NONLINGUISTIC SYMBOLIC AND CONCEPTUAL ABILITIES OF LANGUAGE-IMPAIRED AND NORMALLY DEVELOPING CHILDREN

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This study was motivated in part by the claim that language-impaired children with normal nonverbal intelligence suffer from representational and symbolization deficits (Morehead & Ingram, 1973). The study also examined the developing concepts of class, number, and order in these children to evaluate the claim that their thinking and reasoning in the nonlinguistic domain were within normal limits. Subjects were language-impaired children and two groups of normally developing children, one matched for MA and the other for MLU to the language-impaired group. Each group consisted of ten children. Each child was administered six nonstandardized cognitive tasks from the Piagetian literature. These tasks were designed to assess developing nonlinguistic symbolic abilities and conceptual knowledge of class, number, and order relations. The language-impaired children consistently performed better than MLU-matched controls but more poorly than MA-matched peers. However, only one task—Haptic Recognition—uncovered a significant difference between the language-impaired and MA-matched groups. The difficulty that language-impaired children experienced on this task was taken as evidence that they had deficient nonlinguistic symbolic abilities. Some tentative conclusions are offered concerning the role representational abilities play in language development.

It has been well documented (e.g., Johnston, in press; Weiner, 1972) that a group of children who suffered a language disorder from suspected central nervous system impairment often performed within normal limits on standardized nonverbal intelligence tests. Because these language-disordered children often achieved nonverbal intelligence scores within normal limits, their thinking and reasoning in the nonlinguistic domain were also believed to be normal. These language-disordered children, referred to as language-impaired in this paper, have variously been labeled as developmentally aphasic, dysphasic, and language-delayed in the literature. Language-impaired children have much intrigued researchers because their presumed normal cognitive functioning implied to some that they demonstrated a specific linguistic deficiency. Such a deficiency would provide evidence for the existence of some language acquisition device which, according to Chomsky (1965), allows young children to perceive and acquire certain linguistic relations.

Few, however, were content with theoretical implications of a "pure" language-disordered child's existence. Some investigators, assuming that this "normal" intelligence applied only to certain aspects of cognitive development, looked toward specific dysfunctions of auditory processing skills or attention and memory abilities to explain the developmental language disorder (Eisenson, 1972; Tallal & Piercy, 1973, 1974, 1978). Tallal and Piercy (1978), for example, found that language-impaired children had difficulty processing rapidly changing acoustic information. Yet despite this evidence that language-impaired children typically encounter difficulty in processing and integrating auditory information, many researchers (e.g., Cromer, 1978; Johnston, in press; Rees, 1973) are not comfortable with the claim that such deficiencies are a necessary cause of the linguistic defect. Even Tallal and Piercy (1978) admit that this is the least likely relationship to exist. They argue that it is possible the auditory defect might not be causally related to the linguistic defect at all but might be a result of it. In light of their research interests, however, it seems probable that Tallal and Piercy favor one of the weaker causal relationships they discussed: (a) The auditory defect is a sufficient but unnecessary cause of the linguistic deficit; or (b) defective auditory perception might be secondary to a primary linguistic defect.

Based on these studies in this area, it is unlikely that deficient auditory processing skills are primarily responsible for these children's linguistic deficits. This unlikelihood, coupled with the change in focus several years ago from writing syntactically-based grammars to studying developing semantic relations, prompted investigators to look elsewhere in the cognitive domain for deficiencies which might influence language development. Two articles first published in 1973, one by Rees and the other by Morehead and Ingram, suggested that language-impaired children suffer from a more general cognitive deficit. Rees did not offer specific hypotheses, but Morehead and Ingram suggested that language-impaired children might be deficient in symbolization or representation.

The theoretical justification for Morehead and Ingram's hypothesis is found in Piagetian views on the relationship between language and cognitive development. According to Piaget, language emerges as part of a more general symbolic function—a function defined as the ability to represent symbolically an external event or object in its absence. One hypothesis emerging from this
view of language is that developments in other symbolic behaviors should parallel developments in language. Recent reports (e.g., Bates, Benigni, Bretherton, Camarioni, & Volterra, 1977; Nicolich, 1975; Snyder, 1975) furnished evidence that some relation exists between early symbolic behaviors (e.g., means-end relations and play behavior) and the production of one- and two-word utterances. These findings led in turn to predictions regarding the correspondence between linguistic and nonlinguistic symbolic abilities at later points in development.

