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CHARACTERISTICS OF CHILDREN WITH PHONOLOGIC DISORDERS OF UNKNOWN ORIGIN

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Descriptive data are presented from three studies of children referred for assessment of a developmental speech disorder of unknown origin. Group findings indicate that these children have involvements in mechanism, cognitive, and psychosocial areas that warrant attention in theoretical explication of and early intervention for their communication deficits. The reliability, learnability, and efficiency of a diagnostic classification system that attempts to provide characteristic speech profiles for diagnostic subtypes is also considered.

Surveys by the American Speech-Language-Hearing Association (Hull & Timmons, 1971; Leske, 1981) and the National Institute of Neurological and Communicative Disorders and Stroke Collaborative Perinatal Research Project (Winitz & Darley, 1980) indicate that moderate to severe speech delays of unknown origin are prevalent in 2.5% of preschool children. These disorders may be differentiated from other speech involvements on the bases of both causal origins and severity of involvement. On causal origins criteria, other childhood speech disorders have known etiologies (e.g., speech problems secondary to mental retardation, cleft palate, cerebral palsy), whereas functional speech delays have no well-documented diagnostic correlates. On severity criteria, speech error patterns restricted to articulatory distortions generally are considered *mild* (e.g., distortions of /s/, /r/, or /l/ sounds), whereas error patterns involving numerous speech sound deletions and substitutions may be associated with *moderate* to *severe* speech involvement. A nosology that has been suggested for research needs and clinical practice is to term the persistent distortion errors of school-aged children *residual articulation errors*, and the more involved error patterns, of the type described in this paper, *delayed phonologic development* (for convenience, *delayed speech*) (Shriberg, 1980; Shriberg & Kwiatkowski, 1982a). The term *developmental phonologic disorders* subsumes both subgroups.

Research into the causal origins and correlates of both residual articulation errors and delayed speech has been fractionated and essentially unproductive. Reviews of this literature uniformly conclude that the etiologic bases of both types of speech involvements are unknown (e.g., Bernthal & Bankson, 1981; Hanson, 1983; Shelton & McReynolds, 1979; Shriberg, 1980; Winitz, 1969; Winitz & Darley, 1980). As a group, children with articulation disorders have the same central tendencies and distributions as normally speaking children on such variables as intelligence, gross motor skills, and socioeconomic status (Winitz, 1969; Winitz & Darley, 1980). Research in the 1940s and 1950s predates major paradigmatic shifts in linguistic theories (e.g., generative, neogenerative) and advances in technological methods in the speech-language sciences. Research in the 1960s focused on applied behavioral analyses to correct the errors of children with residual articulation errors, whereas research in the 1970s placed emphasis on linguistic analyses. The within-subject designs and case study reports during those two decades apparently assumed that the origins of speech errors were irretrievable and not relevant for treatment decisions. The goals of those studies were to develop powerful analysis and management tools that would obviate the need for differential diagnosis.

The literature midway through the 1980s reflects increasing interest both in a variety of speech-language issues (e.g., Edwards, 1983; Ingram, 1983; Schwartz, Messick, & Pollack, 1983; Schwartz & Prelock, 1982; Shriberg, 1982b; Smit & Bernthal, 1983) and in the promise of technology for instrumentally assisted assessment (e.g., Weismer, 1984) and management (e.g., Rushakoff, 1984). To date, however, the literature continues to lack a comprehensive etiologic classification system. The two most recent studies that have attempted to understand the origins of residual articulation errors (Arndt, Shelton, Johnson, & Furr, 1977; McNutt & Hamayan, 1984) have not yielded a useable diagnostic classification system. Limitations in these and other studies suggest that research toward a valid system must address the following needs: (a) the need to integrate emerging theoretical approaches with data on normal and delayed speech acquisition; (b) the need to study younger children whose etiologic histories are less confounded, rather than school-aged children; and (c) the need for well-developed procedural conventions for speech sampling, phonetic transcription, and linguistic analyses of phonologic comprehension and performance.

An approach to description and diagnostic classification of developmental phonologic disorders that recently has been proposed (Shriberg, 1982a; Shriberg & Kwiatkowski, 1982a, 1982b, 1982c) and elaborated (Shriberg & Kwiatkowski, 1983) contrasts with many classification proposals based on linguistic typologies (e.g., Compton, 1970; Dinnsen, Elbert, & Weismer, 1980; Elbert, Dinnsen, & Weismer, 1984; Grunwell, 1982; Ingram, 1976). The diagnostic classification system posits seven

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putative etiologic "families" (cf. Shriberg, 1982a) for developmental and acquired phonologic disorders. A long-term research goal is to develop diagnostic speech profiles that are associated reliably with the main subtypes within each of the seven etiologic families. The twofold purpose of the present paper is (a) to provide integrated reference data for 114 children who have speech delays of unknown origin and (b) to assess the reliability, learnability, and efficiency of the diagnostic classification system proposed in a previous report (Shriberg & Kwiatkowski, 1982a).

METHOD

Study A

Selected data for subjects in Study A were reported in Shriberg and Kwiatkowski (1982a). Retrospective data on 43 speech-delayed children who were referred to a university speech-language clinic for assessment or management of their "intelligibility problems" were assembled. Of those children, 10 had been followed twice yearly in a longitudinal study beginning in 1975, and the others had been enrolled for individual and group management programs from 1975 through 1979. Sources of data included a case history report, parent observations, physician records, teacher observations, school records, and clinician observations made in the course of assessment and speech management. Most children were given a standard oral peripheral examination, and some were also assessed in aerodynamic studies and with several experimental indices of developmental apraxia of speech. Hearing screenings by staff audiologists were available for most children; some received follow-up threshold audiometry and tympanometry. All children were assessed for speech-language functioning using the earliest available audiotaped continuous speech sample as material for analyzing natural phonologic processes (Shriberg & Kwiatkowski, 1980) and language comprehension and production (Miller, 1981). Guidelines for determining the length of the speech sample are described in Shriberg (in press) and have been used in associated methodologic studies (e.g., Shriberg & Kwiatkowski, 1985; Shriberg, Kwiatkowski, & Hoffmann, 1984). Essentially, a 90-70-225 rule directs the transcriber to stop transcribing when reaching 90 first-occurrence words, or 70 utterances, or 225 total words. This convention assures that samples will be neither too short nor too long; samples for Studies A, B, and C averaged 6–8 min.

The general procedure for each child was to use all case history data to complete a classification work sheet, shown as Figure 1. Instructions for completing the worksheet are provided in Shriberg and Kwiatkowski (1982a). The procedure for completing the causal-correlates branch was to sort all available data into the six causal-correlates subareas and rate each datum on a 3-point scale that assesses degree of involvement: 0 = no involvement or normal; 1 = questionable or mild involvement; 2 = moderate to severe involvement. Ratings represented a consensus between the first two authors. Disagreements were infrequent and were readily resolved by discussion and interpretation of the available information for each descriptor. The few remaining disagreements were rated as 1 to indicate questionable. A complete list of the descriptors is provided in the Appendix.

Study B

Retrospective data on an additional 38 speech-delayed children seen from 1980 to 1984 in the same university clinic were assembled. The list of assessment information sources was essentially similar to that described for Study A children. All continuous speech-sampling protocols, transcription, and analyses were done by the first two authors, using more well-developed methodologies than were used in Study A as they became available. Essentially, speech-sampling procedures were more standardized than those used in Study A (Shriberg & Kwiatkowski, 1985); phonetic transcription included a narrower level of description (Shriberg & Kent, 1982; Shriberg, Kwiatkowski, & Hoffmann, 1984); and a series of computer-assisted analysis programs included revised formats for error response definitions, severity ratings, and ways to summarize and inspect the speech data (Shriberg, in press). Procedures for rating children's suprasegmentals and causal-correlates data remained essentially unchanged from the procedures described in Shriberg and Kwiatkowski (1982a).

Study C

Whereas Study B was essentially a direct replication of the diagnostic classification procedures used in Study A, Study C was intended as a cross validation of that approach. In 1980, arrangements were made at a county diagnostic center in another midwestern state to provide speech sample tapes and copies of all assessment materials for children referred to the center for delayed speech of unknown origin. Three center clinicians, each of whom was certified by the American Speech-Language-Hearing Association, received a package containing 36 high-quality audiocassette tapes, release of information forms, subject data forms, and copies of instructions and procedures. The directions asked the clinicians to audiotape a continuous speech sample for every available child whose primary problem was reduced speech intelligibility in the absence of known causality. The three participating clinicians were to use their best available audiocassette recorder and external microphone. The goal was to include a speech sample of at least 250 words, if possible, using the sampling and recording procedures described in Shriberg and Kwiatkowski (1980). Clinicians were asked to make photocopies of all diagnostic materials available for the child (coded for subject anonymity),

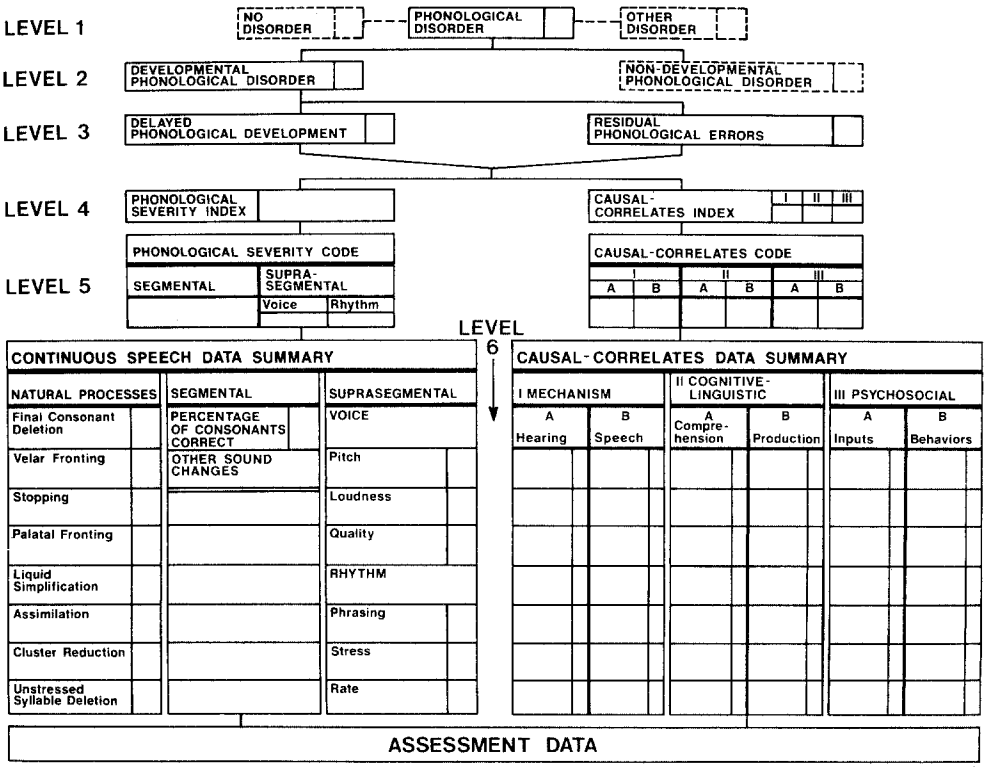

FIGURE 1. A diagnostic classification form (Shriberg & Kwiatkowski, 1982).

including their own summaries of test results and their clinical reports. The subject data form was also to include all relevant annotated information on the child, such as a description of what assessment information might be missing and why. The general goal was to preserve for inspection copies of all the assessment materials normally gathered in the context of a diagnostic evaluation conducted at a busy regional center. During a period of approximately 14 months, 33 evaluations that met subject description criteria were completed by the three center clinicians, with all materials forwarded by mail to the project site.

