Praxis and Gesture Comprehension in 4-, 5-, and 6-Year-Olds

Lynette Lennox, Sharon A. Cermak, Jane Koomar

Key Words: human development • gestures • sensory integration

This investigation examined (a) whether the ability to comprehend pantomimed gestures improves with age in young children and whether the ability to point to the actual object precedes the ability to point to a functional associate and (b) whether there is a difference in the ability to comprehend pantomimed gestures between learning-disabled and normal subjects. The Gesture Comprehension Test, the Imitation of Postures test, and the Test for Auditory Comprehension of Language were administered to 68 normal children and 24 learning-disabled children 4 to 6 years of age. Results indicated that gesture comprehension improved with age and that the ability to point to the actual object preceded the ability to point to its functional associate. Boys performed significantly better than girls. There was no significant difference between normal and learning-disabled subjects' ability to comprehend gestures. A moderate correlation was found between the Gesture Comprehension Test and the Test for Auditory Comprehension of Language; a low correlation was found between the Gesture Comprehension Test and the Imitation of Postures test. These results suggest the possibility that in preschool children and young school-age children, gesture comprehension may be more closely related to language than to nonsymbolic aspects of praxis.

O ccupational therapists have long been interested in praxis (Ayres, 1972; Cermak, 1985; Conrad, Cermak, & Drake, 1983) because “praxis is to the physical world what speech is to the social world” (Ayres, 1985, p. 1). Both the ability to understand gestures and the ability to perform gestures are considered components of praxis. Developmental studies (Kaplan, 1977; Overton & Jackson, 1975) have established that the ability to perform gestures is age related, but there is little research describing the effects of age on the ability to comprehend gestures. In the 1870s clinicians first noted that some adult aphasic patients were unable to understand the meaning of pantomimed actions. Jackson (1878) and Head (1926) interpreted the defective recognition of pantomimed actions as a basic impairment in symbolic thinking. Finkelburg in 1870 used the word “asymbolia” to describe “a generalized disturbance in the capacity to express or comprehend symbols in any modality, including verbal and gestural symbols” (as cited by Hecaen & Rondot, 1985, p. 75). It is suggested that the ability to comprehend gestures may relate to both praxis and language.

The contributions of cognition and perception to praxis ability have been discussed for many years. Piaget (1962) considered the coordination of visual, auditory, and tactile-kinesthetic schemes during the sensorimotor stage (i.e., from birth to age 2 years) to be essential for the normal development of imitation. Piaget did not discount cognitive development but emphasized internalization, imaging, and repetition.

Roy and Square (1985) proposed a two-system control of praxis: (a) a conceptual system, which provides an abstract representation of action and (b) a production system, which combines action programs with perceptual motor processes. The conceptual system requires knowledge of tools and objects and of the actions and functions they serve, as well as the ability to conceptualize single actions in a sequence. Roy appears to agree with Piaget (1962) when he proposes that these perceptual attributes develop through function.

Praxis was defined by Kaplan (1977) as an acquired system of coordinated, intentional movements originating during the sensorimotor stage of development and culminating in gestural representation. In Kaplan’s view, symbolic language is an essential element of praxis. Ayres (1985) proposed that rather than symbolism, it is conceptualization or ideation that plays a significant role in praxis. Kuhn in a cognitive developmental theory of imitation suggested that “the individual only imitates models insofar as he has the requisite cognitive structures to comprehend them” (1973, p. 163), suggesting that people can imitate only those behaviors which they can comprehend. Recently Ayres (1985) elaborated on the rela-

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tion between praxis and language disorders in children and suggested that ideation and motor planning are common to both language and praxis.

The relation between praxis and language has been studied extensively in brain-injured adults (Basso, Faglioni, & Luzzati, 1985; Geschwind, 1975; Hecaen & Rondot, 1985; Kertesz, 1985; Kertesz & Heilman, 1985; Poock, 1985; Rothi, Heilman, & Watson, 1985; Roy & Square, 1985). These researchers found that disturbance of language and praxis are closely related, can be caused by the same lesion, yet can occur independently. Kertesz (1985) said that apraxia and aphasia coexist either because of anatomical proximity of the mechanisms of praxis and language or because of a common underlying neural mechanism. No definitive conclusions regarding the relationship between aphasia and apraxia have, so far, been reached.

