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Developmental Phonological Disorders II: Short-Term Speech-Sound Normalization

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A companion paper (Shriberg & Kwiatkowski, 1994) provides a descriptive profile of three samples of children (n = 178) with developmental phonological disorders. The present paper describes a conceptual framework for short-term and long-term speech-sound normalization research and reports 1-year normalization outcomes for 54 of the children described in the companion paper. Although certain individual speech variables were significantly associated with normalization, there were no speech, prosody-voice, or risk-factor variables that discriminated children who achieved short-term speech-sound normalization in 1 year. Findings are discussed in relation to a two-factor framework to study and predict speech-sound normalization in developmental phonological disorders (Kwiatkowski & Shriberg, 1993; Shriberg, Kwiatkowski, & Gruber, 1992).

KEY WORDS: phonology, disorders, prosody, developmental, prediction

The present study assesses the power of an array of speech, prosody-voice, and risk-factor variables to predict speech-sound normalization in young children with speech disorders of unknown origin. The following discussion provides a conceptual framework for this study and a companion article in long-term speech-sound normalization (Shriberg, Gruber, & Kwiatkowski, 1994).

A Framework for Research in Speech-Sound Normalization

Definitions

Developmental phonological disorders. A recently proposed instrument titled the Speech Disorders Classification System (SDCS) defines a *developmental phonological disorder* as a speech disorder of known or unknown origin that has its onset during the developmental period, nominally 0–12 years (cf. Shriberg, 1980, 1982, 1993; Shriberg & Kwiatkowski, 1982). Unlike classification systems based on etiological considerations, the SDCS is based on a descriptive characterization of the speech involvement in relation to time of onset of the disorder. In addition to two classifications indicating either normal speech acquisition or normalized (i.e., currently normal, but previously disordered) speech, the SDCS includes two primary classification categories for developmental phonological disorders. Children with deletion and substitution errors persisting past 4 years of age are classified as having a *Speech Delay,* whereas children with speech-sound distortions persisting past 9 years of age are classified as having *Residual Errors.*

Speech-sound normalization. In developmental phonological disorders, *speech-sound normalization* may be defined as the processes and behaviors by which speech becomes normally articulate over time. This deliberately broad definition

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allows speech-sound normalization research to embrace theoretical issues and applied needs in a number of otherwise disparate areas within communicative disorders. Relevant speech-sound normalization research literature includes descriptive studies of normal speech acquisition as well as studies addressing such explanatory-predictive questions as (a) Which infants and toddlers will develop a speech disorder? (b) What associated problems are likely? (c) Which children will normalize without treatment? (d) Is the process of speech-sound normalization similar in children who normalize with and without treatment? (e) Is the process of speech-sound normalization similar across treatment approaches? and (f) When is it appropriate to dismiss a child from treatment?

Short-term and long-term speech-sound normalization. It is useful for both theoretical and applied needs to divide time frames for speech-sound normalization into two periods. *Short-term* speech-sound normalization for preschool children identified as having Speech Delay is defined as normalized speech by 6 years of age. Thus, with an average referral age of 4 years, 3 months (Shriberg & Kwiatkowski, 1994), short-term speech-sound normalization for a child with Speech Delay typically occurs within approximately 2 years from the time at which children are first identified as having Speech Delay. For children identified as having Residual Errors, the SDCS system places the boundary for short-term speech-sound normalization at 9 to 11 years of age depending on the specific speech sound(s) in error (cf. Shriberg, 1993, Table A in Appendix). Thus, as with Speech Delay, there is a period of 2 years from the time of diagnostic classification in which short-term speech-sound normalization may occur. *Long-term* speech-sound normalization for a child with Speech Delay is defined as the achievement of articulate speech at any point after the 2-year period for short-term normalization—nominally, at any age from 6 years to adulthood. Long-term normalization for Residual Errors also is any time from 9-11 years to adulthood. The SDCS timelines are based on reviews of the literature in normal and disordered speech acquisition. These timelines are also consistent with clinician observations that many children identified as having a speech disorder "grow out of it" by 6 years for Speech Delay or by 9-11 years for Residual Errors (cf. Bernthal & Bankson, 1993).

Relevant Research Literature

The diversity of cross-sectional and longitudinal research relevant to the study of speech-sound normalization in children is represented by the schema in Figure 1. This graphic divides each of three research parameters into two subdivisions, yielding a total of eight categories within which to assemble research findings relevant to processes underlying speech-sound normalization.

The horizontal axis in Figure 1 divides subject cohorts (i.e., a group followed over time) by their age at first assessment. Placement of the major boundary at 6 years of age appears to be the most appropriate division relative to both theoretical issues (e.g., chronological, cognitive, language, and phonological stages—see Grunwell, 1982; Ingram, 1989) and

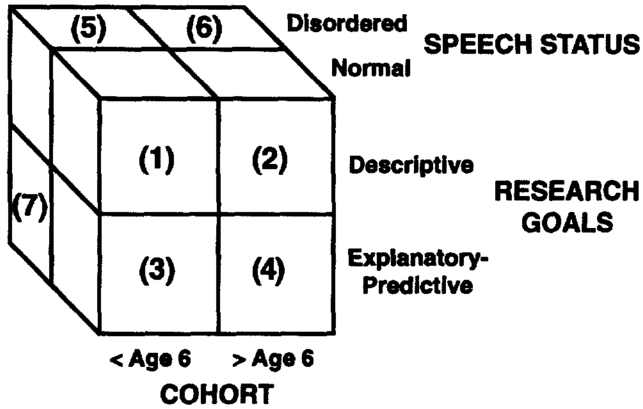


FIGURE 1. An eight-category classification schema for research literature relevant to short-term and long-term speech-sound normalization.

demographic variables (e.g., grade in school, sociolinguistic group) in these literatures. For the array of questions in short-term and especially long-term speech-sound normalization research, further subdivisions of this axis could usefully be developed to span at least seven age cohorts: infants, toddlers, preschoolers, school-age children, adolescents, adults, and seniors.

The vertical axis in Figure 1 divides the research goals of speech-sound normalization studies into two major types: *descriptive* studies and *explanatory-predictive* studies. Descriptive studies provide information on behaviors, including the sequence, rate, and error patterns observed in speech-sound normalization. Explanatory-predictive studies attempt to identify biological and psycholinguistic processes underlying change in speech-sound normalization, for both theoretical explication and for clinical needs.

The third axis in Figure 1 divides studies by subjects' speech status: surveys and other studies of children with normal speech acquisition and studies of children with speech disorders of known and unknown origin. As an organizational heuristic, subordinate classifications for each of the eight categories in Figure 1 could be developed to address the diversity of questions, subjects, and research designs relevant to the linguistic behaviors observed in speech-sound normalization and the processes presumed to underlie these behaviors.

To illustrate the categories represented by the cells in Figure 1, there are many descriptive studies of the segmental characteristics of children acquiring speech normally (Figure 1, cells 1 and 2). An active research literature in the last two decades has also produced numerous descriptions of the speech of children with disorders identified during preschool years (cell 5) and school years and beyond (cell 6). However, considerably less literature is concerned with explanatory-predictive questions for children acquiring speech normally (cells 3 and 4) and for children with clinically significant involvements (cells 7 and 8; cell 8 is behind cell 4 and hence not visible in Figure 1). As addressed in the next section, the emphasis in the present paper is on studies falling within cell 7 in Figure 1—research on variables associated with explanatory-predictive factors in preschool children with developmental phonological disorders.