All diagnostic materials were processed by two first-year master's degree students in communicative disorders who volunteered to participate in a research project. Approximately 3 months were spent in teaching the students to do narrow phonetic transcription using materials similar to those described in Shriberg and Kent (1982) and additional samples of speech-delayed children. The first four authors also heard tapes of other speech-delayed children and worked toward achieving reliable narrow phonetic transcription in continuous speech samples. Several reliability assessment samples were obtained; they involved more than 600 diacritic-level comparisons of segments in words and sentences excerpted from continuous speech samples from approximately 10 mildly to severely involved children. Interjudge and intrajudge percentage of agreement figures averaged in the high 70s to low 80s, which is consistent with previous and subsequent reliability samples for narrow phonetic transcription of children with speech delays (Shriberg, Kwiatkowski, & Hoffmann, 1984). The students were also taught to use the diagnostic classification system, including procedures to rate suprasegmental dimensions of speech, to determine severity of involvement, and to classify assessment data on the set of 127 causal-correlates descriptors.

The purposes of Study C were both to determine how readily clinicians could learn to use the diagnostic classification procedures and to yield reliable subject data from another clinical setting. The two student clinicians were asked to work as a team and to keep diaries of their activities and impressions as they transcribed the speech samples and completed the worksheets (Figure 1) using the assessment information for each child. In transcribing the tapes, they used a consensus procedure to resolve disagreements, and they also worked together in reviewing the assessment materials several times for each child. As described later in a discussion of the clinicians' anecdotal comments, only 14 of the 33 tapes received were eventually considered valid for speech analyses, although all 33 data sets were used for the causal-correlates analyses. All training and data reduction was completed in approximately 1 year.

Transcripts of the speech samples from both Study B and Study C were processed by a software package (Shriberg, in press), and the computed values and causal-correlates data were arranged for statistical analysis. Inferential statistics were not considered appropriate because no specific hypotheses were under test. Rather, cross tabulations and descriptive statistics were used to assemble a reference profile for children with speech delays of unknown origin.

RESULTS AND DISCUSSION

Demographic Characteristics

Table 1 is a summary of sex and age characteristics for the three samples of speech-delayed children. Note that Studies A, B, and C, respectively, contribute 43 subjects (38%), 38 subjects (33%), and 33 subjects (29%) to the total of 114 children whose characteristics are to be described.

The sex distributions in each of the three samples were similar, suggesting that nearly three out of every four children (73%) referred for delayed speech of unknown origin are boys. Essentially similar distributions for other developmental speech-language disorders (e.g., stuttering, Andrews et al., 1983; language, Schery, 1985) raise challenging questions for biological and sociolinguistic contributions to the origins of communicative disorders. Ages of the children in these samples ranged from 1:11 (years:months) to 9:7, with an overall mean across samples of 5:0. Only the data in Study C reflect ages at time of first referral, which for most children is from approximately just over 3 years to just over 5 years of age (M = 4:2 years).

Speech Sample Characteristics

Because the analyses in each of these studies were based on continuous speech samples, distributional characteristics of intended word forms (the glossed form, which may or may not have been articulated correctly) and intended consonant occurrence were first inspected to assess their structural representativeness.

Rank-ordered distributions for intended word forms, as available from Study B and Study C (data from Study A were not processed by the software package and hence were not available for some analyses) and from two comparative normative studies (Study 1 and Study 2), are shown in Table 2. Percentages of occurrence of each of the 10 intended word types (i.e., canonical forms) are quite consistent across studies. Spearman correlation coefficients among the four studies are all above .915. [Data described in detail elsewhere indicate that percentages of obtained word forms, those actually produced by speakers, also are stable across speech samples (Shriberg & Kwiatkowski, 1983).]

TABLE 1. Demographic description of subjects in Studies A, B, and C.

Subjects	*Study A* (n = 43)	*Study B* (n = 38)	*Study C* (n = 33)	*Combined* (n = 114)
Sex				
Boys	74%	71%	73%	73%
Girls	26%	29%	27%	27%
Age at sampling				
M	5:9	4:11	4:1	5:0
SD	1:2	1:6	1:1	1:5
Range	4:0–8:11	2:10–9:7	1:11–6:8	1:11–9:7

The percentage of occurrence of intended consonants in Study B and Study C was also inspected and compared with data from other speech samples. As shown in Table 3, the relative proportions of intended consonants are similar across these and other studies. The first three columns provide overall ranks and the mean percentage of occurrence data for consonants. The next four columns include findings from 3- to 9-year-old children with normally developing speech (Carterette & Jones, 1974; Hoffman, 1982; Irwin & Wong, 1983; Mader, 1954), the next three columns are data from children of the same age but who are speech delayed (Studies A, B, C), and the final column includes data from the most recent adult study of consonant occurrence in continuous speech (Mines, Hanson, & Shoup, 1978). Pearson correlation coefficients computed between each of these eight studies ranged from .84 to .98; among the present three studies the lowest r is .96.

A unifying explanation for the stability of intended word forms and intended consonant types across speech samples was discussed in Shriberg (1982b). Essentially, the shapes of both frequency distributions appear to occur as a direct consequence of children's use of parts of speech. The proportions of, for example, nouns, verbs, articles, and prepositions appear to be consistent across diverse types of continuous speech samples (Shriberg & Kwiatkowski, 1985; Templin, 1957) and among samples of normally developing and speech-delayed children (Shriberg, in press). These regularities, in turn, condition the distributions of both intended word forms and intended consonant types. That is, semantic-syntactic constraints govern the relative occurrence of parts of speech, and several part classes are associated with structural constraints (e.g., there are no two-syllable articles).

These distributional data indicate that the continuous speech samples were structurally comparable across the three studies, thus allowing for the following inspection of the phonologic and phonetic data.

Speech Characteristics

Phonologic analyses. Figure 2 is a graphic summary of the average percentage of occurrence of certain sound changes for the 38 children in Study B (local replication) and the 14 children for whom valid speech samples were available in Study C (off-site cross validation). For comparison, Figure 3 is a summary of similar data for 72 normally developing 3- to 6-year-old children whose speech was assessed using similar procedures for speech sampling, phonetic transcription, and phonologic analysis (Shriberg, in press) and with comparable reliability of transcription data. Represented by the left and center sets of bars in both figures are the percentages of occurrence of sounds that were correct, distorted, and uncoded in word-initial and word-final singletons and clusters. Uncoded sound changes were those deletion and substitution errors that did not meet criteria for one of the eight

TABLE 2. Percentage of occurrence of intended word forms in continuous speech.

Canonical form	*Rank*[b]	*Mean %*	*Study 1*[a] *M*	*Study 1*[a] *SD*	*Study 2*[a] *M*	*Study 2*[a] *SD*	*Study B M*	*Study B SD*	*Study C M*	*Study C SD*
CVC	1	30.63	31.95	4.84	30.01	5.19	29.92	5.94	35.50	10.70
CV	2	22.59	21.09	4.32	23.01	7.24	23.66	6.69	22.13	7.01
2-syllable	3	13.49	13.64	3.64	13.39	3.95	13.44	4.37	12.60	4.55
VC	4	12.46	11.88	2.93	12.52	3.99	12.99	4.63	10.23	3.72
V	5	8.96	9.13	3.03	8.40	3.95	9.34	4.01	8.48	3.73
C(*n*)VC*n*	6	6.11	6.99	2.45	6.09	2.52	5.26	2.65	5.05	2.05
C*n*VC	7	1.98	1.48	1.13	2.15	1.65	2.31	1.60	2.62	3.30
VC*n*	8	1.50	2.21	1.71	1.58	1.50	0.70	0.77	1.00	1.23
3+-syllable	9	1.25	1.18	0.86	1.56	1.00	1.01	1.03	1.34	1.26
C*n*V	10	0.90	0.38	0.58	0.94	0.91	1.39	1.26	1.06	1.25

[a]Detailed information for Studies 1 and 2 is available in Shriberg (in press). Study 1 is a normative description of seventy-two 3- to 6-year-old children (Hoffmann, 1982). Study 2 data are taken from 35 normally developing 3-year-old children studied in the context of a project on early recurrent otitis media (Shriberg et al., 1984). All sampling, transcription, and analyses methodologies were comparable for the four studies in this table. [b]The means and resulting rank order were derived from the four studies.

natural process categories shown to the right. In Figure 2, adjoining bars are the obtained percentage data for each dependent variable in Study B and Study C, respectively.