Only a few studies have addressed this issue. Interestingly, however, these studies typically involved language-impaired children (de Ajuriaguerra, Jaeggi, Guignard, Kocher, Macquard, Roth, & Schmidt, 1976; Inhelder, 1976; Johnston & Ramstad, 1977). Inhelder, for example, discovered that dysphasic children experienced difficulty on tasks involving the evocation and anticipation of transformations of spatial configurations, whereas they performed adequately on tasks not requiring such abilities. These findings implied that dysphasic (i.e., language-impaired) children suffered from a symbolic deficit that influenced not only linguistic performance but nonlinguistic symbolic abilities as well. The recent paper by Johnston and Ramstad (1977) supported these findings. Other than these few studies, however, there has been little systematic investigation of the nonlinguistic symbolic abilities of language-impaired children. One intent of this study was thus to evaluate the nonlinguistic symbolic abilities of language-impaired children to determine the importance of the symbolic function for language learning. An equally important objective was to provide more data on the conceptual development of language-impaired children to evaluate further the assumption that their thinking and reasoning in the nonlinguistic domain are normal.

Six cognitive tasks derived from the Piagetian literature were administered to a group of language-impaired children and two control groups, one matched for mental age (MA) and the other for mean length of utterance (MLU) to the language-impaired group. Three of the cognitive tasks were intended to assess mental imagery abilities. The other three tasks evaluated the developing concepts of class, number, and order.

METHOD

Subjects

The subjects in this study were 10 language-impaired children, 9 boys and 1 girl, and 20 normal children, 15 boys and 5 girls. The 10 language-impaired children were enrolled in therapy at speech and language centers in Southern Indiana, and all were previously diagnosed as having a primary language disorder by certified speech-language pathologists. These judgments were based partly on test scores from one or more standardized measures of language proficiency. Case histories and clinician’s appraisals indicated that the language impairment in these children was not the result of globally depressed intellectual functioning, severe emotional disturbances, hearing loss, or physical defects. These children were further specified according to their MA as measured by the Arthur Adaptation of the Leiter-International Performance Scale (1952) and their linguistic level as indicated by MLU. Only language-impaired children whose MA fell between 4:6 and 6:0 and whose MLU was between 4.00 and 5.50 were included for study. Each child’s CA was within one year of his MA.

Ten normal children were individually matched for MA to the language-impaired children, such that the difference between each subject pair did not exceed ±3 months, which is the difference that the passing or failing of one more task on the Leiter would make. Another group of 10 normal children was individually matched to the language-impaired group for MLU, such that the difference between each pair did not exceed ±2.5 morphemes. Teachers judged this group to have age-appropriate intelligence. Leiter scores were obtainable for five of these children and confirmed teachers’ judgments. Table 1 presents group means and standard deviations for MA, CA, and MLU.

<table>
<thead>
<tr>
<th>Group</th>
<th>CA Mean</th>
<th>CA SD</th>
<th>MA Mean</th>
<th>MA SD</th>
<th>MLU Mean</th>
<th>MLU SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language-impaired</td>
<td>59.3</td>
<td>6.01</td>
<td>60.6</td>
<td>6.45</td>
<td>4.82</td>
<td>.41</td>
</tr>
<tr>
<td>MA-matched</td>
<td>58.3</td>
<td>3.20</td>
<td>61.1</td>
<td>5.58</td>
<td>6.40</td>
<td>.89</td>
</tr>
<tr>
<td>MLU-matched</td>
<td>36.6</td>
<td>2.72</td>
<td>41.5*</td>
<td>6.27</td>
<td>4.81</td>
<td>.45</td>
</tr>
</tbody>
</table>

*MA was assumed to be equivalent to CA for the five subjects who did not have Leiter scores.