Prediction Research and Practice in Developmental Phonological Disorders

Notwithstanding 60 years of research efforts to develop valid predictive instruments for developmental phonological disorders, there currently is no clinically effective procedure to predict which child will normalize with or without intervention. Table 1 includes a representative sample of explanatory-predictive research in developmental phonological disorders. These studies illustrate the types of variables and methods that have been used to attempt to predict the sequence, rate, and error patterns occurring in speech-sound normalization. The independent variables in explanatory-predictive research can be divided broadly into two sets: risk-factor variables and speech variables.

Risk-factor variables. As shown in Table 1, the predictive power of a variety of risk-factor variables has been studied. The most reliable finding for preschool children with speech delay is that those with lowered cognitive and language comprehension performance have the poorest short-term and long-term outcomes (Bishop & Adams, 1990; Bishop & Edmundson, 1987; Shriberg & Kwiatkowski, 1988). However, although many risk factors and other constraints indicate the need for intensive service delivery, it currently is not possible to predict which children in a cohort will normalize without intervention, particularly among children with apparently mild speech involvement. That is, as indicated in Table 1, the association between risk factors and speech improvement is statistically too weak to be useful as a clinical predictor. For example, although a history of early recurrent otitis media is a risk factor for speech, language, and learning, such histories cannot currently be used to indicate the probable need for speech services (cf. Records & Weiss, 1990).

Speech variables. The two speech variables most frequently used in prediction studies are *severity/consistency* of error patterns and *stimulability*. Although the atheoretical dictum "behavior predicts behavior" achieves statistically significant gains in accounting for variance of extreme scores in group-level prediction, severity/consistency and stimulability measures do not have predictive validity at the level of individuals (Diedrich, 1983; Madison, 1979; Powell, Elbert, & Dinnsen, 1991). Specifically, although present speech behavior is positively correlated with future speech behavior within group-level analyses, reviews of the clinical prediction literature indicate that severity/consistency and stimulability measures produce high rates of both false positives and false negatives. Considering the range of individual differences in the speech and language status of children in these studies—including such variables as error sound, error location, error type, language comprehension status, and language production status—it is unlikely that simple stimulability and consistency metrics can capture clinically or even statistically significant predictive variance. Thus, although severity/consistency and stimulability measures are useful for selecting and sequencing intervention targets, they do not provide a sufficient basis for predicting which children will improve with intervention and which without.

Clinical practice. Lacking well-validated predictive instruments, speech-language pathologists continue to make their service delivery decisions on the basis of locally determined procedural criteria. The general solution is to construct time-efficient screening tools, with service delivery criteria standardized across children. A recent example is the work of Smit and colleagues, who developed a severity scale for use with preschool, speech-disordered children in the schools (Smit, Hand, Freilinger, Bernthal, & Bird, 1990). Using locally developed normative data on a pictured-stimuli test, speech-language pathologists make service delivery decisions on the basis of children's severity of involvement on the measure. Thus, all children who fall below age expectations are candidates for service delivery. Although normative speech assessment measures such as the work by Smit and colleagues provide useful descriptions of children's speech status, such measures do not have documented predictive validity.

Summary

Consistent with the broad perspective of speech-sound normalization research proposed in Figure 1—which encompasses studies ranging from surveys of children acquiring speech normally to follow-up studies of children with treated and untreated speech disorders—it is not possible to summarize the relevant findings in all literatures that bear on speech-sound normalization. Clearly, among the many alternative theories of normal phonological development, there currently is no one theory that is the most highly valued. Moreover, among the many hypotheses about sufficient individual or multifactorial causes for disordered speech-sound acquisition, there currently is no one hypothesis with robust empirical support. Given the lack of explanatory accounts, there is no one predictive instrument or procedure that has adequate sensitivity and specificity to predict which children will normalize with and which without intervention. As suggested above (cf. Table 1), the most widely used predictive procedures involve some form of speech assessment and analysis.

The present article examines the risk-factor and speech correlates of short-term speech-sound normalization in a group of 54 children with developmental phonological disorders. Specific goals are (a) to describe the *rate* of speech-sound normalization during a 1-year period, (b) to describe the *pattern* of speech-sound normalization in relation to the concept of speech delay, and (c) to identify any *predictive variables* associated with short-term speech-sound normalization.

Method

Subjects

Approximately 1 year after assessment sessions were completed for the group of 64 children with Speech Delay described in Shriberg and Kwiatkowski (1994), letters were sent to parents requesting their participation in a follow-up study. Following this letter, the two graduate-level student clinicians who had completed the original assessment telephoned caregivers to schedule appointments for the 2-hour

TABLE 1. Sample of findings on short-term and long-term speech-sound normalization.

Domain	Predictor variable	Finding	Reference
Risk-Factor Variables	Assorted Measures	Factor analytic procedures and regression analyses on articulation, auditory, motor, and memory measures yielded significant prediction of improvement in 4- to 6-year-old misarticulating children over a one-year period.	Nagasawa & Matsumoto, 1979
	Socioeconomic	Improvement without speech treatment over a 5-year period beginning in kindergarten was related to SES; improvement during speech treatment was not related to SES.	Andersland, 1961
	Auditory Discrimination	Normalization over a one-year period between kindergarten and second grade was not related to auditory discrimination scores.	Dickson, 1962
		Auditory discrimination of misarticulated sounds was not predictive of improvement in kindergarten children with mild and severe articulation disorders.	Farquhar, 1961
	Language	Children of adults who had articulation disorders 8 years earlier scored poorer than controls on tests of articulation and expressive but not receptive language.	Parlour, Broen & McGue, 1989
		Over a 5-year period, articulation normalized in 50% of children with only articulation problems, compared to 15% of children with articulation and language problems.	Baker & Cantwell, 1987
		Children with articulation errors but no language or cognitive involvement did not develop later reading, writing, or spelling problems; their speech normalized in primary school with or without treatment.	Tyler & Edwards, 1986
		More children with only articulation errors normalized satisfactorily 13–20 years later than those with accompanying language delay.	Hall & Tomblin, 1978
		Children with poor expressive language were less likely to improve articulation without treatment.	McCarthy, 1954; Pronovost, 1966; Templin, 1957
	Intelligence	Articulatory improvement in 5-year-olds receiving speech treatment for 8 months was not significantly associated with intelligence.	Petit, 1957
		Intelligence and a measure of social maturity were not predictive of improvement 5 years later for a group of kindergarten children who received 12 weeks of speech treatment.	Steer & Drexler, 1960
	Psychosocial	Maternal personality and adjustment were related to normalization with and without treatment.	Andersland, 1961
		Children of "attitudinally healthy" mothers made greater gains in treatment than children with "attitudinally unhealthy" mothers.	Sommers and colleagues, 1964
Speech Variables	Early Speech	Two 24-month-old children with simple syllable structures and limited phonetic inventories had atypical babbling patterns at 9 months.	Stoel-Gammon, 1989
		The number of consonants and their frequency of use at 9 months was related to phonological ability at 3 years.	Vihman & Greenlee, 1987
		Consonant and syllable structure inventories were sensitive indicators of expressive vocabulary development in 18- to 34-month-old children with expressive language delays.	Paul & Jennings, 1992
		"While it does not appear to be possible to relate phonological preferences at age 1 to the use of specific phonological processes at age 3, relatively high use of true consonants in both babbling and words at age 1 does seem to be a useful predictor of relative phonological advance at age 3, presumably because early consonant use reflects early maturity both in articulatory skill and in sensitivity to the sound structure of adult language."	Vihman, 1986
		Prospective studies did not yield significant speech or other variables predictive of the eventual need for speech therapy.	Menyuk, Liebergott, & Schultz, 1986
	Assorted Measures	Four speech criteria correctly predicted 89% of kindergarten children with protrusional lisps who did not self-correct by third grade.	Pendergast, Dickey, Selmar, & Soder, 1984
		Number of articulation errors was not predictive of normalization from grade 1 to grade 3.	Irwin, Huskey, Knight, & Oltman, 1974
		Sukuonka articulation (lateral lisp) does not normalize spontaneously.	Nagasawa & Umemura, 1989
		Articulatory improvement during one interval does not assure continued improvement.	Rockman, Elbert, & Saltzman, 1979
		Among children with lateral lisps in kindergarten, 50% normalized without intervention.	Sax, 1972
		Among kindergarten children with errors on /s/ only or /s/ and one or two other sounds, 56% self-corrected during the year.	Stephens & Patti, 1976
		Among children with lisps in kindergarten, 41% of children with interdentalized or retracted /s/ self-corrected by grade 3; no child with lateral /s/ self-corrected by grade 3.	Stephens & Daniloff, 1981

