Expressive Language and Perceptual and Motor Abilities in Language-Impaired Children

Rachel E. Stark, Paula Tallal and E.D. Mellits

Children of normal nonverbal intelligence may show significant and unexpected delays in the development of both comprehension and production of language. By definition, the affected children are free of metnal retardation, hearing impairment, marked behavioral disorder, or frank neurological deficits (Benton, 1966). Thus, no obvious causes for the language deficits of specifically language impaired (SLI) children have been implicated.

The study reported indicates that receptive language in SLI children is more highly correlated with performance on tests of auditory processing than with performance on tests of other perceptual abilities or of motor abilities. This finding might be seen as offering support for the hypothesis advanced by Tallal and Piercy (1973; 1974), namely, that an auditory rate processing deficit is the primary deficit in SLI children. If so, it might be expected that expressive language would also be highly correlated with rate processing in the auditory modality.

Levels of functioning in comprehension (or receptive language) and production (or expressive language) abilities appear to be somewhat independent of one another in language delayed as in normal children (Chapman, 1981; Stark; Tallal 1980). In other words, although receptive and expressive language may be equally depressed in some specifically language impaired (SLI) children, others may be more severely affected in their ability to understand language than in their ability to produce it, or vice versa. Reports of such variation (Graham, Bashir, & Stark, 1983) derive from the use of standardized tests that yield age-related scores and also from individual case studies such as those reported by Lenneberg (1967), and by Yamada (1981) in which the differences are extreme and may be documented readily by gross measures. These findings might suggest that receptive and expressive language disorders show different underlying etiologies.

Rachel E. Stark, Ph.D.
The Kennedy Institute, Baltimore
Paula Tallal, Ph.D.
University of California at San Diego
E.D. Mellits, Ph.D.
John Hopkins University School of Medicine, Baltimore

Address correspondence to:
Rachel E. Stark, Ph.D.
The Kennedy Institute
707 North Broadway
Baltimore, Maryland 21205

Attempts to account for language delay in children have resulted in a number of apparently conflicting interpretations. Benton, 1966 has suggested that subtle neurological deficits or lesions may be characteristic of these children. Others have attempted to explain SLI in children in terms of psycholinguistic deficits (Cromer, 1976; 1981), subtle cognitive or representational deficits (Rees, 1973; Morehead & Ingram, 1973), and auditory processing deficits (Eisenson, 1966; Talal & Piercy, 1973; 1974). Accounts of language delay may differ, however, because researchers have focused upon diverse aspects of language delay in children and not because their views are diametrically opposed to one another.

Recent studies have indicated that SLI children differ significantly from normally developing children with respect to their performance on tests of auditory processing (Aten & Davis, 1968; Lowe & Campbell, 1965; Rosenthal & Wohlert, 1973; Tallal & Piercy, 1973; 1974). This difference is observed in tasks requiring the children to identify, to discriminate, and to sequence both speech-like and nonspeech-like signals. It is thought to be most marked when rate of consonant-vowel or vowel-consonant transitions is high. In addition, rate of sequencing of movements has been found to be lower in SLI than in normal children (Stark & Tallal, 1980). However, until recently, no evidence has been reported to show that such deficits are related to the expressive language abilities of SLI children (Tallal & Stark, in press).

The present study was designed to examine the relation between expressive language and perceptual and motor abilities in SLI and in normal children. Auditory, visual and tactile perception were addressed as well as motor control and coordination. A second objective was to compare receptive and expressive language, in at least a preliminary way, with respect to their perceptual and motor correlates in SLI children.

Methods

Subjects

As described by Tallal (1985), two subject groups, one delayed in language development and the other developing language normally, were selected for the present study. Both groups were selected from kindergarten through third grade classes. The children considered for the SLI group were referred by speech language pathologists from schools and classes for the communicatively impaired in the local public school systems. The children considered for the normal group were referred to the project by teachers of regular classes in the same public school systems. They were identified by their teachers as functioning at average levels in academic subjects, as well as in speech and language.