General Procedures

Each child was first administered the nonverbal intelligence test, the Leiter, followed by the six cognitive tasks: Haptic Recognition, Water Level, Mental Displacement, Classification, Number Conservation, and Linear Order. The first three tasks were designated as Mental Imagery tasks, while the last three were designated as Logic tasks. Although the Linear Order task had similarities to both the mental imagery and logic tasks, it was classified with the logic tasks because the formulation of anticipatory symbolic images did not seem to be required to achieve some success on the task (cf. Kamhi, 1979).

The three mental imagery and three logic tasks were presented in alternating order beginning with a mental imagery task. Within this constraint, the presentation order of the two different types of tasks was counterbalanced. Testing on each of the six tasks was preceded by
a short training period to insure that the children understood the task instructions and the responses required. Testing took place in a setting familiar to each child, namely, in the child's preschool, speech-language center, or home.

Task Descriptions

Five of the tasks were taken directly from the Piagetian literature. The sixth task, Mental Displacement, was a modification of one of the mental imagery tasks in a study by Anooshian and Carlson (1973). The materials and procedures used in each of the six tasks are briefly described below:

1. Haptic Recognition: The child blindly felt geometric shapes and then had to point to a visual drawing of the corresponding shape. The geometric forms included six topological shapes (disk with one hole, disk with two holes, closed ring, open ring, vee, and irregular cross), six simple Euclidean shapes (square, circle, rectangle, triangle, four-cornered star, and Greek Cross) and six complex Euclidean shapes (Maltese Cross, ellipse, irregular quadrilateral, trapezoid, rhombus, and six-cornered star).

The test had two parts. Part 1 consisted of the six topological and six simple Euclidean shapes, while Part 2 was comprised of all the Euclidean shapes. Two cards were constructed to visually portray the shapes, one for each part of the task. Each card contained life-sized drawings of the 12 stimulus shapes plus three foils. The materials and procedures used in this task were most similar to those employed by Laurendeau and Pinard (1970). Scoring of task performance was based on the number of correct responses children made.

2. Water Level: The child's task was to draw a line indicating the level of water in a covered jar as it was rotated through five orientations: 0°, 45°, 90°, 135°, and 180°. Outline drawings of the round-bottom flask were given to the child for each of the five orientations.

3. Mental Displacement: For this task the child had to combine mentally two adjacent simple geometric forms (e.g., a horizontal line and a square) such that one shape was superimposed on the other. Specifically, the child was told to imagine that the shape on the left (horizontal line) moved over and "plopped down" on the shape on the right (square). Understanding of the task was achieved by demonstrating the combinatorial process using transparencies on which sample shapes were colored. The child was asked to choose the correct configuration from four choices. Incorrect responses were of three kinds: (a) the second figure was rotated 90° and superimposed on the first figure; (b) the second figure was rotated 90° and placed adjacent to the first figure; and (c) one of the two figures was noticeably changed and superimposed on the other figure (e.g., a square was changed to a circle). The scoring of the task took into account the nature of the errors made, the correct response receiving the most credit, and the third error type receiving the least.

4. Classification: The child had to sort geometric shapes varying in size (small and large), shape (circles, squares, and triangles), and color (blue and red). Two free sorting trials were given, followed by the use of sectioned matrices to encourage certain groupings, for example, by color or size (2-sectioned matrix), shape (3-sectioned matrix), and combinations of color, shape, and size (6-sectioned matrix).

5. Number Conservation: For this task, the child had to judge the relative quantity of two arrays of checkers. In four of the six trials presented, the experimenter's array was transformed. Length, density, and quantity transformations were made. The procedures used in this task most closely resembled those of Pufall, Shaw, and Syrdal-Lasky (1973).

6. Linear Order: The child's task was to order correctly the objects in three conditions while viewing a visible model of the objects. The three conditions were: (a) aligned—the two trays were perfectly aligned; (b) staggered—one tray was horizontally displaced 2 inches (5.5 cm) to the right; and (c) tee—the two trays formed a "Tee," and the child had to order correctly the toys in the horizontal tray. Both trays had five circular indentations 1 inch (2.5 cm) in diameter. The objects included three each of eight small toys: frying pans, trees, oranges, bowls, records, pennies, nuts, and rings. The three members of each toy set were identical and were small enough to fit into the circular tray indentations.