Continued

TABLE 1. *Continued*

Domain	Predictor variable	Finding	Reference
Speech Variables *(continued)*	Assorted Measures *(continued)*	Discriminant function analysis yielded several speech variables (and others) associated with the eventual need for speech intervention in children with histories of otitis media.	Paden, Novak, & Beiter, 1987
		Gain scores without and within intervention were correlated with speech variables delineating error sound, position in the word, and type of error.	Sommers, Gerber, & Leiss, 1969; Steer & Drexler, 1960
		Severity of intelligibility deficits, but not percentage of consonants correct in conversational speech, was associated with continued need for speech treatment.	Shriberg & Kwiatkowski, 1988
		Sounds produced more accurately in conversational speech than in pictured word testing had the greatest spontaneous improvement.	Snow & Milisen, 1954
		Initial articulation test scores correlated .63 with final articulation test scores for children who did not receive treatment and .76 for children who did.	Reid, 1947
	Consistency	Inconsistency of correct articulation of /v/ and other sounds did not predict generalization to new linguistic contexts.	Baer & Winitz, 1968; Templin, 1966
		Consistent scores early in treatment were predictive of treatment outcomes.	Arndt, Elbert, & Shelton, 1971
		Consistency of error production on /s/ and /r/ in grade 1 was associated with failure to normalize by grade 3.	Ryan, 1969
	Stimulability	Children with greater than 25% improvement of articulation accuracy on a nonsense syllable test compared to a pictured word test normalized without treatment; children with less than 25% improvement did not self-correct.	Carter & Buck, 1958
		Among kindergarten children, a sounds-in-isolation task was predictive of self-correction in 7 months for /s/, but not for /r/ or /l/.	Ackerman, 1963
		Ability to correctly imitate misarticulated sounds in nonsense syllables was predictive of improvement in kindergarten children.	Haws, 1969
		Ability to correctly imitate misarticulated sounds in nonsense syllables and words was related to improvement in speech treatment.	Spriestersbach & Sherman, 1968
		Stimulability scores in kindergarten were significantly related to articulatory improvement 7 months later.	Sommers and colleagues, 1967
		Kindergarten children who were highly stimulable on the Carter-Buck task had greater improvement than low stimulability children retested after 6 months.	Kisatsky, 1967
		Kindergarten, first-grade, and second-grade children with high stimulability scores improve more both with and without treatment than children with low stimulability scores.	Allen and colleagues, 1966; Byrne, 1962; Farquhar, 1961
		Stimulability is positively associated with generalization.	Powell, Elbert, & Dinnsen, 1991
	Other Tasks	An auditory masking task using competing speech was predictive of improvement for /r/ and /s/ during breaks from treatment.	Manning & Hadley, 1987
		Oscillographic evidence of appropriate voice-onset time contrasts is associated with generalization of correct production of that contrast in treatment.	Tyler, Edwards, & Saxman, 1990

reassessment. The caregivers for a total of 54 of the children were contacted; the remaining 10 children either had moved from the state or were at unknown addresses. All of the 54 caregivers reached by phone agreed to participate in the follow-up study, yielding an 84% retention rate relative to the original data set. The mean age of children at follow-up was 5 years, 3 months (SD = 7.8 months).

Assessment

Children were reassessed by the student clinician who had administered the original protocol. The follow-up protocol consisted of subsets of the original measures and two follow-up tasks.

Retest measures. Selected tests and measures from four of the six categories in the original protocol (cf. Shriberg & Kwiatkowski, 1994) were readministered to all 54 children. The four categories included (a) *Hearing:* the Audiologic Evaluation and the Acoustic Immittance Screening, (b) *Speech Mechanism:* the Diadochokinesis Task, (c) *Speech Production:* the Conversational Speech Sample and the Photo Articulation Test (PAT) (Pendergast, Dickey, Selmar, & Soder, 1984), and (d) *History and Behavior:* the Examiner's Observational Checklist. An additional subset of the original measures was administered to children whose original assessment scores were below the range considered normal. These measures included (a) *Speech Mechanism:* the Orofacial Screening Examination, (b) *Speech Production:* the Isolated and Sequenced Volitional Oral Movements Task, (c) *Language Comprehension:* the Peabody Picture Vocabulary Test, Individual Form M (Dunn & Dunn, 1981), and (d) *Language Production:* the Oral Language Sample.

Follow-up questionnaire. While children were being tested, the caregiver(s) were asked to fill out the Parent

Questionnaire. Questionnaire items asked parents to (a) indicate if the child's speech was still of concern, (b) describe observed speech changes, (c) identify the time frame for these changes, (d) report if changes in other developmental areas had been observed concurrent with the speech change, (e) report on the nature and frequency of speech and language services, and (f) identify and evaluate the effect(s) of strategies the parent had tried to improve the child's speech. Parents were also asked to describe the child's middle-ear and educational history during the preceding year and to provide information about any concerns regarding the child's academic, health, or social-emotional development that had arisen during the year. A subsequent interview conducted by the examiner was used to clarify and elaborate written responses to items in the questionnaire.

Data Reduction

Transcription. A two-person consensus transcription team transcribed the children's conversational speech samples and their responses to the PAT. Conventions for phonetic transcription are described in Shriberg (1986), and procedures used to train and calibrate the transcription team are described in Shriberg, Hinke, and Trost-Steffen (1987) and Shriberg and Lof (1991). Point-to-point percentages of intrateam transcription agreement were computed for 427 consonants and 301 vowels taken from six (11%) randomly selected transcripts. The percentage of agreement for broad transcription of consonants and vowels was 89.7% and 92.4%, respectively; percentage of agreement for narrow transcription of consonants and vowels was 77.3% and 81.1%, respectively. As in the original assessment, transcripts of the conversational speech samples obtained during the follow-up assessment were used for both speech and prosody-voice analyses using Programs to Examine Phonetic and Phonologic Evaluation Records (PEPPER) (Shriberg, 1986, 1993) and the Prosody-Voice Screening Profile (PVSP) (Shriberg, Kwiatkowski, & Rasmussen, 1990) procedures and associated software (Shriberg, Kwiatkowski, Rasmussen, Lof, & Miller, 1992). Prosody-voice scoring for all samples was completed by one of the transcribers from the consensus transcription team. Intrajudge and interjudge (with the second author) reliabilities for this transcriber were estimated in an 11% sample (28 tapes, 634 utterances) of a database of 252 continuous speech samples representing a cross section of children and adults with speech and prosody-voice disorders, including samples from the present study (Shriberg et al., 1992). Exact intrajudge agreement for the seven prosody-voice domains ranged from 85.0% (Laryngeal Quality) to 98.9% (Pitch) ($M = 92.6\%$). Interjudge agreement for the seven prosody-voice domains ranged from 74.2% (Laryngeal Quality) to 96.0% (Pitch) ($M = 87.4\%$).