Studies have been conducted with aphasic and nonaphasic adults in pantomime recognition (Varney, 1982) and with aphasic, aphasic-apraxic and normal adults in gesture comprehension (Rothi, Heilman, & Watson, 1985). Varney (1982) found that defects in pantomime recognition were closely associated with defects in reading comprehension but were not associated with other tasks requiring symbolic recognition such as aural comprehension and visual naming. He therefore suggested that aphasic defects in pantomime recognition are not the result of a general asymbolia. In the study by Rothi, Heilman, and Watson (1985) it was found that apraxic-aphasic subjects made more errors than nonapraxic-aphasic subjects in comprehending the meaning of pantomimes. The authors hypothesized that the inability to recognize gestures is not due to aphasia and that although all apraxic individuals have a performance deficit, they can be divided into two groups: (a) those in whom pantomime recognition is defective and (b) those in whom pantomime recognition is preserved.

Although the studies by Varney (1982) and Rothi, Heilman, and Watson (1985) both tested gesture comprehension, different methods were used. In the Varney study, subjects were shown the pantomimmed use of an implement, for example, a hammer, and were required to point to the drawing of the implement from amongst four drawings. In the Rothi, Heilman, and Watson study, subjects were shown the pantomimmed use of an implement, for example, a hammer, and were required to point to the drawing of a functional associate, for example, a nail. These two levels of gesture comprehension may require different abilities, and this has not been studied in adults. Moreover, gesture comprehension has not been studied from a developmental perspective.

This study was designed to examine the following hypotheses:

1. The ability to comprehend gestures improves with age in normal 4-, 5-, and 6-year-olds.
2. The ability to point to the actual object precedes the ability to point to a functional associate.
3. There will be a significant difference in the ability to comprehend gestures between learning-disabled and normal subjects of the same age.

The following additional question was to be considered: Is there a significant relation between the ability to comprehend gestures, the ability to perform nonrepresentational gestures, and auditory comprehension of language?

Method

Subjects. The subjects consisted of 68 normal and 24 learning-disabled girls and boys who ranged in age from 4 to 6 years. In the normal group there were 21 four-year-olds (10 boys, 11 girls), 24 five-year-olds (13 boys, 11 girls), and 23 six-year-olds (10 boys, 13 girls). In the learning-disabled group there were 2 four-year-olds (1 boy, 1 girl), 12 five-year-olds (11 boys, 1 girl), and 10 six-year-olds (7 boys, 3 girls). The mean age of the normal subjects was 67.19 months (SD 10.01); the mean age of the learning-disabled subjects was 69.71 months (SD 7.84). A between-group ANOVA revealed no significant between-group difference in age.

Normal subjects were defined as those who were considered normal by their teachers. For school-age children, the following criteria were applied: (a) performing with passing grades in all academic subjects and (b) not receiving or having a history of receiving remedial services. Preschool children were identified by their teachers as performing comparable to their peers in preacademic, social, language, and motor skills. Learning-disabled children were defined as those who had been identified by their teachers as not performing comparably to their peers in preacademic, academic, social, language, or motor skills and had been referred for remedial services despite average to superior intelligence, adequate sensory and motor systems, and adequate learning opportunities. The children came from a variety of socioeconomic and cultural backgrounds in the Boston area.

Procedure. Four tests were administered to each child individually in one session: (a) Gesture Comprehension Test, Level 1; (b) Imitation of Postures test (Ayres, 1980); (c) Test for Auditory Comprehension of Language (Carrow-Woolfolk, 1973); (d) Gesture Comprehension Test, Level 2. The Gesture Comprehension Tests, Level 1 and Level 2, were always given first and last, with their order counterbalanced. The Imitation of Postures test and the Test for Audi-
tory Comprehension of Language were given in the middle with their order counterbalanced. It took approximately 30 minutes to administer the four tests.