For each of the three conditions, the experimenter randomly selected five of the eight toys for the model array. The remainder of the toys were next placed in front of the child, who was then instructed to make his/her tray look just like the model. The materials, procedures, and scoring for this task were similar to those used by Johnston (1978).

Scoring

Subjects were given a stage score for each task by comparing task solutions to a scale of typical response types. Recent research involving the five Piagetian tasks (e.g., Johnston, 1975; Johnston & Ramstad, 1977; Laurendeau & Pinard, 1970; Pufall, Shaw, & Syrdal-Lasky, 1973; Thomas & Jamison, 1975) led to some modification in Piaget's original stage designations. Scoring for the Mental Displacement task was based on quantitative differences in children's performances rather than qualitative differences. A full list of the scoring procedures used for each task is provided in the Appendix. Importantly, the stage level scores obtained by children accurately indicated their developmental level relative to the other children in this study. These scores could not, however, be used to compare performance across tasks because the tasks differed in complexity.

RESULTS

The stage level scores for each of the three groups are presented in Tables 2-7. Performances on these tasks were initially compared using the Kruskal-Wallis One-Way Analysis of Variance procedure (Siegel, 1956). Significant differences were uncovered among groups for all six tasks at the .01 level. Of primary interest was whether or not the differences between the language-impaired and two matched control groups reached significance. The Mann-Whitney U Test (Siegel, 1956) revealed a significant difference between language-impaired and MA-matched groups on the Haptic Recognition task (p < .01) and between the language-impaired and MLU-matched groups on the Haptic Recognition (p < .01) and Linear Order tasks (p < .02). No other significant dif-
ference was found involving the language-impaired group. Differences in the stage scores obtained by the two groups of normal children were thus primarily responsible for the overall significant difference found among groups.

Another way to evaluate these data is to analyze the distribution of stage scores obtained by the three groups. A look at the stage scores for each task presented in Table 2-7 reveals a consistent distributional pattern: The distribution of scores always favored the older normal children over the language-impaired children and the language-impaired children over the younger normal children. For example, in the Number Conservation task (Table 6), four children in the MA-matched group performed at the two highest stage levels, while no child performed at the lowest stage. In contrast, not one language-impaired child obtained a stage score in the two highest levels, whereas two obtained the lowest score possible. Finally, six children in the MLU-matched group achieved the lowest score possible. The probability of this order of group performance (i.e., MA-matched group > language-impaired group > MLU-matched group) occurring by chance for all six tasks was less than .01, based on Kendall's Coefficient of Concordance (W = 1.00, s = 72; Siegel, 1956). The measure of concordance, W, was a perfect 1.00.

The analyses performed thus far suggest that the symbolic and conceptual abilities of language-impaired children fall somewhere in between those of MLU- and MA-matched normal children. The most striking difference uncovered among groups involved the Haptic Recognition task. For this reason, children's performance on this task will be further analyzed.

### Haptic Recognition Task: Response Analysis

The initial analysis (see Table 2) of children's responses on the Haptic Recognition task involved simple quantitative data, the number of correct selections made by each child. Children's incorrect responses can vary, however, in the extent to which they maintain the spatial characteristics of the haptically perceived figures. Laurendeau and Pinard (1970), in their developmental study of children's haptic recognition abilities, noted three types of responses which maintained certain features of the stimulus items:

1. **Topological successes**: responses which maintained the topological features of the haptically perceived figure. Topological features include surrounding, enclosing, opening, and so forth. For example, a square and an open ring are topologically different, whereas a square and a rhombus are topologically similar.
2. Curvilinear-rectilinear (C-R) successes: responses which maintained the curvilinear or rectilinear features of the stimulus shape, that is, the outline of the shape.

3. Topological and C-R successes: responses which maintained both the topological and C-R features of the stimulus shape. Laurendeau and Pinard referred to these responses as "elementary successes."