Examiner checklist and parent questionnaire. The caregivers' written and verbal responses were recoded by one of the examiners. Some items required only a clerical conversion of responses to number keys; others required some clinical judgment using the three-level ordinal system (i.e., *normal, questionable, involved*) first described in Shriberg & Kwiatkowski (1982). Intrajudge agreement for six randomly selected children was completed 3 weeks after the recoding. Exact intrajudge percentage of agreement was 100% for all items that required only clerical recoding and 87% (range: 82%–91%) for all items requiring some level of interpretation.

Results

Group-Level Descriptive Analyses of Speech-Sound Normalization

Speech profiles. Figure 2 and Figure 3 are group-averaged speech profile analyses of the 54 children's conversational speech in the original (Time 1; filled circles) and follow-up (Time 2; open circles) samples. The format and statistical rationales for speech profile analyses are described in the first report in this series (Shriberg & Kwiatkowski, 1994); for convenience, this information is repeated here.

The four panels in Figure 2 describe the average percentage of consonants correct (Panel A) and error type percentages (Panels B, C, and D). Each of the four panels includes a summary *numeric* section at the top and a larger *graphic* section below. The consonant phonemes in each of the panels in Figure 2 are divided into groups termed *developmental sound classes:* the *Early-8* sounds, the *Middle-8* sounds, and the *Late-8* sounds. Division of the 24 English consonants into these three developmental sound classes was suggested by their clustering on a rank-ordered trend reflecting average percentage correct in speech-delayed children (cf. Shriberg, 1993). Thus, the descending trends in the graphic section of Figure 2, Panel A reflect the percentages correct for each of the 24 consonant targets in singletons and clusters. The numeric section at the top of Panel A provides means and standard deviation data for consonant singletons (S), consonant clusters (C), and all consonants (T) for each of the three eight-sound groups and across all 24 sounds.

The data in the remaining three panels in Figure 2 provide information on the error types observed in the narrow transcription of the conversational speech samples. The trends in the graphic sections are the average *relative* error types for each consonant, with the summary data in the numeric sections of each panel providing information on both *absolute* (A) and *relative* (R) errors. *Absolute* errors (omissions, substitutions, and distortions) are the percentage of each error type in the conversational speech sample. The numerator for each absolute error percentage is the number of incorrect sounds (errors) of that type in the sound class addressed, and the denominator is the total number of correct plus incorrect sounds for that sound class. As is done for the PCC metric, the data in each of the three 8-sound classes are weighted by the contribution of each sound in the class. Thus, more frequently intended (i.e., target) sounds in a speech sample contribute more heavily than less frequently intended sounds to the subgroup percentages for the Early-8, Middle-8, Late-8 sound groups and the total for all sounds. *Relative* omission, substitution, and distortion errors provide error-pattern information that adjusts for subjects'

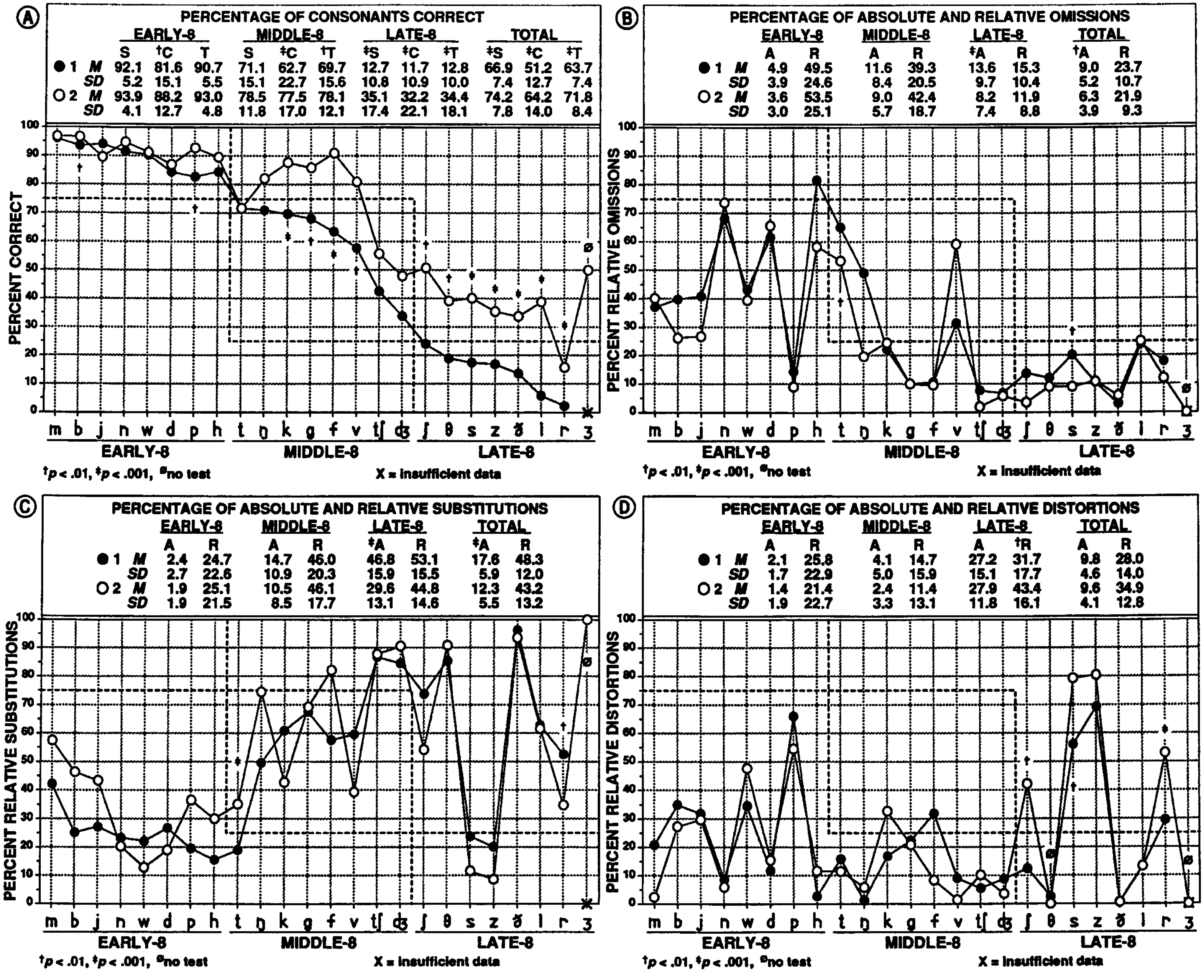


FIGURE 2. A *Speech Profile: Consonants* comparison of children's speech-sound production at the original assessment (Time 1) and the follow-up assessment (Time 2).