The Gesture Comprehension Tests, Levels 1 and 2, each consist of the same trial item and 12 pantomimed acts, which are recorded on a videotape. Twelve of the items were obtained from a videotape developed by Rothi, Heilman, and Watson (1985). One item was developed by the first author. Each pantomime shows a person pretending to use a common object, such as a comb, spoon, or pencil. The child is seated with the response book in front of him or her. Each page of the response book displays four drawings. The child is required to point to the drawing of what is being pretended. For Level 1, the implement itself is the correct choice, that is, if the pantomimed act is hammering, the correct choice is a hammer. For Level 2, the correct choice is the functional associate of the implement, that is, if the pantomimed act is the use of a hammer, the functional associate is a nail. The four types of response choices consist of (a) correct choice, (b) semantic foil, (c) motoric foil, (d) neutral foil. The semantic foil is a drawing that could be associated with the correct choice but would require a different action to pantomime its use, for example, the semantic foil for Level 1 for the action of cutting is a pencil. The motoric foil is a drawing of an object that requires a similar pantomim ed motor action to the correct choice but would be executed on a different plane, for example, the motoric foil for cutting is a screwdriver. The neutral foil is an unrelated object, as a telephone. An accuracy score, with a maximum score of 12, was obtained for each level. The child's responses were timed. A maximum time of 15 seconds per item was allowed. For each subject, the times taken for the items on which a response was made were added together, and a mean time score per item was calculated. Thus each subject obtained an accuracy score and a mean time score.

The imitation of postures test was administered in the standardized manner (Ayres, 1980). A score of 2, 1, or 0 was given for each item, based on the quality of the response and the time taken. There are 12 items enabling a maximum score of 24. Raw scores were converted into standard scores.

The test for Auditory Comprehension of Language, a test of the early stages of language comprehension, was administered in the standardized manner (Carrow-Woolfolk, 1973). The test consists of 101 items, which are scored correct or incorrect; the maximum score is 101. Raw scores were converted into standard scores.

Results

To investigate Hypotheses 1 and 2, three-way (Age X Sex, level of gesture comprehension) analyses of variance with one repeated measure were performed, one for accuracy and one for time on the data for the normal subjects. On the accuracy scores for the Gesture Comprehension Test, a significant age effect was obtained, $F(2, 62) = 24.66, p < .001$. Sex was significant, $F(1, 62) = 4.37, p < .05$, with boys scoring higher than girls. Level was significant, $F(1, 62) = 111.85, p < .001$, with scores on Level 1 higher than on Level 2. The Age X Level interaction was significant, $F(2, 62) = 3.32, p < .05$ (see Figure 1). No other interactions were significant. Scheffe multiple comparisons revealed that Level 1 was higher than Level 2 at each age. However, for both Level 1 and Level 2, there was a significant difference between the 4- and the 5-year-olds, but not between the 5- and the 6-year-olds. Means and standard deviations of accuracy scores are shown in Table 1.

Analysis of variance of the time scores revealed a significant age effect, $F(2, 62) = 19.46, p < .001$, with

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Means and Standard Deviations for Accuracy Scores of Normal Subjects on the Gesture Comprehension Test, Levels 1 and 2 (n = 68)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gesture Comprehension Test</td>
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<tr>
<td></td>
<td>Level 1</td>
</tr>
<tr>
<td>Age</td>
<td>Sex</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
</tr>
</tbody>
</table>
the time to respond decreasing with increasing age. Scheffe multiple comparisons revealed significant mean differences between 4-year-olds and 6-year-olds. No other comparisons were significant. Sex was not significant, \( F < 1.0 \). There was a significant level effect, \( F(1, 62) = 55.84, p < .001 \), with increased time for Level 2. No interactions were significant. Means and standard deviations are shown in Table 2.

To investigate Hypothesis 3, Group (normal control, learning disabled) \( \times \) Age (5 years, 6 years) analyses of variance with repeated measures (level) were performed, one on the accuracy score and one on the time score for the Gesture Comprehension Test. As there were only two 4-year old learning-disabled subjects, the learning-disabled and normal control 4-year-olds were excluded from these analyses. Thus the comparison was made between normal and learning-disabled 5- and 6-year-olds. In the analysis of the accuracy scores, group was not significant, \( F(1, 65) = 3.14, p = .08 \). There was a significant age effect, \( F(1, 65) = 5.14, p < .05 \), with the 6-year-olds scoring higher than the 5-year-olds. Level was significant, \( F(1, 65) = 100.75, p < .001 \), with Level 1 scores being higher than Level 2 scores. There were no significant interactions.