Following Laurendeau and Pinard's lead, children's responses were regrouped three times according to topological successes, C-R successes, and elementary successes. As shown in Table 8, the MA-matched children had higher proportions of topological and elementary successes than did the other two groups. Both the language-impaired and MA-matched groups had high proportions of C-R successes, suggesting that both were sensitive to the C-R features of figures. The true importance of the curvilinear-rectilinear distinction for children, however, can be determined only by partialing out the influence of topological features on C-R successes. Responses which maintained C-R features of the stimulus shapes but not topological ones (i.e., C-R success/topological error) were thus tabulated. As shown in Table 8, the language-impaired group produced twice as many of these responses as their MA-matched peers. These data suggest that language-impaired children were more attuned to the C-R features of objects than were MA-matched normal children.

To determine whether or not these among-group differences were significant, the probability of occurrence of each response type was compared to the frequency with which each response occurred. These computations indicated that the MA-matched children had significantly more topological and elementary successes than would be predicted by chance alone (chi square, \( p < .001 \)). In contrast, the language-impaired and MLU-matched children were responding at chance levels for these two response types. Both the language-impaired and MA-matched groups responded at above-chance levels in producing C-R successes, but only the language-impaired children made C-R successes with accompanying topological errors at above-chance levels (chi square, \( p < .01 \)).

The sparsity of data from the MLU-matched children makes it difficult to reach any conclusions about the uniqueness of the language-impaired children's performance on this task. Fortunately, however, it was possible to compare the task performances of children in this study to the developmental data gathered by Laurendeau and Pinard (1970) on 50 children at each of 13 age levels from 2:6 to 12:0. The only difference between task procedures in this study was the addition of three response choices to the 12 stimulus figures. For this reason the most appropriate comparisons between studies involved the analyses of actual and chance probability levels of the various response types.

The first comparison was between the responses of the 5-year-old MA-matched group and Laurendeau and Pinard's 5-year-old group. Both of these groups were found to obtain significant differences between actual and chance probability levels for topological, C-R, and elementary successes. The fact that these two groups of normal children evidenced similar response profiles indicated that the comparison between younger normal children in the normative study and the language-impaired group would be a valid one. These data revealed that every group of children in Laurendeau and Pinard's study 3:0 and older responded above chance levels in producing topological, C-R, and elementary successes. On the other hand, none of these groups ever produced C-R successes with topological errors significantly above chance levels. The language-impaired children thus appear to have a unique response pattern on this task, one in which relatively few topological and elementary successes were made in comparison to responses which maintained the C-R features of the stimulus figures but not the topological ones.

A final analysis examined the actual number of language-impaired subjects who demonstrated this unique response pattern. Of the 10 subjects, 8 chose figures which maintained C-R features but not topological ones more than 45% of the time. In contrast, no MA-matched subject making more than two incorrect responses produced these responses more than 40% of the time. The one subject who made only two incorrect responses evidenced one response of this type. Thus, 8 of the 10 language-impaired children appeared to be invoking a response strategy different than that of normal children of any age. The two language-impaired children

<table>
<thead>
<tr>
<th>Table 8. Proportion of responses which maintained specific spatial features of the stimulus items.</th>
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<tbody>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>Language-impaired</td>
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<tr>
<td></td>
</tr>
<tr>
<td>MA-matched</td>
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<tr>
<td></td>
</tr>
<tr>
<td>MLU-matched(^b)</td>
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<td></td>
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</table>

\(^a\)The denominators equaled the total number of incorrect responses made by each group. Each child made 12 responses, so that the total number of responses for the language-impaired and MA-matched group equaled 120. Only 36 responses were made by the MLU-matched group.