The similarity in the profiles obtained for Study B and Study C children is notable. Several comparisons, such as those for word-initial Correct, word-initial Stopping, and word-initial Liquid Simplification, are within a few percentage points of one another. In comparison to the normative data in Figure 3, in which most children's errors are either singleton or cluster distortions, Study B and Study C children (Figure 2) appear to distribute their errors across the eight sound-change categories termed *natural phonologic processes* (Shriberg & Kwiatkowski, 1980; 1983). These errors of deletion (Final Consonant Deletion, Cluster Reduction, Unstressed Syllable Deletion) and substitution (Stopping, Liquid Simplification,

TABLE 3. Percentage of occurrence of intended English consonants in continuous speech.[a]

			Normally developing children				*Speech-delayed children*			*Adults*
Sound	*Rank*	*Mean*[b] *%*	*Mader (1954)*	*Carterette & Jones (1974)*	*Hoffmann (1982)*	*Irwin & Wong (1983)*	*Study A*[c] *(1982)*	*Study B (1983)*	*Study C (1986)*	*Mines et al. (1978)*
/n/	1	11.95	13.14	13.63	11.22	9.84	11.7	12.63	11.94	11.49
/t/	2	11.80	11.74	7.91	12.43	14.05	13.7	13.23	11.46	9.88
/s/	3	6.88	6.50	6.94	6.78	6.66	7.1	6.07	7.12	7.88
/r/	4	6.77	7.83	8.20	7.06	5.99	5.2	6.07	7.17	6.61
/d/	5	6.13	10.25	6.31	4.26	6.89	5.8	5.26	4.54	5.70
/m/	6	5.97	4.63	7.49	5.20	5.52	5.6	7.62	6.61	5.11
/ð/	7	5.39	6.40	4.42	6.90	6.04	4.1	4.27	5.64	5.37
/k/	8	5.28	4.25	4.96	4.60	5.20	6.0	5.60	6.33	5.30
/l/	9	5.25	5.55	4.96	3.42	5.41	5.6	5.53	5.28	6.21
/w/	10	4.77	5.33	5.57	4.19	4.70	4.8	4.34	4.43	4.81
/z/	11	4.65	3.70	4.58	8.69	4.88	3.0	3.94	3.67	4.70
/h/	12	4.36	3.33	3.37	7.47	5.17	4.2	5.14	3.96	2.23
/b/	13	3.37	2.97	3.18	2.84	3.40	3.5	4.34	3.50	3.24
/g/	14	3.21	2.38	2.90	3.93	3.29	4.1	3.14	3.93	2.02
/p/	15	3.19	2.73	2.12	2.98	3.12	3.9	3.79	3.77	3.07
/f/	16	2.10	1.83	2.21	2.38	1.64	2.4	1.52	2.14	2.65
/j/	17	1.70	0.77	1.41	1.22	1.49	2.2	1.98	2.67	1.87
/ŋ/	18	1.57	1.61	1.05	0.94	1.86	2.5	1.21	1.55	1.85
/v/	19	1.53	1.91	1.64	1.03	1.46	1.2	0.64	1.39	2.97
/ʃ/	20	0.88	0.84	0.84	0.87	1.14	1.5	0.55	0.33	0.95
/θ/	21	0.86	0.93	1.03	0.59	0.84	0.9	0.68	0.74	1.19
/dʒ/	22	0.65	0.69	0.53	0.62	0.50	0.6	0.33	0.98	0.95
/tʃ/	23	0.57	0.55	0.51	0.34	0.31	0.7	0.68	0.59	0.85
/ʒ/	24	0.04	0.01	0	0.01	0.01	0	0	0.12	0.15

[a]Ages: Madar (1954), 1st, 2nd, 3rd grade children; Carterette & Jones (1974), 1st grade children; Hoffmann (1982), 3–6 years; Irwin & Wong (1983), 3–6 years; Studies A, B, and C—see Table 1; Mines, Hanson, & Shoup (1978), 15–65 years. [b]The means and resulting rank order were derived from the four studies. [c]Calculations were available only to one decimal place (see Shriberg & Kwiatkowski, 1982a).

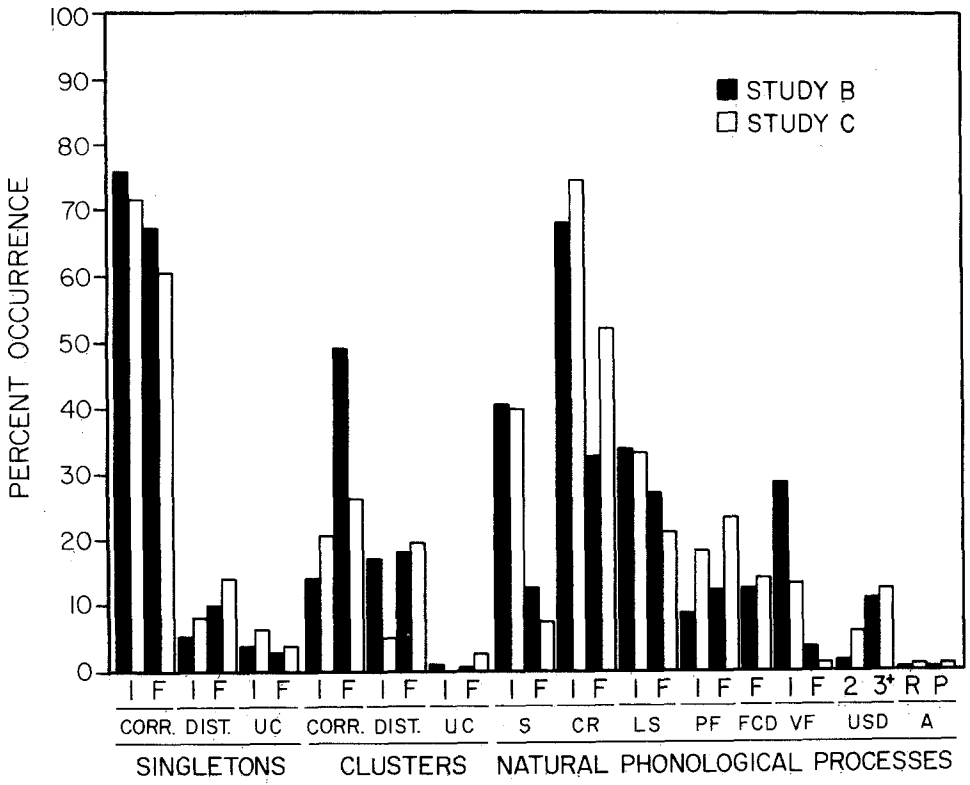

FIGURE 2. Percentage of occurrence of several sound-change categories for the 38 children in Study B (filled bars) and the 14 children in Study C (open bars). I: Initial; F: Final; CORR: Correct; DIST: Distortion; UC: Uncoded; S: Stopping; CR: Cluster Reduction; LS: Liquid Simplification; PF: Palatal Fronting; FCD: Final Consonant Deletion; VF: Velar Fronting; A: Assimilation—Regressive, Progressive; USD: Unstressed Syllable Deletion—2 syllables, 3 or more syllables.

Palatal Fronting, Velar Fronting, and Assimilation) occur on a group average of from approximately 1% to 75% of their potential occurrences. In children whose speech is developing normally, the group range is from 0% to approximately 15%. A finding of interest in both Figure 2 and Figure 3 is the relatively low proportion of Uncoded errors, presumably the category that includes non-natural phoneme deletions and substitutions. In the normally developing children, this category averages less than 2% across age groups, and for the speech-delayed samples, the figure is less than 10%. These findings seem to support a position that these eight natural sound changes capture over 90% of the deletion and substitution errors made by normally developing and speech-delayed children above age 3. [It is clear from the literature, however, that below the age of 3 years, the speech of even normally developing children does include deletions and substitutions that cannot adequately be captured by these eight sound change categories (e.g., Irwin & Wong, 1983; Schwartz, Leonard, Folger, & Wilcox, 1980).]

Comparable phonologic data for normally developing and speech-delayed children have appeared in several recent sources (e.g., Dunn & Davis, 1983; Dyson & Paden, 1983; Grunwell, 1981; Hodson & Paden, 1981; Ingram, 1981; McReynolds & Elbert, 1981). Although conceptual views of the term *phonologic processes* differ widely across these studies, and response definitions for "coding" sound changes are not similar, the present data profiles are congruent with other findings. The similarity in percentages of sound changes across studies reflects the fact that phonologic process descriptions function as cover terms. Large-domain sound-change categories, such as Cluster Reduction and Stopping, capture those articulation errors that constitute the core of speech delay. Empirical support for differential positional effects, such as the consistency of findings for Stopping and Velar Fronting (both more frequent in word-initial position), suggests that these error categories are robust aspects of speech development and delay. Recent proposals that such changes may further be sorted into typologic classes representing a continuum of phonologic knowledge (e.g., Elbert, Dinnsen, & Powell, 1984) or that they may be employed in the context of a cognitivist, two-lexicon model of phonologic development (Menn, 1983) warrant continued study.

Suprasegmental analyses. The diagnostic classification system proposed in Shriberg and Kwiatkowski (1982a) includes rating procedures for describing a child's status on six suprasegmental characteristics. Assignment of 0 indicates no difference from normal on a parameter, 1 indicates that a notable difference from normal was heard on the parameter on at least one utterance but not on more than 15% of utterances, and 3 indicates that the sample contained more than 15% of utterances in which

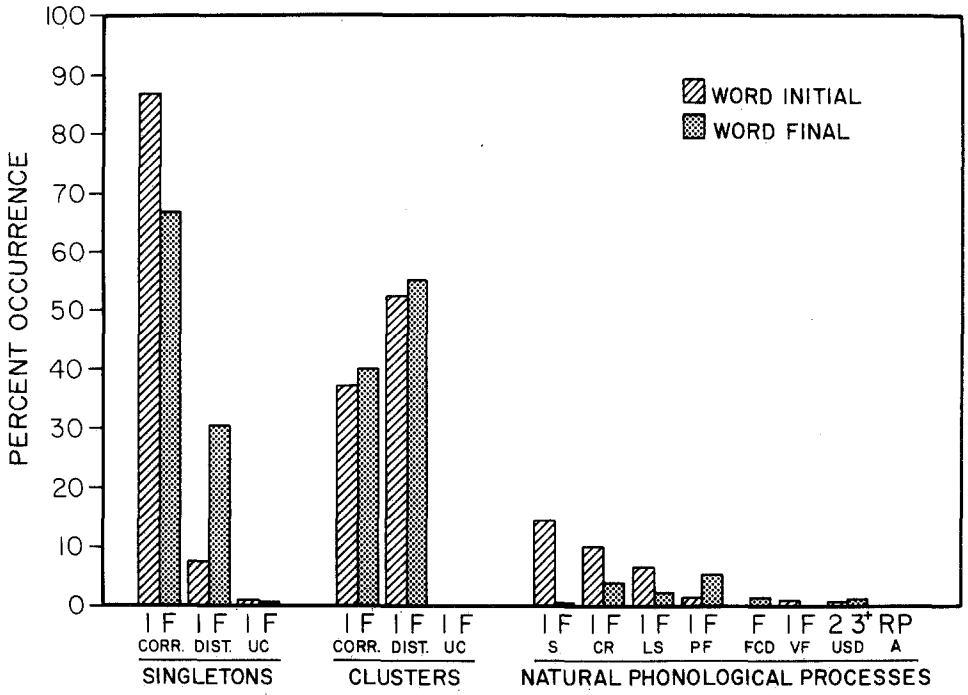

FIGURE 3. Percentage of occurrence of several sound-change categories in seventy-two 3- to 6-year-old children with normally developing speech (Shriberg, in press).

some notable difference from normal was heard on the parameter.