Because there were more boys than girls in the learning disabled group and because in the normal sample, boys received higher accuracy scores than did girls in the Gesture Comprehension Test, a between-groups analysis of variance was performed on only the male 5- and 6-year-old subjects. There was no significant difference between the groups, \( F(1, 37) = 2.05, p = .16 \). The rest of the results followed the same pattern as those already reported.

In the analysis of time scores, group was not significant, \( F(1, 65) = 2.95, p = .09 \). There was a significant age effect, \( F(1, 65) = 10.47, p < .01 \), with 5-year-olds taking longer than 6-year-olds. Level was significant, \( F(1, 65) = 54.14, p < .001 \), with increased time for Level 2. The group-by-age-by-level interaction was significant, \( F(1, 65) = 7.00, p < .001 \) (see Figure 2). Scheffe multiple comparisons revealed no significant difference between Level 1 and Level 2 scores for learning-disabled 5-year-olds and normal 6-year-olds. There was a significant difference between Level 1 and Level 2 scores for normal 5-year-olds and learning-disabled 6-year-olds. The only significant between-group or between-age difference was between the 5- and the 6-year-old normal control subjects on Level 2.

A between-group (learning disabled, normal control) analysis of variance for the Imitation of Postures test revealed a significant between-group difference, \( F(1, 65) = 25.78, p < .001 \). An analysis of variance between normal control subjects and learning-disabled subjects on the Test for Auditory Comprehension of Language also revealed a significant between-group difference, \( F(1, 65) = 4.25, p < .05 \).

To investigate the question of whether there is a significant relationship between the ability to comprehend gestures, the ability to perform nonrepresentational gestures, and auditory comprehension of language, Pearson product moment correlations were performed on the standard scores of the Imitation of Postures test (Ayres, 1980) and the Test for Auditory Comprehension of Language (Carrow-Woolfolk, 1973): for the normal controls subjects, the result was \( r = .049 \), for the learning-disabled subjects, the result was \( r = .297 \). Neither was significant at \( p < .05 \). As only raw scores were available for the Gesture Comprehension Test, partial correlations (with age in months as a covariate) were performed between the raw scores for the Gesture Comprehension Test—Level 1, Level 2, and Level 1 plus Level 2, and the raw scores of the Imitation of Postures test and the Test for Auditory Comprehension of Language. A correlation was performed between Level 1 and Level 2 accuracy scores to establish if they could be combined. In normal control subjects, the result was \( r = .529 \); in the learning-disabled subjects, the result was \( r = .755 \). The correlation may have been low for the normal subjects.

### Table 2

**Means and Standard Deviations for Time Scores of Normal Subjects on the Gesture Comprehension Test, Levels 1 and 2 (n = 68)**

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Level 1 Mean (SD)</th>
<th>Level 2 Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>M</td>
<td>4.2 (1.5)</td>
<td>5.6 (1.7)</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>4.2 (1.5)</td>
<td>5.6 (1.7)</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>2.2 (0.8)</td>
<td>3.2 (1.1)</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>2.2 (0.8)</td>
<td>3.2 (1.1)</td>
</tr>
</tbody>
</table>

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**Figure 2**

**Group-by-Age-by-Level Interaction of Time Scores for 5- and 6-Year-Old Normal and Learning Disabled Subjects on the Gesture Comprehension Test**
The finding that the improvement in accuracy scores was greater between 4- and 5-year-olds than between 5- and 6-year-olds suggests that gesture comprehension develops quite rapidly between the ages of 4 and 5 years. Additionally, the time taken to respond decreased with increasing age.

The significant difference in both the accuracy and time scores between Level 1 and Level 2 of the Gesture Comprehension Test implies that the stimulus responses are of critical consequence and methodology is an important consideration in studies of gesture comprehension. Level 2 appears to require higher level ability than does Level 1. Varney (1982) found that in apraxic adults, pantomime recognition (i.e., Level 1) was closely associated with defects in reading comprehension but was not associated with other tasks requiring symbolic recognition. This remains to be investigated in children. Rothi, Heilman, and Watson (1985) found that apraxic-aphasic adults made more errors than non-apraxic-aphasic adults in comprehending the meaning of pantomimes (i.e., Level 2). However, they did not compare Level 1 and Level 2.