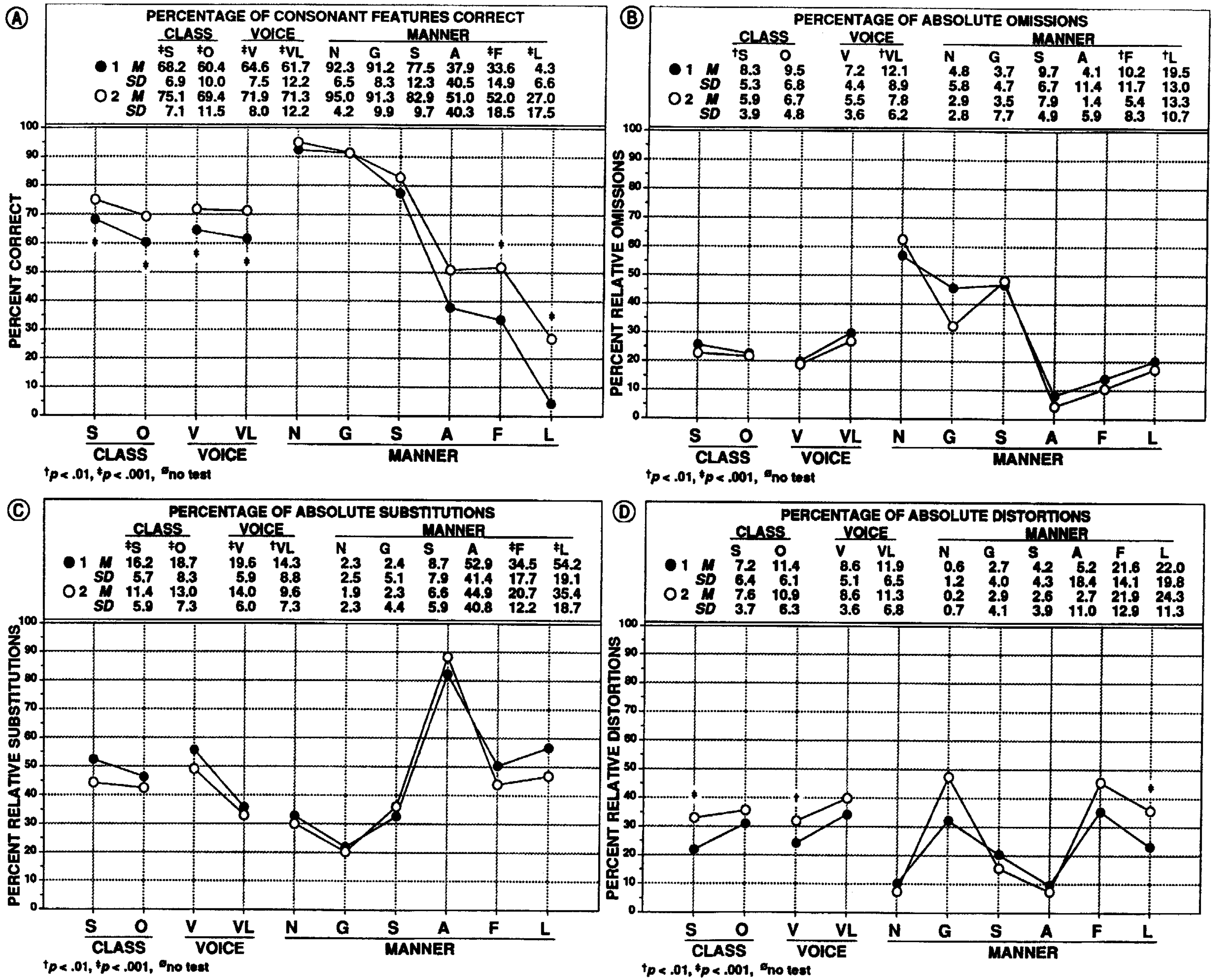


FIGURE 3. A *Speech Profile: Consonant Features* comparison of children's speech-sound production at the original assessment (Time 1) and the follow-up assessment (Time 2).

severity of involvement by basing the percentage on each subject's total number of errors. In the numeric section of the panel, the relative data are based on all sounds in each of the three developmental sound classes. The numerator for each child is the number of errors of that type, and the denominator is the total number of incorrect sounds in the sound class addressed. In the graphic sections, the relative data computed for each phoneme are displayed. Thus, the absolute and relative errors provide alternative metrics for questions about how speakers err in the production of target phonemes.

The four panels in Figure 3 are conceptually similar to those in Figure 2, but aggregated by phonetic features. Feature *Class* data are provided for sonorants (S) and obstruents (O); analysis by *Voice* includes data summed for all voiced (V) and voiceless (VL) sounds; and analysis by *Manner* includes percentages for all target nasals (N), glides (G), stops (S), affricates (A), fricatives (F), and liquids (L). The numeric sections of Panels B, C, and D in Figure 3 include data on the percentage of absolute errors, whereas the graphic sections in these panels display the percentage of relative errors.

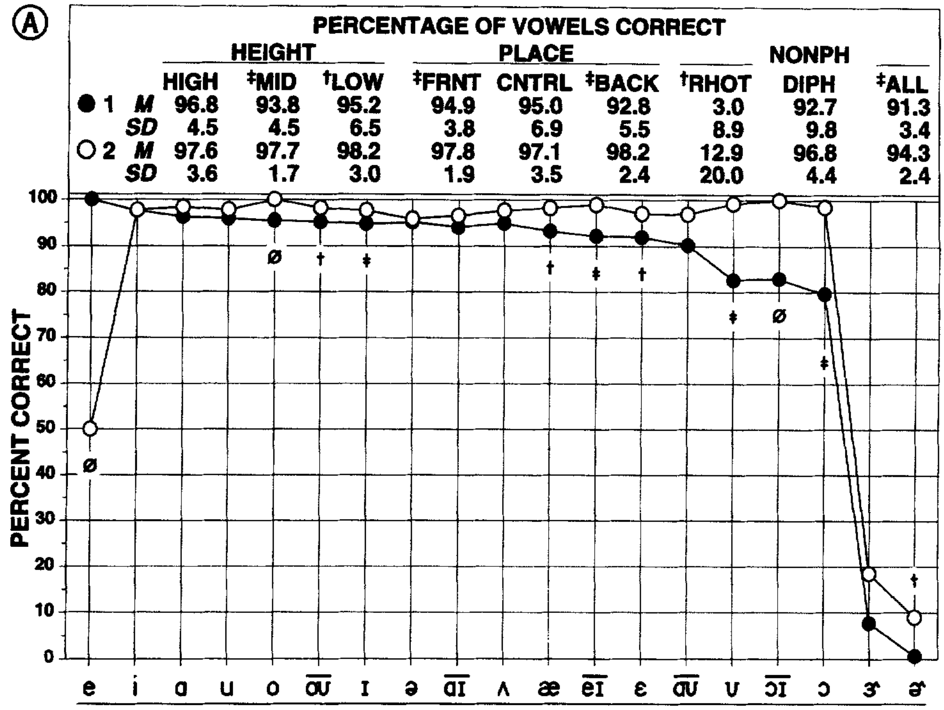
The daggers and double daggers in the numeric and graphic sections of each speech profile panel indicate significant between-group differences at the .01 and .001 levels respectively. For the present data the statistic was the nonparametric Mann-Whitney test (Siegel & Castellan, 1988). Although means and standard deviations provide the most meaningful descriptive statistics for the numeric and graphic displays, nonparametric statistics typically provide the most appropriate inferential tests of differences in the articulatory behaviors of two or more groups. Specifically, nonparametric tests allow for (a) the nonnormality of distributions for each comparison, including high frequencies of 0% and 100% scores that cannot be transformed for parametric analyses; (b) the correlation of means and standard deviations at extremes of measurement; and (c) the typically small and/or disproportionate sample sizes. The two probability levels, .01 and .001, bracket, respectively, liberal and conservative family-wise alpha levels for the number of tests in the numeric and graphic sections of each panel. By presenting the graphic and numeric data in original percentages and using the appropriate nonparametric statistics at two advisory alpha levels, the speech profile analyses (and subsequently, the prosody-voice profile analyses) attempt to balance the goals of exploratory data analysis, advisory inferential statistics, and the avoidance of Type I or Type II errors of inference. The following descriptions highlight the group-level changes in the speech of the 54 speech-delayed children over the one-year period.