Table 4 includes summary data for the three studies on the six suprasegmental parameters. A major source of variance underlying differences in percentages among studies may be in the judges' ratings. Previous reliability studies indicate that at the individual level, interjudge and intrajudge reliability are not high for this procedure; across 180 sets of ratings (6 suprasegmentals × 30 speech samples), average reliability was 66.5% (Shriberg & Kwiatkowski, 1982a). However, consensus agreement decisions from a group (Study A) or pair (Studies B and C) of judges yield a form of consensual validity, much like the panel decisions that continue to be used for nasality ratings (McWilliams, Morris, & Shelton, 1984). The present system is used as a screening device with more detailed perceptual and acoustic analyses indicated for certain children. Emerging procedures for instrumentally aided perceptual analyses should allow for more efficient measures of both segmental and suprasegmental information.

What these data suggest is that, in addition to their segmental error patterns, children with delayed speech also may be involved in other ways that affect perceived severity of involvement and intelligibility (to be described). The combined Voice and combined Rhythm categories (lower rows, Table 4) suggest that over 50%, or one of every two speech-delayed children, may have some consistent voice difference in continuous speech samples (most often in voice quality) and that approximately 25%, or one of every four children, may have a consistent rhythm difference (distributed among phrasing, stress, and rate). In the absence of normative reference data, it is difficult to interpret the significance of these prevalence findings. Once again, there is a clear need in child language research for integrated methodologies to assess prosodic as well as phonetic and phonologic behaviors (Shriberg & Kwiatkowski, 1985).

Severity of involvement and intelligibility analyses. The computer-aided procedure used to assess severity of phonologic involvement tallies all deletion and substitution errors, as well as certain distortion errors (Shriberg, in press). The rationale for dividing distortions into those that are considered errors and those that are not is provided in Shriberg (in press) and Shriberg, Kwiatkowski, and Hoffmann (1984). Essentially, decisions were based on the social consequences of distortion error types and reliability of phonetic transcription concerns. For example, a dentalized /s/, [s̪], is considered a phonetic error because of its perceptual saliency and hence social consequences. A dentalized /d/, [d̪] (which is less noticeable perceptually) is, in contrast, not considered an error. Another example: a palatalized /s/ [ʃ], is not considered an error on both criteria—it is a frequent and perceptually less salient "distortion" in continuous speech, and it is difficult to transcribe reliably (Shriberg & Kent, 1982). Speech data were formatted for computer entry to accord with a comprehensive list of such error/nonerror phonetic distortions. A metric termed Percentage of Consonants Correct (PCC) (Shriberg & Kwiatkowski, 1982c) yields an index of severity of involvement based on the total number of intended consonants that were correctly articulated, divided by all the consonants in the sample, including sounds on which there were errors of deletion, substitution, and error-specified distortions/additions.

Percentage of Consonants Correct metric. Table 5

TABLE 4. Suprasegmental ratings for children in Studies A, B, and C.

Variable	Rating	Study A (n = 38) n	%	Study B (n = 38) n	%	Study C (n = 14) n	%	Combined (n = 90) n	%
Voice									
Pitch	0	27	71.1	30	79.0	7	50.0	64	71.1
	1	3	7.9	1	2.6	3	21.4	7	7.8
	2	8	21.1	7	18.4	4	28.6	19	21.1
Loudness	0	34	89.5	32	82.4	12	85.7	78	86.7
	1	3	7.9	2	5.3	0	0	5	5.5
	2	1	2.6	4	10.5	2	14.3	7	7.8
Quality	0	15	39.5	21	55.3	4	28.6	40	44.4
	1	5	13.2	3	7.9	1	7.1	9	10.0
	2	18	47.4	14	36.8	9	64.3	41	45.6
Rhythm									
Phrasing	0	21	55.3	37	97.4	7	50.0	65	72.2
	1	9	23.7	1	2.6	2	14.3	12	13.3
	2	8	21.1	0	0	5	35.7	13	14.4
Stress	0	30	79.0	29	76.3	11	78.6	70	77.8
	1	4	10.5	3	7.9	1	7.1	8	8.9
	2	4	10.5	6	15.8	2	14.3	12	13.3
Rate	0	28	73.7	33	86.8	8	57.1	69	76.7
	1	5	13.2	1	2.6	3	21.4	9	10.0
	2	5	13.2	4	10.5	3	21.4	12	13.3
Combined									
Voice	0	13	34.2	18	47.4	2	14.3	33	36.7
	1	5	13.2	2	5.3	2	14.3	9	10.0
	2	20	52.6	18	47.4	10	71.4	48	53.3
Rhythm	0	14	36.8	27	71.1	5	35.7	46	51.1
	1	13	34.2	4	10.5	4	28.6	21	23.3
	2	11	29.0	7	18.4	5	35.7	23	25.6

provides descriptive statistics for children in the three samples on the Percentage of Consonants Correct (PCC) metric. PCC data from two studies of normally developing children (Study 1 and Study 2) are included for comparison. These data for speech-delayed children in Studies A and B are more in agreement than either set is with the data for Study C. Although the largest group difference was only 6.1% (between Study B and Study C), it seemed important to examine the data to determine if any factors might be associated reliably with the somewhat lowered average PCC scores for Study C. That is, because a difference of a few percentage points can affect decisions about severity level (see next section), it is important to know whether the distribution of PCC scores is stable across sites.

One possible explanation for the somewhat lowered PCC values for Study C is that children in that sample were younger than children in Studies A and B (see Table 1). Available correlational coefficients between age and PCC range from $r = <.10$ (Shriberg & Kwiatkowski, 1982c) to low moderate (Study A: $r = .41$; Study B: $r = .33$; Study C: $r = .56$). To assess further the strength of this potential source of variance, the PCC data for children in each of the present studies were individually partitioned into age groups of 3, 4, 5, 6, and 7 years of age. Inspection of the mean PCC value at each age indicated that the association of age and PCC scores was not monotonic; there was a large spread of scores, particularly from 4 through 6 years (see also Shriberg, in press). These data provide additional support for previous findings that PCC values in young speech-delayed children are not strongly associated with age.

Differences in transcription conventions among studies is a second source of variance that might have accounted for the lowered PCC scores in Study C. At the time data were processed in each of the three studies, explicit conventions had not been completed for many needs, such as determining acceptable casual and fast speech forms and determining error/nonerror distortion rules (Shriberg, in press; Shriberg, Kwiatkowski, & Hoffmann, 1984). Most of these newer conventions have the effect of giving the subject the "benefit of the doubt" (i.e., they act to raise a speaker's PCC score). These emerging conventions became available to the transcribers in both Study B and Study C, however, so changes in transcription procedures cannot explain the lowered PCC scores in Study C.

The remaining explanations for the lowered average

TABLE 5. Descriptive data for children's Percentage of Consonants Correct (PCC).

	Normally developing children[a] Study 1	Study 2	Speech-delayed children Study A	Study B	Study C
N	72	35	29	38	14
M	77.57	81.44	70	68.30	62.20
SD	7.54	6.20	11	10.30	12.90
Range	58–99	69–95	48–91	46–89	36–77

[a]See footnote to Table 2 for references for Study 1 and Study 2.

PCC values for Study C children are that they either reflect some type of sampling error associated with the small number of usable tape samples (14) obtained in this off-site study, or that they reflect true differences in the severity levels of children referred to a regional diagnostic center in a non-university area. Additional population samples will be needed to provide more extensive reference data for the PCC metric.

PCC severity adjective. A second way to use the PCC computer data is to use this value in conjunction with other information to derive a severity adjective (i.e., Mild, Mild-Moderate, Moderate-Severe, or Severe involvement). The original procedures for assigning severity adjectives (Shriberg & Kwiatkowski, 1982c) have been supplemented so that they better reflect certain measurement accuracy and concurrent validity issues. Five conditional conventions that best fit the original statistical data and are consistent with subsequent information about this metric are used currently to assign and interpret a severity adjective.

1. If a child's PCC score is within four percentage points of the next more severe adjective category (85–100% = Mild; 65–84.9% = Mild-Moderate; 50–64.9% = Moderate-Severe; <50% = Severe

and

2. If the child has been rated a 2 on at least one of the six suprasegmental variables,

or

3. If the child is older than 6 years,

or

4. If the child has produced fewer than two-thirds glossable utterances,

then

the severity level is dropped to the next more severe adjective category.

However,

5. If most of the child's PCC errors (>50%) are due to phonetic distortions rather than to phoneme deletions and substitutions, the PCC severity adjective should not be used.

The first conditional convention addresses measurement accuracy, and Conventions 2, 3, and 4 reflect substantive findings for the correlates of severity ratings in the original study. The final conditional convention (5) follows from the previously described distinction between children with speech delays (deletions, substitutions) versus those with normally developing speech or only residual articulation errors (distortions). Since the original PCC study, which was based solely on speech samples from children with speech delays, it has become apparent that use of the PCC severity adjectives with children who make primarily distortion errors (i.e., children with residual errors) is inappropriate.

Table 6 includes the descriptive data for the PCC severity adjectives for each group. Allowing for the changes in conventions for deriving severity adjectives, the data in Table 6 suggest that approximately 85% of speech-delayed children have Mild-Moderate to Moderate-Severe involvement. Mild-Moderate involvement is most prevalent in all three studies, with at least 50% of children categorized in this group. Children who are so severely involved that over 50% of their consonants are incorrect (i.e., the Severe group) constitute a very small percentage (less than 10%) of children referred for speech delays of unknown origin.

TABLE 6. Distribution of children among the four severity categories of the Percentage of Consonants Correct (PCC) measure.