\(^b\)Proportions are based on the responses of the three subjects who were able to complete the task.
DISCUSSION

It was initially hoped that the data from the three tasks, Haptic Recognition, Water Level and Mental Displacement, would yield some information concerning language-impaired children's developing nonlinguistic symbolic abilities. But in the administration of the Water Level and Mental Displacement tasks and in the compilation of results, it became clear that children had alternative performance strategies available to them other than those involving anticipatory imagery skills. It was conceivable in solving both of these tasks for children to circumvent the anticipatory mental imagery component. In the Water Level task, for example, a child's response could have been influenced by the orientation of the drawn figures and not an anticipatory symbolic representation of the water in the jar. In the Mental Displacement task, three other strategies were available to children in addition to the one involving anticipatory imagery abilities. These included (a) matching the stimulus figures to the figures in the response choices, (b) being influenced by extraneous factors such as the "graphineness" or uniqueness of a response choice, and (c) a random response strategy.

Only for the Haptic Recognition task, then, was the formulation of anticipatory symbolic images clearly required in order for the correct shape to be chosen. In fact, anticipatory imagery skills were needed even to select shapes which had some features in common with the stimulus figures. It was therefore noteworthy that the language-impaired children obtained significantly lower stage scores on this task than did the MA-matched group. Moreover, because all of the language-impaired children maintained some of the features of the stimulus forms in their response choices, it was not likely that they had difficulty transferring information from one modality, touch, to another, visual. It seemed more likely that the integral role the symbolic image plays in the development of spatial relations (cf. Piaget & Inhelder, 1967) was primarily responsible for most of the language-impaired group's poor overall performance on this task. Eight of these children's particular propensity to select figures with similar outlines (i.e., curvi-rectilinear successes/topological errors) was no doubt motivated by the difficulty they experienced in symbolically evoking more complex spatial relations. In other words, the unique response pattern demonstrated by these language-impaired children was probably caused by their symbolic deficiencies. Further study using other nonlinguistic symbolic tasks for which task solutions depend on anticipatory imagery abilities is clearly needed to substantiate these claims.

The three other tasks assessed the developing concepts of class, number, and order. The performance of the language-impaired group on the Classification task closely resembled that of the MA-matched children. There were only slight differences in the distribution of scores in favor of the normal group. The disparity between these two groups increased in the Number Conservation task, probably because the concept of number involves the coordination of both class and asymmetrical relations. The finding that half of the language-impaired children could not even make quantity judgments based on length indicated that they had little understanding of the concepts entailed by the terms same and more.

The findings from the Linear Order task could be predicted from the results of the other tasks. When a simple transformation was required, as it was in the Aligned Condition, the language-impaired group experienced little difficulty correctly ordering the objects. However, when the transformations became more complex (Staggered and Tee Conditions), these children did not perform as well as the MA-matched control group. The physical presence of the elements was thought to contribute to the relative success achieved by the language-impaired children on this task.

Although it should be apparent from this study that more research is needed to explore the nonlinguistic symbolic and conceptual abilities of language-impaired children, several tentative conclusions are offered to stimulate research in this area.

First, despite the intellectual strengths indicated by normal performance IQ, the language-impaired children typically exhibited noticeable delays in other areas of conceptual development. There was some indication in this study, however, that language-impaired children with relatively high IQ levels (e.g., above 115) performed more like their MA-matched counterparts. Nevertheless, for the majority of language-impaired children, performance tests such as the Leiter appear to provide only a limited picture of overall conceptual development.

Second, the extent of the conceptual delays manifested by language-impaired children appears related to the involvement of the symbol in developing a particular concept. That is, the development of knowledge about space necessarily would be more delayed than the development of knowledge about class and number because of the indispensable role the symbolic image plays in the development of the concept of space.

Finally, it was probably not coincidental that the language-impaired children obtained significantly higher performance levels than MLU-matched children on the two tasks which clearly necessitated anticipatory symbolic skills—the Haptic Recognition and Linear Order tasks. This finding indicates that the nonlinguistic symbolic abilities of the language-impaired children in this study were less delayed than their linguistic abilities. This conclusion is, of course, based on the assumption that the two group's linguistic abilities are roughly equivalent.

Generally speaking, then, a symbolic deficit alone can
probably not account for the extent and type of linguistic deficiencies demonstrated by language-impaired children. It should also be apparent that the conceptual delays exhibited by language-impaired children are not of sufficient magnitude to explain their linguistic behavior. It appears, therefore, that not only does the development of language involve more than knowledge about the world, but it requires more than the ability to represent symbolically objects and events in the world.