Sex differences were not expected, yet boys obtained higher mean accuracy scores in both levels of the Gesture Comprehension Test at all ages. In designing a test such as this, one has difficulty avoiding environmental influences. Five of the twelve items demonstrated the use of a tool (i.e., screwdriver, axe, shovel, saw, hammer) that could be considered more "male oriented" than "female oriented." Further research needs to be conducted to establish whether young boys are indeed better at gesture comprehension than are young girls or whether these particular items favored boys.

The finding of no significant difference in the ability to comprehend gestures between learning-disabled subjects and normal subjects of the same age could be interpreted in two ways: (a) indeed, there is no difference or (b) a difference could be found in another sample of learning-disabled subjects. In this study, the sample size was quite small. Additionally, the sample was not random; the learning-disabled subjects were made available because the children had either been referred for occupational therapy evaluation or were receiving occupational therapy services. Although as a group they scored more poorly than the normal control subjects on the Imitation of Postures test and the Test for Auditory Comprehension of Language, they were a heterogeneous group. A more homogeneous group of dyspraxic children or language-disabled children may produce different results. In this study, as in studies of adults, the relationship between disorders of language and praxis is not clear-cut.

Although the correlations appear to indicate that gesture comprehension may be more closely related to language than to praxis, this tentative finding requires further investigation because the type of praxis examined in this study was nonrepresentational in nature and represents only one component of praxis. Nonrepresentational gestures were chosen for this study because the Imitation of Postures test is the test of praxis most frequently used by occupational therapists with children. However, it must be noted that most of the literature on studies with adults, which proposes a relationship between praxis and language, has examined the ability to perform representational rather than nonrepresentational gestures. Future research should examine the relationship between different measures of language and praxis. Specifically, the relationship between gesture comprehension and the ability to perform representational gestures needs to be examined. Other aspects of praxis to consider are sequencing praxis and praxis to verbal command (Ayers, 1984). Similarly, this study addressed single actions only. Roy and Square (1985) proposed that praxis requires the ability to conceptualize single actions in a sequence. Speech also requires a sequence of actions (Vygotsky, 1962). Further research may find a relationship between the ability to comprehend a series of related actions, dyspraxia, and language difficulties.

Summary and Conclusions

In adults, impairment of language comprehension correlates highly with apraxia (although the compe-

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Table 3

Partial Correlations (With Age in Months as a Covariate) for Gesture Comprehension Test With Two Other Tests

<table>
<thead>
<tr>
<th>Group</th>
<th>Imitation of Postures</th>
<th>Auditory Comprehension of Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1 &amp; L2</td>
<td>0.40***</td>
<td>0.48***</td>
</tr>
<tr>
<td>GCT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1 &amp; L2</td>
<td>0.28*</td>
<td>0.44**</td>
</tr>
</tbody>
</table>

Note: GCT = Gesture Comprehension Test.  
* p < .10.  ** p < .05.  *** p < .01.
hension deficit is not the cause of apraxia). This study has indicated that not all developmental language disorders are related to dyspraxia and that not all dyspraxia is related to delayed language. However, limited measures of praxis and language were included. This relationship needs to be more fully explored in children, particularly since research in occupational therapy has demonstrated that the use of sensory integration procedures has resulted in improved academic scores of children whose identified problems lay primarily in the language domain (Ayres, 1972). Ayres (1985) has suggested that there may be a general planning or programming mechanism serving speech, language, and praxis. If some neural process is common to both language and praxis and/or there is an underlying factor that is needed for both language comprehension and skilled motor movement, it is important to identify the particular subtypes of children with this common linkage in order to investigate whether treatment that influences one area of function may also influence the other. If treatment is found to influence more than one area of function, it is possible that programming or planning adaptive behavior, as in sensory integration procedures, may help program speech/language and/or behavior in general.

Acknowledgments

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References