The children in both groups were required to have normal oral sensory and motor functioning, to have normal hearing, to have no history of hearing impairment, and to be within normal limits in non-verbal intelligence. In addition, they were required to present neither signs of neurological impairment nor a history of neurologic deficit or lesion.

Children who met the above criteria were given an extensive battery of standardized speech and language tests. The overall language functioning of children selected for the SLI group was required to be at least one year below both their chronologic age and their performance mental age. The SLI children were also required to be at least six months below performance mental age in receptive language functioning and at least 12 months below performance mental age in expressive language function. In addition, the speech articulation abilities of the SLI children had to be at least commensurate with their expressive language abilities and the reading scores of those aged seven years and above had to be at least commensurate with their overall language abilities. The overall language functioning of children selected for the normal group was required to be no more than six months below their chronological age. In addition, their speech articulation abilities and (for those aged seven years and above) their reading scores, had to be commensurate with their chronologic age. The numbers of children who did and did not meet the above criteria were expressed by Stark and Tallal (1980).

Thirty-five SLI children and 36 normal children were found who met the above criteria. In both groups, there were four to six children at each half-year age level from five to eight and one-half years. The two groups were matched by proportional sampling for age, race, performance IQ, and socioeconomic status. They were not matched with respect to sex. Approximately equal numbers of males and females were sought for the normal group but the composition of the SLI group was not predetermined with respect to sex. The characteristics of the two groups of children are shown in Table 1.

Procedures

The children selected for the two subject groups were given an extensive battery of experimental tests. This battery included perceptual tests (identification, sequencing, rate processing and serial memory) that were administered in the auditory and visual modalities and also cross modally (auditory plus visual). The children were also given an oral motor and oral sensory test battery (including speech and non speech motor subtests), a neurodevelopmental battery (including tests of motor control and coordination, balance, tactile perception, and laterality relationships), and a series of visual scanning or cancellation tests in which they were required to select and mark letters, digits, words, nonsense shapes, and forms presented among similar items on an 8″×11″ page. These tests resulted in approximately 425 independent variables that were available for comparison, including 28 demographic and/or social, family, and medical history variables.

Table 1.

Description of Demographic Variables for the Normal and SLI Children

Variables	Normal Group	SLI Group	Sign Level
Number of subjects	38	36	
Mean CA (months)	75 (SD ± 14.2)	78 (SD ± 15.6)	NS
Verbal IQ	110 (SD ± 13.15)	82 (SD ± 11.4)	p<.001
Performance IQ	105 (SD ± 11.10)	100 (SD ± 8.8)	NS
Full Scale IQ	108 (SD ± 12.43)	90 (SD ± 9.0)	p<.01
Sex	23M, 24F	28M, 11F	p<.05
Race	31 White, 7 Black,	27 White, 9 Black	NS
SES (Hollingshead Scale)	3.3 (SD ± 1.6)	3.4 (SD ± 1.8)	NS
Lang. Dev. History	37 normal, 1 delayed	6 normal, 30 delayed	p<.01
Maternal Education	35 high school + 12 high school -	28 high school + 11 high school -	NS
Lang "Age" (months)			
Receptive	84 (SD ± 8.64)	65 (SD ± 10.85)	p<.001
Expressive	80 (SD ± 11.98)	53 (SD ± 12.57)	p<.001
Speech Articulation Raw Score (Templin-Darley)	49 (SD ± .22)	38 (SD ± .62)	p<.001

In order that relationships between these experimental variables and expressive language abilites might be estimated, it was necessary to develop a weighted score that represented the level of expressive language functioning in each of the subjects. The weights were derived from standard tests of expressive language (Lee, 1974). Multivariate analyses were then carried out to discover to what extent the experimental variables might be correlated with or "predict" the weighted index of expressive language derived for each of the children. Only 33 normal chidlren and 34 SLI children could be included in all analyses.