In conclusion, I would like to offer some speculative remarks concerning the nature of the structures underlying developments in language. It has been shown that language-impaired children have difficulty processing rapidly changing auditory information (Tallal & Piercy, 1978). In light of these findings, it is quite conceivable that the auditory nature of linguistic input coupled with its symbolic aspect accounts for much of the difficulty language-impaired children encounter learning the linguistic system. By themselves, neither a symbolic deficit nor auditory processing difficulties seem able to explain the extent and nature of the linguistic deficiencies demonstrated by language-impaired children. At the same time, the possibility cannot be ruled out that these children's linguistic deficiencies are caused at least partly by an impairment to neurological structures which are specifically tuned to deal with linguistic input. Unfortunately, to confirm or deny the existence of such structures, as yet undeveloped technological tools and methodological procedures are needed. While awaiting these advances, we must continue our efforts to discover links between the development of language and general cognitive processes, mechanisms, and structures.

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3. **Mental Displacement**

Stage 0 - 0-2 correct.
Stage 1 - 3-4 correct; or 0-2 correct, ≥ 4 Type 1 errors, and ≤ 3 Type 3 errors; or 0-2 correct, ≥ 5 Type 1 + Type 2 errors, and ≤ 3 Type 3 errors.
Stage 2 - 5-6 correct; or 3-4 correct, ≥ 3 Type 1 errors, and ≤ 2 Type 3 errors; or 3-4 correct, ≥ 4 Type 1 errors + Type 2 errors, and ≤ 2 Type 3 errors.
Stage 3 - 7-8 correct; or 5-6 correct, ≥ 2 Type 1 errors, and ≤ 1 Type 3 error; or 5-6 correct, ≥ 3 Type 1 + Type 2 errors, and ≤ 1 Type 3 error.
Stage 4 - 9-10 correct.

4. **Classification**

Stage 0 - Little or no evidence of the use of a principled logical criterion to group shapes. The patterns constructed are essentially random.
Stage 1 - Preliminary evidence of the use of a principled logical criterion is found in the child's groupings.
Substage 1A - There is some evidence of resemblance relations being used, but patterns invoke other types of associations as well (e.g., graphic collections).
Substage 1B - All but a few items are grouped according to a principled logical criterion (e.g., shape or color).
Stage 2 - Groupings are formed on the basis of a principled logical criterion.
Substage 2A - Groupings are formed on the basis of a principled logical criterion such as shape, color, shape/size. Subsequent groupings are based on the same criterion as the initial grouping.
Substage 2B - Some flexibility is noted in the child's groupings. The criterion for grouping is changed in subsequent trials. Preliminary evidence of class inclusion relations is evident in the collections and subdivisions of shapes.

5. **Number Conservation**

Stage 0 - The child either is unable to complete the task or gives a similar response for all six conditions.
Stage 1 - The child is unable to consistently make quantity judgments. No apparent criterion is used to judge the arrays; the child is able to complete the task, however.
Stage 2 - The child is able to make quantity judgments. One criterion, length, is used for these judgments.
Substage 2A - The child uses length to judge 5 of the 6 configurations.
Substage 2B - The child uses length to judge all of the configurations.
Stage 3 - The child demonstrates the ability to make quantity judgments by taking into account the length and density of the arrays. The coordination of length and density, however, is based on perceptual considerations because number is still not conserved.
Stage 4 - Conservation of number is demonstrated.

6. **Linear Order**

Stage 0 - Less than three instances of correspondence.
Stage 1 - Item correspondence.
Substage 1A - At least partial correspondence as defined by three or four corresponding items.
Substage 1B - Correspondence on the aligned and staggered placements.
Stage 2 - Reconstructed order despite linear displacement or 90° rotation.
Substage 2A - Correct reconstructed order on the aligned placement.
Substage 2B - Correct reconstructed order on the aligned and staggered placements.
Substage 2C - Correct reconstructed order on all three placements; however, at least three attempts were required to reconstruct the order for one or more of the three placements.
Substage 2D - Correct reconstructed order on the first attempt for all three placements.