Consonants. Beginning with the numeric sections in the upper left panels (Panel A) in Figures 2 and 3, statistically significant sound changes were evident for singletons and clusters within each of the three eight-sound groups (Figure 2) and between nearly all sounds by major class, voicing, and two of the six manner features (Figure 3). As indicated in the numeric section of Figure 2, Panel A, the greatest changes occurred on the Late-8 sounds, with a total average increase from 12.8% correct to 34.4% correct. In the same panel the rightmost column in the numeric section indicates that the average child with a developmental phonological disorder gained approximately 8 percentage points in consonants correct (63.7% to 71.8%) during the 1-year period. As indicated in the graphic section below these summary data, statistically significant percentage-correct gains (Mann-Whitney nonparametric tests, Siegel & Castellan, 1988) occurred on 13 of the 23 consonants—all but two of which were members of the Middle-8 or Late-8 developmental sound classes.

The pattern of consonant error types was fairly similar for the original and follow-up assessment sessions, as indicated by the generally parallel trends in the graphic sections of Panels B, C, and D in Figures 2 and 3. That is, profiles for each assessment were generally similar across each of the three error-type classes: omissions (Panel B), substitutions (Panel C), and distortions (Panel D). As indicated in the numeric sections of these panels in both figures, many statistically significant differences were obtained for both absolute error types (percentage calculated by dividing errors by the total number of intended sounds) and relative error types (percentage arrived at by dividing each error type by the total number of errors), especially for Late-8 sounds and their associated features. Inspection of these patterns indicates that children's errors over the 1-year period shifted from proportionally more omissions and substitutions to proportionally more distortions.

Vowels-diphthongs. Figure 4 is the Panel A data from a speech profile analysis of children's vowel and diphthong status on the original and follow-up assessment approximately 1 year later. As in Figures 2 and 3, the graphic section of this display provides percentage correct data and statistical tests for each of 19 vowels and diphthongs. The summary data in the numeric section provides means, standard deviations, and statistical tests for vowels classified by *Height* (High, Mid, Low) and *Place* (front [FRNT], central [CNTRL], BACK), with separate columns for the rhotic (RHOT) vowels (/ɚ/,/ɝ/) and for the two nonphonemic diphthongs (NONPH DIPH) (/o͡ʊ/, /e͡ɪ/), as well as ALL vowels-diphthongs. As shown in the graphic section of Figure 4, the children averaged above 90% correct on the first 13 of the 19 vowels and diphthongs assessed at the first assessment session (filled circles). At the 1-year follow-up assessment (open circles), statistically significant (Mann-Whitney) increases in percentage correct occurred for 8 of the 17 statistically testable comparisons. As shown in the numeric section at the top of Figure 4, the sounds for which differences were statistically significant were distributed across place-height dimensions of the vowel quadrilateral. The summary data in the numeric section indicate statistically significant improvement for sounds subgrouped on 5 of the 8 place-height-type features, as well as the overall index (ALL) of vowels-diphthongs correct.

Prosody-voice profiles. Figure 5 is the summary panel (Panel A; cf. Shriberg, 1993) from a prosody-voice analysis from the 54 children for whom original (filled circles) and follow-up (open circles) prosody-voice data were available. As indicated by the dotted horizontal lines in the graphic section of Figure 5, a *pass* on this screening measure requires a 90% or higher percentage of appropriate utterances and a *questionable pass* is for 80%–89.9% appropriate utterances for each of the six prosody-voice variables



†$p < .01$, ‡$p < .001$, ∅no test

FIGURE 4. A *Speech Profile: Vowels/Diphthongs* comparison of children's speech-sound production at the original assessment (Time 1) and the follow-up assessment (Time 2). Only the data indicating the percentages of correct vowels and diphthongs are shown.

(Phrasing, Rate, Stress, Loudness, Pitch, Quality [Laryngeal, Resonance]). As indicated by the overlapping trends in the graphic section and similar means in the numeric section, there were no statistically significant differences between the original and follow-up scores. With the exception of lowered Laryngeal Quality scores (cf. Shriberg & Kwiatkowski, 1994), these speech-delayed children had essentially normal prosody-voice profiles at both the original assessment session and the 1-year follow-up session.

Summary. The trends and statistical results of the data in Figures 2 through 5 indicate that considerable speech-sound normalization occurred during a 1-year period. The shape of the speech profile data suggest that normalization is best characterized as an "across-the-board" developmental process in which change occurs proportionally across all consonants and vowels-diphthongs (cf. Shriberg & Kwiatkowski, 1994). Unlike later age periods, in which there appears to be only low rates of speech-sound normalization in children with delayed speech (cf. Shriberg, Gruber, & Kwiatkowski, 1994), the preschool period of this 1-year study (mean age at first assessment, 4 years, 3 months; *SD*, 7.8 months) is marked by considerable change toward articulate speech.

Individual-Level Predictive Analyses of Speech-Sound Normalization

Method. The primary goal of this article, in addition to providing the descriptive data above, is to determine whether any speech or risk-factor variables were associated with children's short-term speech-sound normalization. The system used to classify subject status at the original and 1-year follow-up assessments was the Speech Disorders Classification System (SDCS). The specific interest at follow-up was whether subjects were still classified as Speech Delayed or whether they now could be classified as Normalized Speech Acquisition. Rationale and validity data for the SDCS are provided in Shriberg (1993). Using age-based decision rules derived from reviews of the normative and disorders literature in child phonology (cf. Shriberg, 1993, Appendix), the SDCS software classifies a narrow phonetic transcription of a speaker's conversational speech sample into 1 of 10 categories. The 10 categories differentiate normal or normalized speech from Speech Delay (deletions, substitutions) or Residual Errors (distortions), with each of the latter categories subcategorized as questionable (i.e., borderline) or nonquestionable. SDCS classification results indicated that 10 of the 54 originally speech-delayed children (18.5%) had Normalized Speech Acquisition at the 1-year follow-up assessment. Not all of these 10 children had perfectly adult-like speech 1 year later, but their remaining articulation errors were considered to be within the normal range for their age (cf. Shriberg, 1993, Appendix).

Descriptive comparison of the two outcome groups. Speech profiles for consonants, features, and vowels-diphthongs and prosody-voice profiles were obtained to compare the follow-up speech and prosody-voice profiles of the 10 normalized children to the follow-up profiles of the 44 non-