These multivariate analysis techniques took the form of a stepwise forward multiple regression procedure. In this procedure, experimental variables were ranked according to their contribution to the prediction of receptive language functioning. The first variable selected in the course of this procedure was the one with the largest simple correlation coefficient. All other variables were then examined in tandem with the first variable. That additional variable which was found to reduce the variance of the "prediction" or estimation of level of receptive language to the greatest extent then entered the prediction equation together with the first variable.

Three different approaches were applied in deciding whether variables should be included in the prediction equation. These included: 1) An F test of the extent to which the error in the fitted regression line using N variables was reduced when N+ 1 variables were entered; 2) examination of the reduction in the standard error; and 3) examination of the increase in the resulting multiple regression co-efficient. It should be emphasized that the variables identified in this manner made a contribution to prediction over and above the contribution made by variables already included in the prediction equation. Thus, variables that were found to be highly significant in univariate analyses did not necessarily make a significant contribution in multivariate analyses. If they did not, it was because they had been preempted by other, more powerful predictors with which they were highly correlated.

Because so many experimental variables were included in the project, variables were first assigned to sixteen different categories for the purposes of analysis:- 1) discrimination tests, 2) sequencing tests, 3) rate processing tests, 4) serial memory tests, 5) all timed tests, 6) auditory non-speech perception tests, 7) auditory speech perception tests, 8) non-verbal tests, 9) verbal visual tests, 10) non-verbal cross modal tests, 11) verbal cross modal tests, 12) all non verbal tests, 13) all verbal tests, 14) demographic variables, 15) oral motor and speech motor tests, and 16) neurodevelopmental tests. It was possible for a given variable to be represented in more than one category. For example, a given visual cancellation test might be entered into the "all timed test", "verbal visual test", and "all verbal test" categories.

Variables from each of these categories were selected for subsequent multivariate analyses if they had shown significant differences ($p < .05$) across normal and SLI children on univariate analyses (t tests and/or chi square tests). The selected variables were entered into 16 separate multivariate analyses. Those variables that were found to make a significant contribution to prediction in each of the sixteen separate multivariate analyses were then entered into a final composite multivariate analysis. The procedures were carried out separately for the normal and for the SLI chldren.

Results

The results of the multivariate analysis must be regarded as preliminary because of the relatively small number of SLI and normal children who were included and the large number of variables. They suggested that, in the SLI children, a different group of variables was correlated highly with expressive language than with receptive language. Speech motor variables were most highly correlated with expressive language in the SLI children, followed in order of importance by auditory speech perception variables (sequencing and rate processing of tones and of consonant vowel syllables), visual cancellation of word-like stimuli, and rate of sequencing of hand movements.

For the normal children a similar set of correlations was found to exist between receptive and expressive language. Specifically, visual cancellation of letters and of nonverbal visual stimuli were most highly correlated with expressive language, together with the ability to categorize CV syllables as having 'b' initial or 'd' initial phonemes, and with memory for series of letter-like shapes.

Multiple Regression Equations

The results obtained from the 16 separate multivariate analyses for expressive languge in the normal and for the SLI children are summarized in Table 2A. This table shows that all sets of variables were highly correlated with expressive language in the normal children. The variables showing the lowest multiple R's are the Nonverbal Auditory Processing (Multiple $R = .67$) and Neurodevelopmental variables (Multiple $R = .69$). Many sets of variables were highly correlated with expressive language in the specifically language impaired (SLI) children as well. However, the Multiple R's tended to be lower overall for the SLI than the normal children. Two exceptions to the tendency for lower correlations in the SLI group may be observed in the case of the Neurodevelopmental (Multiple $R = .78$) and the Speech Motor (Multiple $R = .76$) categories.

Those variables least highly correlated with expressive language in the SLI children were: Verbal Auditory Processing (Multiple R of .50 for the SLI children, .83 for the normals); Verbal Cross-Modal Processing (Multiple R of .59 for the SLI children and .72 for the normals); and Demographic variables (Multiple R of .38 in the SLI children and .81 in the normals). It was also observed that, even in those categories where verbal auditory processing items could have entered the primary regression equations — e.g., discrimination, sequencing and rate processing — they did so infrequently.

