types of intervention for the different problems.

Acknowledgments
Sincere appreciation is extended to Edith Kaplan for her assistance and guidance with this project. The ideas that originally shaped this project and that are reflected in this paper are hers. Thanks are extended to all the children from the Landmark School for Children with Learning Disabilities who participated in this study. Appreciation is extended to Rebecca Kenney, Director of Motor Training at Landmark School, for her assistance in subject selection and scheduling, and for her support. This research was supported in part by a Boston University Faculty Research Grant 390—SAR and by an NICHD Grant HD 09508 to Boston University School of Medicine.

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