	Study A		*Study B*		*Study C*		*Combined A, B, C*	
PCC severity level	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Mild	3	10	2	5.3	0	0	5	6.2
Mild-Moderate	16	55	27	71.1	8	57.2	51	63.0
Moderate-Severe	9	31	6	15.8	4	28.6	19	23.5
Severe	1	3	3	7.9	2	14.9	6	7.4
Total	29		38		14		81	

PCC intelligibility data. A third section of the PCC output includes a measure of a child's intelligibility in the context of continuous speech. The software computes the percentage of total words that were intelligible by dividing all words that were glossable but not considered fillers, repetitions, interjections, etc. (Shriberg, in press) by the total "words" (intelligible + unintelligible) that occurred in the continuous speech transcript. The data in Table 7 are combined across studies to allow sufficient cell size for cross-tabulation by severity adjective. These intelligibility data indicate that speech-delayed children average approximately 80% intelligible words, with two thirds of children falling between ±15 percentage points (i.e., 65–95% intelligible). It should be kept in mind that the figures reflect data for children who are testable using contextualized, continuous speech formats. Only a few children, those with little speech and typically below age 3, have been untestable by some type of continuous speech sampling procedure (Shriberg & Kwiatkowski, 1985). Moreover, the data do not reflect the task faced by typical conversational partners of these children. Rather, they are percentage scores derived from an interview procedure, glossed by experienced transcribers (and aided by the examiner's gloss), who were allowed several audiotaped replays. Hence, these intelligibility data should be viewed as "best case," controlled estimates, rather than as intelligibility values derived from ecologically valid settings.

TABLE 7. Average intelligibility indices for the four Percentage of Consonants Correct (PCC) severity categories for Studies B and C.

		Intelligibility index	
PCC severity category	*n*	*M*	*SD*
Mild	2	97.6%	.88
Mild-Moderate	35	80.6%	15.60
Moderate-Severe	10	77.2%	11.00
Severe	5	78.0%	14.72
Total	52	80.3%	14.65

Causal-Correlates Findings

The Appendix provides a detailed summary of the causal correlates ratings for each of the three studies. Since 1982, a few original descriptors that more appropriately belonged with the speech data were deleted from the system, and descriptors dealing mostly with additional assessment and management data (e.g., children's learning styles) were added. The net change was from 90 descriptors in Study A to 127 descriptors in Study B and Study C. The right-most column gives the overall ratings percentages for each descriptor. These item-level values are provided for the interested reader who may wish to inspect the consistency of the prevalence findings across the three studies.

Because the number of children rated on each of the descriptors in the Appendix ranged from 1 to 105, the approach was to inspect only those descriptors that were rated for an arbitrary number of children. Tabulations indicated that 50% of the ratings for the 127 descriptors involved 39 children and 25% of the ratings involved 51 or more subjects. With these distributional data as a guideline, descriptors that were rated for 39–50 children (single asterisk) and for 51 or more children (double asterisks) were removed for additional analyses. Although the data for descriptors that did not meet these criteria are nevertheless interesting to inspect in the Appendix, they were not included in the following analysis.

Figure 4 is a display of the causal-correlates descriptors that were rated for 39–50 subjects (open bars) or more than 50 subjects (shaded bars), as described above. For each of the six domains, the percentage of available subjects rated 1 is shown below the horizontal division within each bar, with the added percentage rated 2 indicated above the division line. The circled number below each bar corresponds to the item numbers in the Appendix. The following is a summary of these data.

Among the seven Hearing descriptors in Figure 4, over 40% of the rated children had 1 or 2 on frequent middle-ear infections, abnormal impedance findings, lowered pure-tone thresholds, or caregiver observations of periodic hearing difficulty (see the Appendix, Descriptors 9, 8, 11, and 4, respectively). Moreover, approximately 30% of the rated children had histories of allergy problems (5), wax buildup (7), or elevated acoustic reflex findings on at least one occasion (1). Interpretation of the significance of these prevalence findings is not possible in the absence of well-matched control group data. Because these children had been the source of concern to caregivers and health service providers, their middle-ear histories could have been affected by several interrelated factors. For example, unintelligible, as opposed to normally developing, speech could prompt caregivers and physicians to take more aggressive approaches towards assessment and management of these children's medical and associated hearing needs. Currently, referrals for suspected middle-ear involvements and interpretation of findings underlying medical and surgical management recommendations reflect a complex of clinical factors and judgments. Although these percentage data indicate that many speech-delayed children have histories of significant middle-ear involvement, a series of local, unpublished studies using cross-sectional data have not, to date, cross-validated the associations between middle-ear history and specific sound changes reported in Shriberg & Smith (1983). As discussed in critical reviews of this literature (e.g., Bluestone & Cantekin, 1979; Paradise & Rogers, 1986; Ventry, 1980), studies are needed that include longitudinally concurrent assessment information on speech, language, hearing, immitance, and otologic status.

As shown in the second panel of Figure 4, 25 Speech descriptors were rated for either 39–50 children (open bars) or 51 or more children (filled bars). Ratings of 1 or 2 were scattered across these descriptors, which reflect case history and oral mechanism results, indicating deficits in structure or function (see the Appendix). These data indicate that few speech-delayed children (less than approximately 15%) were reported or observed to have potentially speech-related involvements on 18 of these 25 frequently rated descriptors. In decreasing percentage order, the seven descriptors that were rated 1 or 2 for approximately 40% to 15% of children were: mouth breathing (37), jaundice at birth (18), inconsistent articulation (41) (this originally inappropriately placed item has been discarded), reduced diadochokinetic rate (39), drooling (26), maloclussion (54), and hypernasality (38). Again, in the absence of information on the prevalence of each of these findings in a matched control group, interpretation of these data is limited. They do seem consistent with literature findings that speech-delayed children do not have any one obvious developmental difference affecting the speech mechanism. However, these percentage figures appear to suggest that certain children may have mechanism involvements and that continued study using more sensitive instrumentation is warranted.

The third panel in Figure 4 indicates that 6 of the 14 descriptors of Cognitive-Linguistic Comprehension functioning were rated for at least 39 of the 114 children. For each of these norm-referenced variables, approximately 38% to approximately 20% of the children were considered to have reduced performance. In decreasing percentages, these were deficits in learning (65), grade placement (64), reading ability (67), auditory memory performance (68), performance on the Miller-Yoder Test of Grammatical Comprehension (71), and question comprehension (72). These data suggest that significant cognitive-linguistic deficits are prevalent in as many as one third of children referred for speech delay of unknown origin. Such findings appear to have implications both for understanding causal origins of speech-language delay and for developing the types of speech-language intervention procedures that might be necessary for some, but not all, speech-delayed children. A significant finding here is that among the 42 children rated on grade placement (64), 3 children (7%) had repeated at least one grade, and 12 children (29%) had significant learning problems requiring special class placement (see the Appendix for additional detail). Concern about a child's academic future is a major impetus for early identification of and intervention for spech-delayed children. These descriptive data

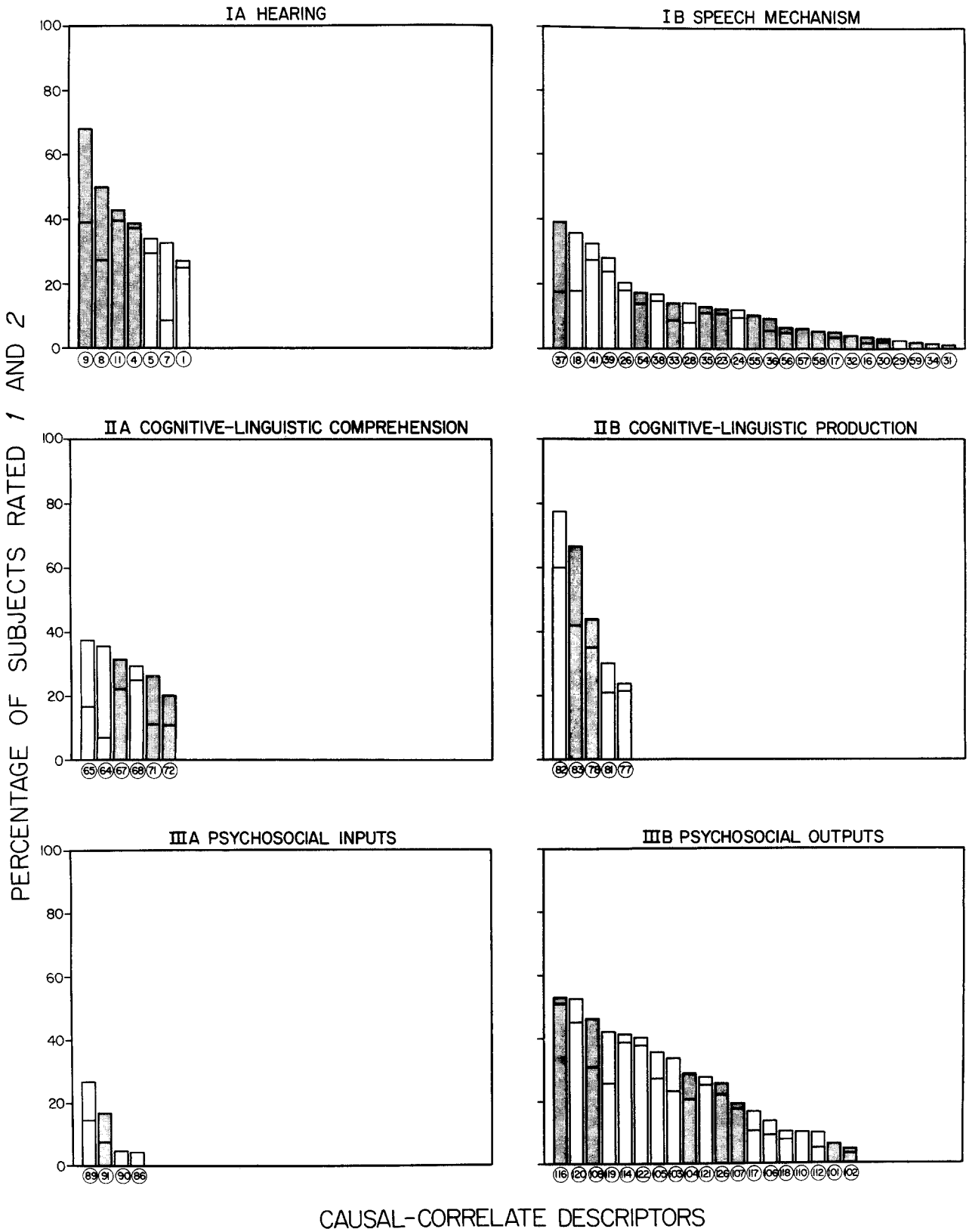

FIGURE 4. Percentage of subjects rated 1 or 2 on causal–correlates descriptors. Data are included only for causal–correlates items rated for 39–50 subjects (open bars) or more than 50 subjects (shaded bars). For each of the six domains, the percentage of subjects rated 1 is shown below the horizontal division within each bar; the additional percentage rated 2 is indicated by the area above the horizontal division. Circled numbers below each bar correspond to item numbers in the Appendix.

indicate that such concerns are realistic, and they underscore the need for continued efforts to understand the antecedents and consequences of cognitive-linguistic deficits.