Table 2.

Multiple Regression for 16 Classes of Variables in the Normal and SLI Children

A. Level of Expressive Language

Variable Category	Multiple R Normal (N = 33)	Multiple R SLI (N = 34)
Discrimination	.91	.93
Verbal Auditory Processing	.83	.50
Nonverbal Auditory Processing	.67	.63
Sequencing	.86	.79
Rate Processing	.76	.75
Serial Memory	.83	.75
Timed Tests	.90	.80
Verbal Visual Processing	.79	.76
Nonverbal Visual Processing	.83	.66
Verbal Cross-Modal Processing	.72	.59
Nonverbal Cross-Modal Processing	.75	.72
All Verbal	.91	.79
All Nonverbal	.84	.76
Neurodevelopmental	.69	.78
Speech Motor	.70	.76
Demographic	.81	.38

B. Level of Receptive Language

Variable Category	Multiple R Normal (N = 33)	Multiple R SLI (N = 34)
Discrimination	.95	.76
Verbal Auditory Processing	.82	.78
Nonverbal Auditory Processing	.64	.81
Sequencing	.92	.67
Rate Processing	.79	.60
Serial Memory	.90	.75
Timed Tests	.93	.63
Verbal Visual Processing	.93	.63
Nonverbal Visual Processing	.84	.52
Verbal Cross-Modal Processing	.72	.39
Nonverbal Cross-Modal Processing	.74	.55
All Verbal	.94	.78
All Nonverbal	.87	.55
Neurodevelopmental	.83	.79
Speech Motor	.74	—
Demographic	.82	.46

The results obtained from the 16 separate multivariate analyses for receptive language in the normal and the SLI children are shown in Table 2B. A comparison of Tables 2A and 2B indicates that, for the normal children a similar set of correlations was obtained for level of receptive and expressive langauge. The only exceptions were in the case of Neurodevelopmental variables (higher Multiple R for receptive than expressive language) and Verbal Visual Processing (also higher Multiple R for receptive than for expressive language). A similar set of correlations was not obtained for receptive and expressive language in the SLI group. In their case, similar correlations (as for Neurodevelopmental variables and Serial Memory) were the exception rather than the rule.

It is important not to overinterpret such data. They may merely reflect greater heterogeneity among SLI than among normal children in their language and/or in their perceptual motor abilities. It is striking, however, that verbal auditory processing variables showed such low correlation with level of expressive language in the SLI children. As reported by Tallal (1985) these variables not only correlated highly with level of receptive language in the same children but were entered exclusively into the final multiple regression equation, preempting all other variables.

Table 3.

Final Multiple Regression for Normal Children (N = 33)

Level of Expressive Language

Variable Name	F. Ratio	Multiple R
Visual scan for 's p o t' in string of graphemes	.001	.81
Identification of 'b' initial vs. 'd' initial CV syllables	.01	.85
Visual scan for 'e' in string of words	.001	.90
Visual scan for arrow with specific orientation in string of arrows of different orientations	.001	.93
Serial memory for letter-like shapes (ϕ and Σ)	.07	.94

The final multiple regression equations for the normal and the SLI children are shown in Tables 3 and 4. Table 3 shows that five variables entered this equation in the case of the normal children. The first in order of importance was a visual cancellation variable (scanning for and marking graphemes in the seuqences s p o t among strings of graphemes). This was followed by categorization of a group of CV syllables according to whether they had an initial 'b' or an initial 'd' phoneme. Two further visual cancellation variables and serial memory for grapheme-like stimuli were also included.