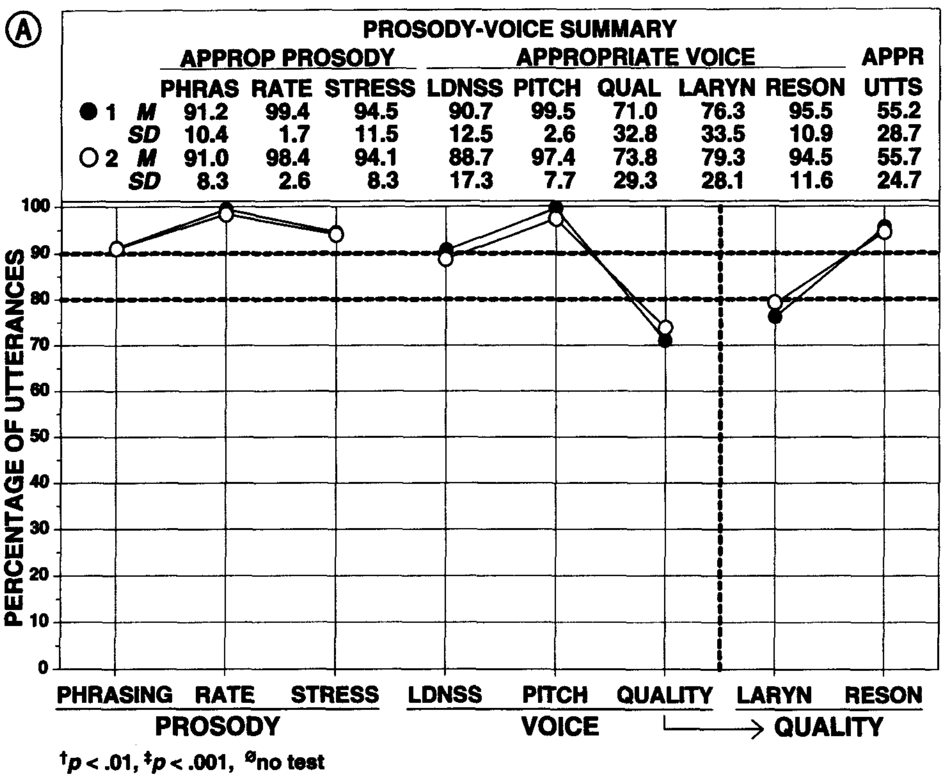


FIGURE 5. A ***Prosody-Voice Profile*** **comparison of children's prosody-voice status at the original assessment (Time 1) and the follow-up assessment (Time 2). Only the data indicating percentages of utterances with appropriate prosody-voice are shown.**

normalized children. Figure 6 and Figure 7 are the Panel A and Panel B data from the consonant and feature analyses, respectively, for the 10 normalized (Group A, open triangles) and 44 nonnormalized (Group B, filled triangles) children. The information in these panels illustrate the relative findings from the speech profile analyses. As indicated in the rightmost column of the numeric section in Figure 6, Panel A, the normalized group averaged a statistically significant 8% higher percentage of consonants correct (78.3% compared to 70.3%). The adjacent columns indicate that a statistically significant difference between sounds in clusters (75.7% compared to 61.6%) contributed most to the overall difference in average scores of the normalized (Group A) and nonnormalized (Group B) children. As indicated by the inferential statistical findings (Mann-Whitney) in the numeric section of Figure 6, normalization was characterized primarily by significant improvement on the Middle-8 sounds both as singletons and in clusters. As shown in the graphic sections of Panel A in both Figures 6 and 7, the profiles of the normalized and nonnormalized groups differed across sounds and features, with some comparisons reaching statistical significance even at the low power available in cell sizes for the nonparametric Mann-Whitney tests.

The error-type finding that defined the two groups at follow-up was that the normalized children had significantly fewer absolute and relative omission errors, particularly on the Late-8 sounds (see Figure 6, Panel B, numeric section). This finding is also clearly evident at the level of class, voicing, and manner features (as shown in the numeric and graphic sections of Figure 7, Panel B). Profile analyses completed for vowels-diphthongs and prosody-voice indicated no statistically significant differences in the outcome profiles of the normalized compared to the nonnormalized group.

Predictor variables: Speech and prosody-voice profiles. The next series of analyses attempted to determine if membership in the normalized compared to the nonnormalized group could have been predicted by a child's speech or prosody-voice status at the original assessment session. Figure 8 is the Panel A data from a speech profile analysis comparing the normalized (Group A, open squares) and nonnormalized (Group B, filled squares) groups at the original assessment sessions. As indicated by the generally intertwined trends in the graphics section, the profiles of the two outcome groups did not differ statistically at the first assessment. Although the children who normalized had higher average percentage of consonants correct on 17 of the 23 comparisons, these aggregated differences were not statistically different at the summary levels tested in the numeric sections of Figure 8. As illustrated best in the numeric section of Figure 8, the means of the two groups differed by only a few percentage points on nearly all variables within the three developmental sound classes, with nearly identical means (M = 64.8, 63.5) and standard deviations (SD = 7.0, 7.5) for total (T) Percentage of Consonants Correct.

Profile analyses were also completed for consonant features, vowels-diphthongs, and prosody-voice status at origi-

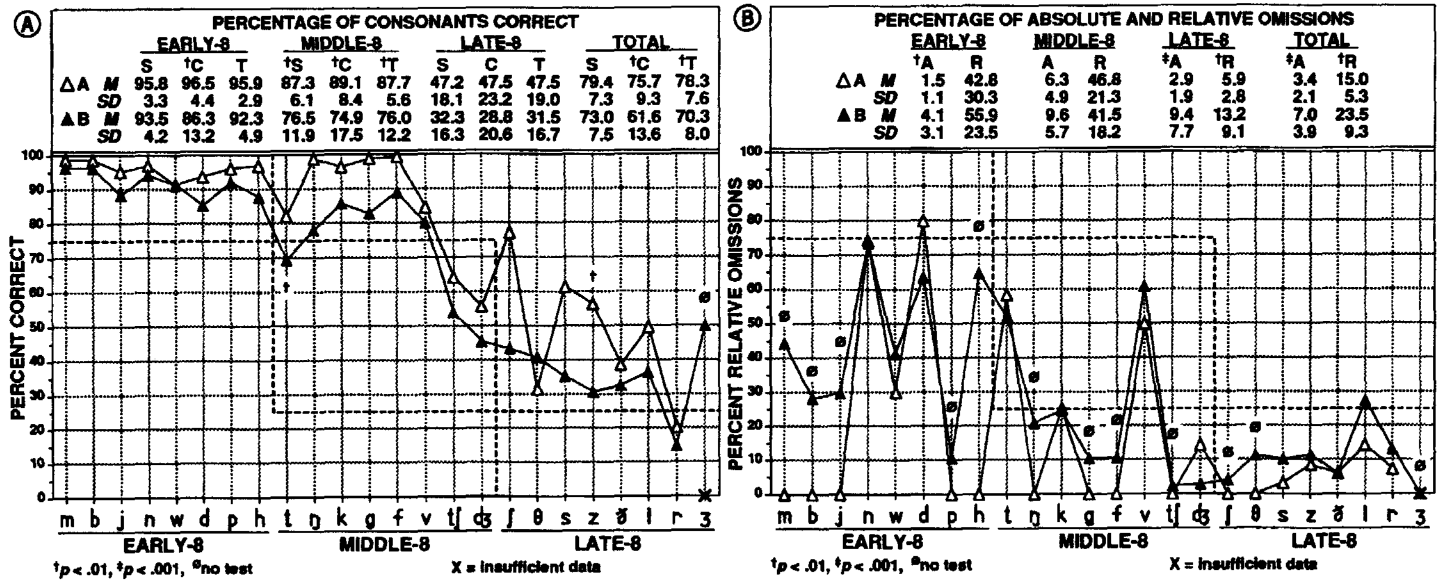


FIGURE 6. A *Speech Profile: Consonants* comparison of the follow-up profiles of 10 children who normalized (Group A) and the 44 children who did not normalize (Group B) in the 1-year period.