Among the nine descriptors making up the Cognitive-Linguistic Production data, five were rated for more than 39 of the subjects (Figure 4). In decreasing percentages, from approximately 78% to approximately 22%, rated children had productive errors on pronouns (82), delayed syntax (83), delayed onset of speech (78), lexical retrieval problems (81), or language formulation problems (71). Once again, these data support a conclusion that many, if not most, speech-delayed children have some degree of language involvement.

The final two panels in Figure 4 provide data for the Psychosocial Input and Psychosocial Behavior descriptors that were used to rate at least 39 of the 114 children. Only four descriptors were so used for Psychosocial Input variables, with involvements for more than 15% of these children indicated for caregiver's type of behavior management (89) and overconcern about the child's problem (91). Among the 19 Psychosocial Behaviors descriptors rated for at least 39 children, 13 indicated involvements for at least 15% of the children. In decreasing percentage of occurrence these descriptors were shyness (116), speech avoidance (120), immaturity (108), need for external reinforcement (119), oversensitivity (114), unwillingness to repeat or clarify an utterance (122), distractibility (105), manipulative behavior (103), compliance problems (104), inconsistency of intelligibility (121), unwillingness to talk (126), difficulty separating from caregiver (107), and questionable play preferences (117). As with the Hearing and Speech Mechanism descriptors, these Psychosocial data are difficult to interpret in the absence of available reference data for normally developing children. However, the data for descriptors that deal specifically with speech-related behaviors indicate that an unintelligible speech pattern may be associated with significant social consequences for at least some speech-delayed children.

An additional way to describe the causal-correlates findings is presented in Figure 5. These data reflect the causal-correlate descriptors at the level of individual children. The numbers above the histograms indicate the percentages of children who received 0, 1, or 2 as their highest rating on at least one descriptor in each of the six domains. These data may be summarized as follows: (a) approximately two thirds (67%) of the subjects in the three studies have some case history data indicating middle-ear or Hearing involvement (i.e., their highest rating is 1 or 2), and over 70% of the subjects have at least one Speech mechanism descriptor rated 1 or 2; (b) descriptors for Cognitive-Linguistic function indicate that about 40% of the children have at least one Comprehension descriptor rated 1 or 2, whereas approximately 75% have at least one Production descriptor rated 1 or 2; and (c) the summary Psychosocial data suggest that over 35% of the subjects have at least one Input descriptor rated 1 or 2, and over 60% have at least one Behavior descriptor rated 1 or 2.

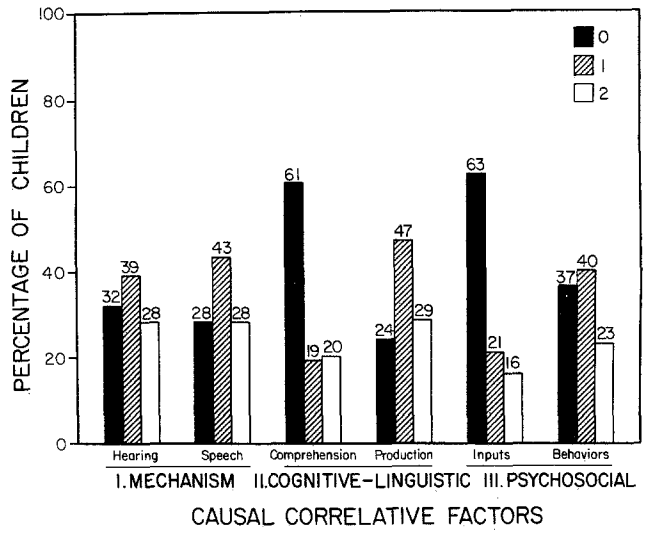

FIGURE 5. Percentage of subjects who received 0, 1, or 2 as their highest rating on at least one descriptor within each of the six domains.

A summary descriptive statistic that may be useful is the overall percentage of subjects rated 1 or 2 on any of the 127 descriptors. For 1 ratings, the mean value across the 18 comparisons (3 studies × 6 domains) was 34.6% (SD = 15.9%; range = 10.5%–71.1%); for 2 ratings, M = 22.6% (SD = 11.3%; range = 4.1%–44.7%). These data indicate that approximately 35% of children had a 1 as their highest rating on any of the 127 descriptors, and approximately 23% of children had at least one 2 descriptor somewhere among one of the six causal-correlates domains.

Reliability, Learnability, and Efficiency of the Diagnostic Classification System

The second goal of this research was to examine the reliability, learnability, and efficiency of the diagnostic classification system. Several observations concerning these factors emerged in the context of data reduction for Study C.

The first observation relates broadly to assessment issues. As described earlier, only 14 of the 33 packets of subject data collected off-site could be fully processed by the graduate student research assistants. Annotations indicated that 11 subject tapes could not be transcribed due to the unacceptable quality of the tape recordings (e.g., poor signal-to-noise levels, extraneous room noises, etc.) or to technical difficulties in speech sampling (e.g., failure to gloss on-line, insufficient length or productivity of the continuous speech samples). Audiocassette technology appears to be adequate for a variety of speech sampling approaches, provided that clinicians follow technically stringent protocols for obtaining quality samples (Ingram, 1976; Shriberg, in press; Shriberg & Kwiatkowski, 1985; Stoel-Gammon & Dunn, 1985). The finding that one third of a clinical sample (11/33) was lost to linguistic analysis

underscores the importance of such methodologic details. An additional 8 subject packets could not be processed because the diagnostic information was insufficient; for example, they lacked information on hearing-speech mechanism or psychosocial inputs. The finding that approximately one fourth (8/33) of the clinical diagnostic data were incomplete for the present purposes may suggest that not all speech-delayed children receive adequate diagnostic evaluations, especially in settings where caseloads are high. Given the current press to provide services for children with exceptional educational needs, diagnostic time is at a premium. Children with "functional" speech delays may not be scheduled for the full resources of a diagnostic evaluation. Yet, the causal-correlates findings just reviewed suggest that such factors as middle-ear history and psychosocial background are important domains to assess in detail, and that obtaining detailed language information is particularly important.

A second and more circumscribed suggestion that arose from Study C is the need for clarification and elaboration of the causal-correlates descriptors listed in the Appendix. The research assistants in Study C reported that they needed to make many passes through the folders in order to sort and code the diagnostic information. They suggested that more guidelines were needed to match diagnostic data to existent descriptors, that more descriptors were needed to accommodate available data, and that whenever possible, such subjective terms as "occasional" and "frequent" should be replaced by more quantitative descriptors. Each of these suggestions has been implemented in a revision of the system, which currently numbers nearly 175 descriptors.

A third methodological observation by the student clinicians was that the system was generally efficient. They noted that almost all of the diverse assessment information available in the folders was used for some descriptor. They estimated that once the process was learned, making the paper and pencil entries took about 45 min per subject. A current version has been computerized, providing more efficient data entry, data base search-retrieval, and computer-aided report writing. A very approximate time estimate is that the complete process—including a 2-hr diagnostic assessment, phonetic transcription and suprasegmental rating of the speech sample, and computer-aided entry and analyses of the speech and causal-correlates data—requires 7 hr per child. Whether such time expenditures are defensible in a clinical setting will depend on the potential of the system to yield subclassification profiles and, in turn, on the potential benefits of diagnostic classification for prediction and management planning.

CONCLUSION

This description of children with phonologic disorders of unknown origin is presented as a first step toward a reference data base. The system used to collect, organize, reduce, and interpret diagnostic information appears to be learnable and reliable, although both the speech and the causal-correlates variables involving subjective judgments require additional development. Among the research needs are studies that attempt to link specific patterns of mechanism, cognitive-linguistic, and psychosocial involvements to specific profiles of speech involvement.

One research approach is to use these descriptive methods to study children with documented involvements in each of the six causal-correlates domains in order to determine how such factors as velopharyngeal dysfunction, intellectual deficits, emotional disturbance, and so forth affect the distribution and precision of allophone-level speech targets. Another approach is to attempt to assess and classify additional large groups of children with speech delays of unknown origin, using measurement instruments and statistical approaches not available in the present retrospective case study data. A diagnostic classification system consisting of seven causal-correlate categories has been proposed for this purpose (Shriberg, 1982a; Shriberg & Kwiatkowski, 1982a). Studies along both of the lines proposed above are in progress; to date, no one profile of segmental and suprasegmental behaviors has yet been associated with any of the putative categories.

What does seem clear is that if such terms as *childhood apraxia, mild neuromotor involvement, immature speech,* and others are to be used at all, their associated diagnostic profiles need to be identified for refined study. Clinical experience continues to suggest that subgroups do exist among children with "functional" articulation disorders and that effective intervention may depend on early identification and programming that addresses relevant individual differences.

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APPENDIX

Causal-correlates descriptor ratings for speech-delayed children in Studies A, B, and C. (See text for explanations of asterisks.)