For the SLI children, as shown in Table 4, seven variables entered the regression equation. Visual cancellation and verbal and nonverbal processing variables appeared for the SLI children as well as for the normals. First in order of importance for the SLI children, however, was number of errors on the Templin Darley Articulation Test. In addition, a rate of movement variable, i.e., simple rate of marking on a visual cancellation pretest where all visual stimuli were to be cancelled, appeared as sixth in order of importance.

Table 4.
Final Multiple Regression for SLI Children
(N = 34)

Variable Name	Level of Expressive Language F. Ratio	Multiple R
Number of errors, articulation test	.001	.74
Visual scan of 'en' in words	.001	.84
Sequencing bæ/dæ (80 ms. formant transition)	.001	.89
Rate processing 250 ms tones	.03	.91
Visual scan for 'run as cup' sequence in string of words	.03	.93
Rate of marking on visual scans	.04	.95
Rate processing ba/da (80 ms formant transition)	.03	.96

Visual cancellation variables were highly correlated with expressive language groups of children. These variables reflect knowledge of phoneme-grapheme correspondence, and other skills involved in reading and writing. Knowledge of grapheme and of phoneme sequences in turn could be related to both speech perception and speech production abilities. In addition, the visual cancellation subtests were timed. Thus the children's scores depended in part upon their rate of marking. The rate of movement deficit in SLI childrn is such they carry out repetitive movement sequences without error, but at a significantly slower rate than normal children. Visual cancellation variables therefore, might enter a multiple regression equation because of their association with this rate-of-movement variable. Indeed, a specific rate of marking subtest entered the final multiple regression equation for the SLI children.

It is perhaps not surprising that speech motor variables are more highly correlated with expressive (spoken) language in the SLI children, who exhibited speech articualtion deficits, than in the normal children who did not. It is not known at this time, however, to what extent the speech production difficulties of the SLI children might relate to speech perception or to rate of movement deficits.

Discussion

The most striking finding of this study, taken together with those reported by Tallal, in which the relationship of perceptual-motor variables to receptive language was documented, is that a quite different set of variables was found to correlate with expressive than with receptive language in the SLI children. For the normal children there was very little difference in these sets of correlations with receptive and expressive language.

The differences for the SLI children in receptive and expressive language relationships may be summarized as follows:
1. both verbal and nonverbal *auditory* processing variables were highly correlated with receptive language, much less highly with expressive language;
2. speech motor variables were highly correlated with expressive language, *not at all* with receptive language;
3. verbal *visual* processing variables were highly correlated with expressive language, somewhat less highly with receptive language.

What are the implications of the findings for the original Tallal and Piercy hypothesis, namely, that an auditory rate processing deficit is the primary deficit in language impaired children? Conceivably an auditory rate processing deficit could give rise to a dissociation between expressive and receptive language skills in affected children. Speech perception and speech production skills, for example, might be less well integrated in SLI than in normal children. SLI children might be less likely to employ analysis-by-synthesis techniques in decoding spoken language than are normal children. They might depend more heavily upon visual input in acquiring speech production skills and less heavily upon auditory input than do normal children. On the other hand, expressive language disorders in SLI children might have quite different bases from receptive language disorders.

Recently, Tallal and Stark (in press) have suggested that an overall rate processing deficit may be present in SLI children, i.e., in the tactile, visual and somesthetic sensory modalities as well as the auditory modalty. It will be recalled that the SLI children in their study also showed a significant rate of movement deficit. Speech movements take place at a high rate; thus, a rate of movement deficit could conceivably give rise to speech errors. Is this rate of movement deficit a separate problem or one arising directly from a rate processing deficit? Other investigators have shown that rate of movement is reduced in normal subjects when auditory or visual feedback is reduced or eliminated experimentally. Children with primary motor deficits, however, will also show reduced rate of movement. Clearly it will be important in asking questions about such deficits and their relationship to expressive language disorders, to study children with speech motor disorders, especially dyspraxia, and with one or other of the auditory agnosias.