		Rating definitions		*Study A*			*Study B*			*Study C*				*Combined*		
Item	*0*	*1*	*2*	*0*	*1*	*2*	*0*	*1*	*2*	*0*	*1*	*2*	*n*	*%0*	*%1*	*%2*
I MECHANISM																
A. Hearing																
1 Allergies	none	mild; controlled with mild medication	severe; persistent; strong medication	0	3	0	27	5	1	8	4	0	48	73	25	2
2 Asthma	not present	mild	severe	—	—	—	28	3	0	—	—	—	31	90	10	0
3 Sinuses	normal	intermittent sinus condition warrants medication	chronic sinus condition; treated with medication	0	2	0	13	1	0	1	2	0	19	74	26	0
4 Hearing; observationally **	normal	"does not always seem to hear; is sometimes indifferent to sound"	"seems to always have trouble hearing"	7	3	1	19	18	0	15	4	0	67	61	37	2
5 Wax buildup	none	periodic wax buildup warrants medical attention	frequent; excessive wax buildup warrants medical attention	0	3	2	27	6	0	2	4	0	44	66	30	5
6 Eustachian tube function	normal	suspected or confirmed dysfunction in one ear	confirmed dysfunction in both ears	0	4	2	1	3	1	—	—	—	11	9	64	27
7 Acoustic reflex	normal	slightly elevated on at least one occasion	confirmed dysfunction in both ears	3	1	4	13	2	0	15	1	7	46	67	9	24
8 Impedance	normal	negative pressure in one ear on at least one occasion	negative pressure in both ears on at least one occasion	9	5	1	8	8	7	14	4	6	62	50	27	23
9 Infections	none	frequent; require medical attention and possible PE tubes	frequent; PE tubes placed in both ears	1	7	6	14	13	8	7	7	6	69	32	39	29
10 Tympanic membrane	normal	scoring in one ear	scoring bilaterally	0	1	0	3	1	0	6	1	0	12	75	25	0
11 Pure tone **	normal	mild conductive loss in one or both ears on at least one occasion	mild–moderate conductive loss on repeated occasions in one or both ears	18	13	1	19	14	2	15	9	0	91	57	40	3
12 Heredity factor	no family history	one parent has congenital malformation or sensorineural loss since childhood	both parents have congenital malformation or sensorineural loss since childhood	—	—	—	—	—	—	7	1	0	8	88	13	0

Item	Rating definitions 0	1	2	Study A 0	1	2	Study B 0	1	2	Study C 0	1	2	Combined n	%0	%1	%2
B. Speech																
13 Adenoids; size	normal	slightly enlarged	significantly large	0	1	0	2	6	2	1	2	0	14	21	64	14
14 Heredity factor	not present	single family member with same problem	more than one family member with same problem	0	1	0	4	8	2	1	3	1	20	25	60	15
15 Prematurity	full term	1 month premature	greater than 1	—	—	—	10	3	0	—	—	—	13	77	23	0
16 Pregnancy **	normal	threat of miscarriage late in pregnancy	frequent threat of miscarriage throughout pregnancy	0	1	1	31	0	0	21	0	0	54	96	2	2
17 "Blue" **	not present	blue at birth; short period; oxygen not required	blue at birth for extended period; oxygen required	0	1	0	33	1	0	19	0	1	55	95	4	2
18 Jaundice *	not present	jaundice at birth: short duration	jaundice at birth: extended duration	0	0	1	25	3	6	0	4	0	39	64	18	18
19 Delivery position	normal	"transverse," "breech"; required C-section		—	—	—	17	5	1	0	4	0	27	63	33	4
20 Neurological	normal	suspected minimal brain damage; "soft signs"	medically confirmed minimal brain damage	0	1	0	3	0	0	1	1	0	6	67	33	0
21 Seizures	not present	periodically: effectively controlled with medication or occur only with fevers	periodically/ frequently: not effectively controlled with medication or grand mal seizure pattern	—	—	—	32	1	0	—	—	—	33	97	3	0
22 Neuromotor	normal	suspected dysarthria or dyspraxia	confirmed dysarthria or dyspraxia	2	5	1	9	11	0	—	—	—	28	39	57	4
23 Walking onset **	normal	slightly delayed	significantly delayed	2	2	0	28	4	1	26	1	0	64	88	11	2
24 Chewing *	normal	noticeably slow, but coordinated	significant difficulty coordinating movements	2	1	1	27	3	0	7	0	0	41	88	10	2
25 Choking	none	periodically chokes on food	frequently chokes on food	0	1	0	27	2	0	7	0	0	37	92	8	0
26 Drooling *	none	drools when concentrates on tasks	chronic drooling	0	1	1	28	6	0	7	1	0	44	80	18	2
27 Pooling of saliva	none	periodic	frequent	—	—	—	32	2	0	—	—	—	34	94	6	0
28 Larynx quality *	normal	somewhat hoarse	hoarse to aphonic	0	0	3	34	3	0	8	1	0	49	86	8	6
29 Laryngeal web	not present	web present, but not obstructing airway or vocal folds	web present; obstructs movement of vocal folds	0	1	0	38	0	0	—	—	—	39	97	3	0
30 Lip movement **	normal	slightly limited during speech	significantly limited during speech	24	1	1	35	1	0	30	0	0	92	97	2	1
31 Structure; palate **	normal	repaired cleft	unrepaired cleft	26	0	0	34	1	0	25	0	0	86	99	1	0
32 Mandible movement **	normal	slight extraneous movement relative to tongue movement	considerable extraneous movement relative to tongue movement	5	1	0	32	2	0	30	0	0	70	96	4	0

Item		Rating definitions 0	1	2	Study A 0	1	2	Study B 0	1	2	Study C 0	1	2	Combined n	%0	%1	%2
33	Palate; hard **	normal	slightly high and narrow	significantly high and narrow	0	1	0	24	3	3	24	1	0	56	86	9	5
34	Palate; structure **	normal	repaired cleft (surgically or in-utero) or suspected submucousal cleft	unrepaired cleft or confirmed submucousal cleft	3	0	0	29	1	0	25	0	0	58	98	2	0
35	Palate; soft, length **	normal	somewhat short; x-ray recommended prior to adenoidectomy	significantly short; associated with velo-pharyngeal incompetence	0	4	1	26	2	0	20	0	0	53	87	11	2
36	Palate; soft, movement **	normal	limited	limited, with demonstrated velopharyngeal incompetence	0	3	1	29	0	0	18	0	1	52	90	6	4
37	Respiratory; mouth breathing **	not present	intermittent	habitual	0	2	2	23	7	7	8	0	2	51	61	18	22
38	Resonance hypernasality	not present	mild–intermittent	moderate–severe; persistent	0	2	1	34	3	0	5	2	0	47	83	15	2
39	Diadokokinesis	normal	accurate, but slow and/or arrhythmic	significantly slow and/or arrythmic	2	1	0	16	9	1	15	1	1	46	72	24	4
40	Dyspraxia test	normal	mild involvement	moderate–severe involvement	2	1	3	2	1	0	—	—	—	9	44	22	33
41	Consistency of word production during spontaneous speech *	consistent production for correct and incorrect	production of correct is consistent; production of incorrect is variable	production of correct and incorrect is inconsistent	—	—	—	25	11	2	2	0	0	40	68	28	5
42	Consistency of production of words in imitation	consistent production for correct and incorrect	production of correct is consistent; production of incorrect is variable	production of correct and incorrect is inconsistent	—	—	—	13	18	5	—	—	—	36	36	50	14
43	Use of starters, fillers prior to identifiable utterances	none	periodic use	frequent use	—	—	—	30	4	2	—	—	—	36	83	11	6
44	Precision	normal	noticeable decrease in precision with increase in rate	imprecise at all rates	0	3	1	3	2	1	3	0	0	13	46	39	15
45	Rate	normal	noticeably slow	significantly slow	0	1	2	—	—	—	2	0	0	5	40	20	40
46	Sequencing test	normal	mild problem with rate and accuracy of sound/syllable sequencing	moderate–severe problem sequencing sounds and/or syllables	0	2	0	2	2	0	16	1	1	24	75	21	4
47	Stimulability at sound level	readily stimulable on variety of sounds	readily stimulable on a limited number of sounds	not readily stimulable	—	—	—	11	16	9	—	—	—	36	31	44	25
48	Stimulability at word level	readily stimulable on variety of sounds	readily stimulable on a limited number of sounds	not readily stimulable	—	—	—	7	16	13	—	—	—	36	17	58	25
49	Cues needed in therapy	only auditory	auditory and visual	cues in addition to auditory and visual	—	—	—	6	20	9	0	1	0	36	19	44	36

Item	Rating definitions 0	1	2	Study A 0	1	2	Study B 0	1	2	Study C 0	1	2	Combined n	%0	%1	%2
50 Ability to retain speech target and produce word naturally	achieves within reasonable amount of time spent practicing	achieves after repeated trials	problems: loses production of target sound as tries for natural production	—	—	—	12	11	9	—	—	—	32	38	34	28
51 Quality of production of target with repeated concentrated practice	production improves	production becomes variable	production deteriorates significantly	—	—	—	20	10	2	—	—	—	32	63	31	6
52 Assimilation across words	not evident	occurs at times	occurs frequently	—	—	—	5	3	0	—	—	—	8	63	38	0
53 Teeth, condition	good	some cavities, filled or not; missing teeth	extensive cavities, filled or not; extensive missing or capped teeth	0	1	1	25	1	0	—	—	—	28	89	7	4
54 Teeth, occlusion **	normal	mild malocclusion; jumbled teeth	moderate–severe malocclusion; jumbled teeth	1	7	1	27	1	1	19	0	0	57	83	14	4
55 Tongue, elevation **	normal	noticeably difficult	significantly difficult	22	4	0	28	5	0	26	0	0	85	89	11	0
56 Tongue, extraneous movement **	none	slight	significant	0	1	1	29	3	0	26	0	0	59	93	5	2
57 Tongue, lateral movement **	normal	noticeably difficult	significantly difficult	20	1	0	28	3	0	26	1	0	79	94	6	0
58 Tongue; position at rest **	normal	slight deviation from midline	significant deviation from midline	0	1	0	30	1	0	20	1	0	53	94	6	0
59 Tongue; size **	normal	somewhat large in relation to oral cavity	significantly large in relation to oral cavity	1	1	0	29	0	0	20	0	0	51	98	2	0
60 Tonsils; size	normal	slightly enlarged	significantly enlarged	0	4	0	12	7	1	7	2	4	37	51	35	14
61 Uvula	normal	slight structural difference (e.g., partial bifidity)	bifid	—	—	—	19	2	0	0	0	1	22	86	9	5
62 Clumsiness	not present	parent reports frequent clumsiness, or OT/PT reports describe slight delay in motor development	OT/PT reports describe >1-year delay, based on any test	—	—	—	—	—	—	4	2	1	7	57	29	14
II COGNITIVE-LINGUISTIC																
A. Comprehension																
63 Directions	grade level	up to 1-year delay in ability to follow directions	beyond 1-year delay in ability to follow directions	3	2	0	16	7	2	—	—	—	30	63	30	7
64 Grade *	age appropriate	repeated grade	special class placement, confirmed learning problem	2	2	3	25	1	9	—	—	—	42	64	7	29
65 Learning *	normal	parent/teacher question learning ability	special class placement, confirmed learning problem	10	1	6	20	7	4	—	—	—	48	63	17	21

Item		Rating definitions 0	1	2	Study A 0	1	2	Study B 0	1	2	Study C 0	1	2	Combined n	%0	%1	%2
66	Reading	grade level	up to 1-year delay	beyond 1-year delay	0	1	0	3	2	0	—	—	—	6	50	50	0
67	Lexical, PPVT **	age appropriate	up to 1-year delay in vocabulary comprehension	beyond 1-year delay in vocabulary comprehension	17	6	2	20	9	4	21	4	2	85	68	22	9
68	Memory; auditory *	normal	questionable	confirmed deficits	0	1	0	23	8	2	8	2	0	44	71	25	5
69	Overgeneralization of targets in therapy	not overgeneralizing	some overgeneralization	clearly overgeneralizing	—	—	—	23	6	3	—	—	—	32	72	19	9
70	Discrimination of speech errors in another's production **	discriminates all errors	discrimination some errors	cannot discriminate any errors	—	—	—	30	1	0	—	—	—	31	97	3	0
71	Syntax; Miller-Yoder Test	age appropriate	passed 80% of age-level items	passed <80% of age-level items	4	0	1	13	1	6	22	5	1	53	74	11	15
72	Syntax; questions **	age appropriate	up to 1-year delay in comprehension of question forms	beyond 1-year delay in comprehension of question forms	12	1	1	17	3	3	22	3	2	64	80	11	9
73	Second language spoken at home	not applicable	one or both parents occasionally speak a different language	one or both parents consistently speak a different language	—	—	—	—	—	—	0	1	0	1	10	0	0
74	Piagetian cognitive tasks	age appropriate	informal tests indicate up to 1-year delay	informal tests indicate greater than 1-year delay	—	—	—	—	—	—	6	1	0	7	86	14	0
75	Discrimination of correct production of speech sounds in another's production	normal	some errors when discriminating sounds normally produced by the child	frequent errors when discriminating sounds normally produced by the child	—	—	—	—	—	—	19	3	0	22	86	14	0
76	Auditory reception; subtest of ITPA	normal	performance within 1–2 *SD* below $\bar{x}$	performance >2 *SD* below $\bar{x}$	—	—	—	—	—	—	4	0	2	6	67	0	33
B. Production																	
77	Formulation *	age appropriate	suspected problem in ability to formulate ideas	confirmed problem in ability to formulate ideas	0	4	1	32	5	0	—	—	—	42	76	21	2
78	Talking onset **	normal	parents report up to 1-year delay	parents report beyond 1-year delay	0	1	0	18	14	2	14	6	2	57	56	35	9
79	Babbling	normal	limited	none/very little	—	—	—	22	1	2	—	—	—	25	88	4	8
80	Preschool Language Scale: Zimmerman, Steiner, & Evatt	age appropriate	up to 1-year delay on Verbal Ability scale	beyond 1-year delay on Verbal Ability scale	2	2	0	9	2	3	—	—	—	18	61	22	17
81	Lexical; retrieval *	normal	suspected problem in ability to retrieve words	confirmed problem in ability to retrieve words	0	2	3	30	6	1	0	1	0	43	70	21	9
82	Use of pronouns *	no errors	error on only one of person forms	error on more than one person forms	0	1	0	9	22	7	0	1	0	40	23	60	18
83	Syntax development **	age appropriate	up to 1-year delay	beyond 1-year delay	4	21	12	19	12	7	12	11	7	105	33	42	25

Item	Rating definitions 0	1	2	Study A 0	1	2	Study B 0	1	2	Study C 0	1	2	Combined n	%0	%1	%2
84 Uses jargon	N/A	parents report child occasionally produces jargon	parents report child frequently produces jargon	—	—	—	—	—	—	0	1	0	1	0	100	0
85 Other preschool screener	pass	failed expressive language section	failed both comprehension and expressive language sections	—	—	—	—	—	—	0	1	0	1	0	100	0
III. PSYCHOSOCIAL																
A. Inputs																
86 Friends *	age appropriate	somewhat limited to younger children	plays only with younger children	2	1	0	35	1	0	8	0	0	47	96	4	0
87 Acceptance by peers	readily accepted	accepted after initial period of nonacceptance	never fully accepted	4	0	0	26	1	1	—	—	—	32	94	3	3
88 Parents; abuse	no reports	suspected child abuse	confirmed child abuse	0	0	1	18	0	0	2	0	1	22	91	0	9
89 Parents; behavior management *	normal	somewhat ineffective	considerably ineffective	0	1	3	27	5	2	3	0	0	41	73	15	12
90 Parents; caregiving *	supportive	somewhat nonsupportive	considerably nonsupportive	0	0	1	31	0	0	10	0	1	43	95	0	5
91 Parents; concern **	appropriate	somewhat overconcerned with child's problems	considerably overconcerned with child's problems	0	1	3	29	3	2	15	0	0	53	83	8	9
92 Parenting effectiveness	effective	need some parenting training	need extensive parenting training	0	0	2	23	7	2	—	—	—	34	68	24	9
93 Independence training	normal	somewhat reluctant to train child to be independent	considerably reluctant to train child to be independent	0	1	0	30	2	0	—	—	—	33	91	9	0
94 Language stimulation	normal	somewhat limited	significantly limited	0	0	1	9	3	1	2	1	1	18	61	22	17
95 Marital stability	normal	unsettled; some separation threats and disputes	considerably unstable; disputes	0	3	0	5	0	0	0	0	1	9	56	33	11
96 Parental responsibility	normal	slightly overwhelmed by parental responsibilities	considerably overwhelmed by parental responsibilities	0	2	1	28	2	1	1	0	0	35	83	11	6
97 Parental expectation	normal; age appropriate ability level expectation	slightly high or low level expectation; somewhat inconsistent with age/ability level	considerably high or low expectations; significantly inconsistent with age/ability level	—	—	—	32	3	1	—	—	—	36	89	8	3
98 Sibling comparison	normal	somewhat unfavorable comparison of child to sibling(s)	considerably unfavorable comparison of child to sibling(s)	0	0	1	24	3	0	1	0	0	29	86	10	3
99 Therapy support	positive	parent somewhat indifferent to child's speech progress	parent does not make effort to see or support child's speech therapy	0	1	1	30	4	0	2	0	0	38	84	13	3
100 Parents' understanding of therapy	normal	question their understanding of therapy and of what they are to do when practicing with their child	parents do not understand therapy or what they are to do when practicing with their child. They need explicit directions.	—	—	—	29	2	2	1	0	0	34	88	6	6

Item		Rating definitions 0	1	2	Study A 0	1	2	Study B 0	1	2	Study C 0	1	2	Combined n	%0	%1	%2
B. Psychosocial Behaviors																	
101	Affect **	appropriate	limited	significantly limited	0	2	0	36	2	0	25	0	0	65	94	6	0
102	Aggression **	normal	periodically overaggressive	consistently overaggressive	0	1	1	37	1	0	24	0	0	64	95	3	2
103	Degree of manipulative behavior in therapy *	not overmanipulative	periodically overmanipulative	constantly manipulative	—	—	—	25	9	4	1	0	0	39	67	23	10
104	Compliance **	normal	compliant when expectations are made clear	compliant only in highly structured situations	0	4	1	26	8	4	26	3	1	73	71	21	8
105	Attention in therapy *	normal	somewhat distractible; can attend for short periods	highly distractible	—	—	—	22	13	2	9	0	2	48	65	27	8
106	Dependence on adults *	normal	somewhat too dependent	overly dependent	0	0	2	36	2	0	2	2	0	44	86	9	5
107	Separates from adults **	normal	separates from parents only after encouragement	cannot be encouraged to separate from parents	0	0	1	33	5	0	13	5	0	57	81	18	2
108	Maturity **	age appropriate	somewhat immature behaviors	considerably immature behaviors	1	2	6	23	10	2	4	4	0	52	54	31	15
109	Need for approval	normal	somewhat high	considerably high	0	0	2	30	6	0	—	—	—	38	79	16	5
110	Nervous habits *	none	limited to some situations	consistently, in many situations	0	2	0	36	2	0	—	—	—	40	90	10	0
111	Psychosocial development	normal	somewhat delayed	significantly delayed	0	0	1	10	2	2	5	3	0	23	65	22	13
112	Self-concept *	positive	somewhat poor	significantly poor	0	0	1	34	2	1	3	0	0	41	90	5	5
113	Sensitivity to others	normal	somewhat overconcerned about others' feelings	considerably overconcerned about others' feelings	0	1	0	33	2	0	—	—	—	36	92	8	0
114	Sensitivity to self *	normal	somewhat too sensitive; feelings easily hurt	overly sensitive; feelings very easily hurt	0	1	1	23	13	0	0	1	0	39	59	39	3
115	Social responsiveness; first year	normal	somewhat shy, quiet, fearful	considerably shy, quiet, fearful	0	0	1	31	0	0	—	—	—	32	97	0	3
116	Social responsiveness; new situations **	normal	somewhat shy, quiet, fearful	considerably shy, fearful	0	9	1	24	14	0	0	3	0	51	47	51	2
117	Social responsiveness; play *	normal	often chooses to play alone	consistently chooses to play alone	1	1	2	33	4	1	6	0	0	48	83	10	6
118	Social responsiveness; questions *	normal	somewhat unresponsive to direct questions	generally unresponsive to direct questions	0	0	1	35	2	0	0	1	0	39	90	8	3
119	Social responsiveness; reinforcement	normal	needs somewhat more external reinforcers	needs considerably more external reinforcers	2	2	2	23	9	4	0	0	1	43	58	26	16

Item		Rating definitions 0	1	2	Study A 0	1	2	Study B 0	1	2	Study C 0	1	2	Combined n	%0	%1	%2
120	Speech related; avoidance	normal	some avoidance of difficult speech tasks	frequent avoidance of difficult speech tasks	0	2	1	18	15	2	1	1	0	40	48	45	8
121	Intelligibility *	consistency	somewhat variable by situation's context	considerably variable; associated with situational context	0	0	1	28	10	0	1	0	0	40	73	25	3
122	Requests for clarification *	normal	often unwilling to repeat an utterance	consistently unwilling to repeat an utterance	0	2	0	24	13	0	0	0	1	40	60	38	3
123	Response to speech therapy	normal	often frustrated; needs encouragement	consistently frustrated	0	2	0	23	11	0	—	—	—	36	64	36	0
124	Willingness to work on targets in therapy	very willing	somewhat unwilling during speech tasks at times	unwillingly frustrated	—	—	—	17	15	4	—	—	—	36	47	42	11
125	Rate of change	making steady progress	moderately slow	significantly slow	—	—	—	14	12	6	—	—	—	32	44	38	19
126	Willingness to talk **	normal	hesitant in many situations	hesitant in most situations	0	1	0	27	10	1	14	1	1	55	75	22	4
127	Confidence in own ability to communicate	normal	questions own ability at times	often questions own ability	—	—	—	22	16	0	—	—	—	38	58	42	0

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