While it may not be surprising that speech perception variables are correlated with level of receptive language and that speech motor (speech production) variables are highly correlated with expressive language in both normal and SLI children, the exact nature of these relationships remains unclear. There is no evidence that their nature is one of cause and effect. It is possible, for example, that ability to express oneself and the ability to carry out sequences of rapid movement with the speech articulators develop together. Both may reflect higher level motor learning and may involve some degree of conscious effort on the part of the child at certain developmental levels. Still higher level abilities such as those involved in oral reading may show correlation with expressive language only after speech production has become highly overlearned and automatic.

Although it is not at present defensible to regard the relationships between perceptual and motor abilities and language production or reception as causal in nature, it is clear that they are important. It is probable that, if we understood these interrelationships we would be better able to evaluate and alleviate language deficits in children.

References

Aten, J. & Davis, J. (1968). Disturbances in the perception of auditory sequence in children with minimal cerebral dysfunction. *Journal of Speech and Hearing Research, 11,* 236-245.

Benton, A.L. (1966). Language disorders in children. *Canadian Psychologist, 7,*298-312.

Chapman, R. (1981). Cognitive development and language comprehension in 10 to 21 month olds. In R.E. Stark (Ed.), *Language behavior in infancy and early childhood.* New York: Elsevier-North Holland.

Cromer, R.F. (1976). The cognitive hypothesis of language acquisition and its implications. In D.M. Morehead & A.E. Morehead (Eds.), *Normal and deficient child language.* Baltimore: University Park Press.

Cromer, R.F. (1981). *Roots of language disablement and routed to intervention: The importance of basic research.* Plenary address to the Second International Congress for the Study of Child Language, Vancouver.

Eisenson, J. (1966). Perceptual disturbances in children with central nervous system dysfunction and implications for language development. *British Journal of Disorders of Communication, 1,* 21-33.

Graham, J.M. Jr., Bashir, A.S., & Stark, R.E. (1983). Communicative disorders. In M.D. Levine, W.B. Carey, A.C. Crocker, & R.T. Gross (Eds.), *Developmental behavioral pediatrics.* Philadelphia: W.B. Saunders Co.

Lee, L.L. (1974). *Developmental sentence analysis.* Evanston: Northwestern University Press.

Lenneberg, E. (1967). *Biological foundations of language.* New York: John Wiley & Sons, Inc.

Lowe, A.D. & Campbell, R.A. (1965). Temporal discrimination in aphasoid and normal children. *Journal of Speech & Hearing Research, 8,* 313-314.

Morehead, D.M. & Ingram, D. (1973). The development of base syntax in normal and linguistically deviant children. *Journal of Speech & Hearing Research, 16,* 330-352.

Rees, N.S. (1973). Auditory processing factors in language disorders: The view from Procrustes' bed. *Journal of Speech & Hearing Disorders, 38,* 304-315.

Rosenthal, W.S. & Wohlert, K.L. (1973). *Masking level differences (MLD) effects in aphasic children.* Paper presented at the convention of the American Speech & Hearing Association, Detroit.

Stark, R.E. & Tallal, P. (1980). Perceptual and motor deficits in language impaired children. In R.W. Keith (Ed.), *Central auditory and language disorders in children.* Houston: College-Hill Press.

Tallal, P. (1985). Neuropsychological research approaches to the study of central auditory processing. *Human Communication Canada, this issue.*

*Tallal, P, & Piercy, M. (1973). Developmental aphasia: Impaired rate of nonverbal processing as a function of sensory modality. Neuropsychologia, 11,*389-398.

Tallal, P, & Piercy, M. (1974). Developmental aphasia: Rate of auditory processing and selective impairment of consonant perception. *Neuropsychologia, 12,*83-94.

Tallal, P, & Stark, R.E. in press. The relationship between auditory temporal analysis and receptive language development: Evidence from studies of developmental language disorder. *Neuropsychologia.*

Yamada, J.E. (1981). *On the independence of language and cognition; evidence from a "hyperlinguistic" retarded adolescent.* Paper presented at the Second International Congress for the Study of Child Language. Vancouver.