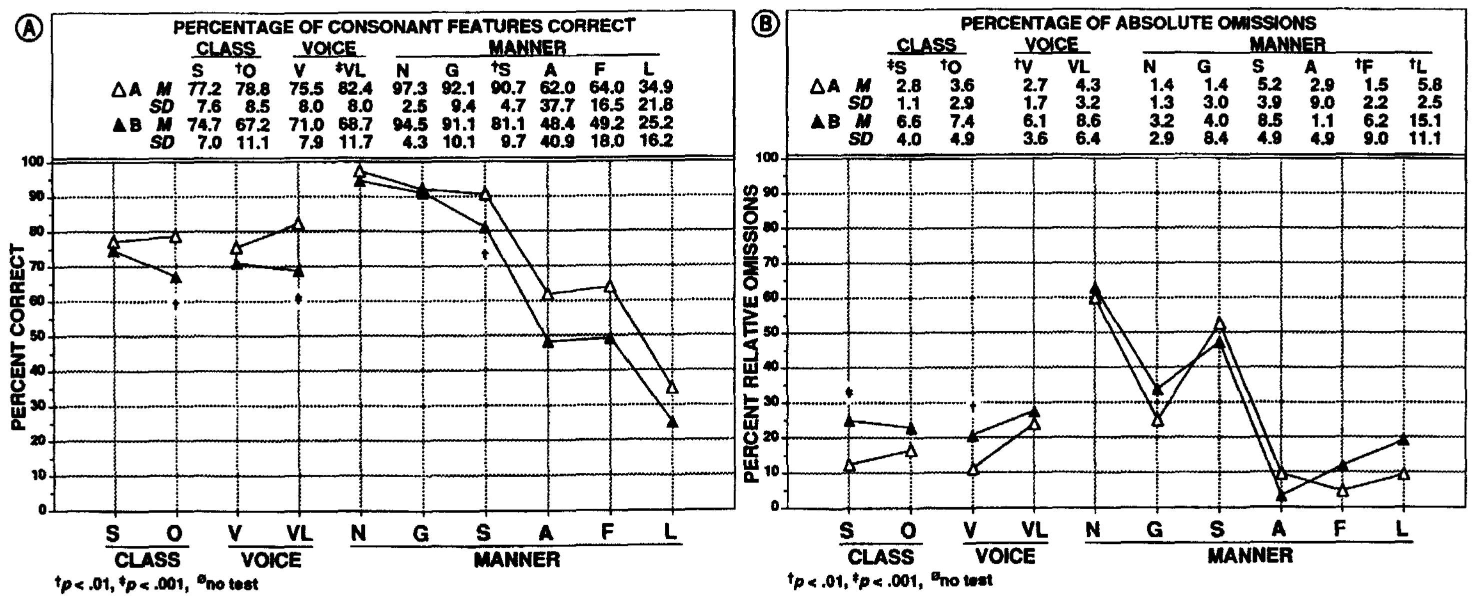


FIGURE 7. A *Speech Profile: Consonant Features* comparison of the follow-up profiles of 10 children who normalized (Group A) and the 44 children who did not normalize (Group B) in the 1-year period.

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PERCENTAGE OF CONSONANTS CORRECT

		EARLY-8			MIDDLE-8			LATE-8			TOTAL		
		S	C	T	S	C	T	S	C	T	S	C	T
□A	*M*	94.1	87.2	92.9	74.0	67.3	73.1	14.7	12.6	14.0	68.1	54.5	64.8
	SD	3.4	8.4	3.3	15.4	23.5	15.2	16.8	10.6	14.2	7.1	9.7	7.0
■B	*M*	91.6	80.3	90.2	70.5	61.6	68.9	12.3	11.5	12.5	66.7	50.5	63.5
	SD	5.5	16.1	5.8	15.2	22.6	15.7	9.1	11.0	9.0	7.5	13.2	7.5

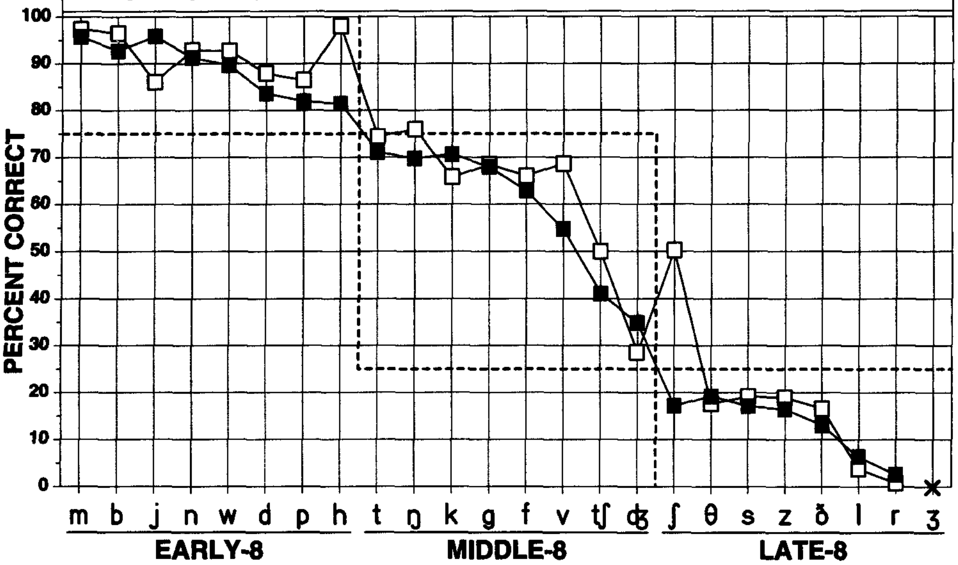


FIGURE 8. A *Speech Profile: Consonants* comparison of the original profiles of 10 children who normalized (Group A) and the 44 children who did not normalize (Group B) in the 1-year period.

nal assessment. The three speech profiles (consonants, consonant features, vowels-diphthongs) were also run on the articulation test data obtained at the original assessment. There were no statistically significant differences on any of these analyses between the normalized and nonnormalized groups. As with the data in Figure 8, intertwined trends in each analysis suggested that the lack of statistically significant findings was not due to the small sample size of the normalized group.

The trends in Figure 9 are included for their possible predictive value in future studies. The two panels in Figure 9 include the relative error-type percentages for each of the two groups, the 10 children who normalized (upper panel) and the 44 children who did not normalize (lower panel). Because the relative percentages of omission, substitution, and distortion errors are not independent (i.e., the three percentages sum to 100%) it was not appropriate to perform inferential statistics on between-group differences. Surprisingly, the descriptive trends in Figure 9 suggest that it is the error types on the Early-8 sounds that may be sensitive to eventual normalization outcomes. Whereas the error-type trends for the Middle-8 and Late-8 sounds are generally similar in magnitude for the two outcome groups, error types on the Early-8 sounds are graphically different. Specifically, there appears to be a trend towards a trade-off between omission and substitution errors on the Early-8 sounds. Whereas over 52% of the Early-8 errors for the children who did not normalize were omissions and 21% were substitutions, the children whose speech normalized averaged only approximately 38% omissions and 41% substitutions. Each group had approximately the same relative percentage of distortion errors (approximately 27% and 21%, respectively). Thus, although both groups originally had relatively high mastery of the Early-8 sounds—sounds that typically are not deemed important predictors because of their high correct rates—omission errors could prove to be statistically useful in eventual prediction algorithms.

To summarize, these group-level comparisons indicate that the short-term speech-sound normalization differences shown in the outcome data were not statistically predictable by group-wise differences in speech and/or prosody-voice profiles on original assessment. That is, with the exception of the descriptive trends illustrated in Figure 9, the 10 children who normalized in 1 year did not have a profile of correct targets that differentiated them statistically from the profiles of children who did not normalize in 1 year. Because of the limited cell size of the normalized group, it was not appropriate to complete inferential statistics using two or more predictors (e.g., multiple regression, discriminant function) from the conversational speech or the articulation test data.

Predictor variables: Phonological processes. Among the many alternatives to the types of speech profile analyses undertaken above, one widely used approach currently is to invoke the construct of *phonological processes*. The descriptive power of these units is that they aggregate articulation errors crossing individual targets, syllable structures, word positions, and error types into one sound-change category. Thus, they may reveal linguistically significant generalizations within and among speakers that might be missed when

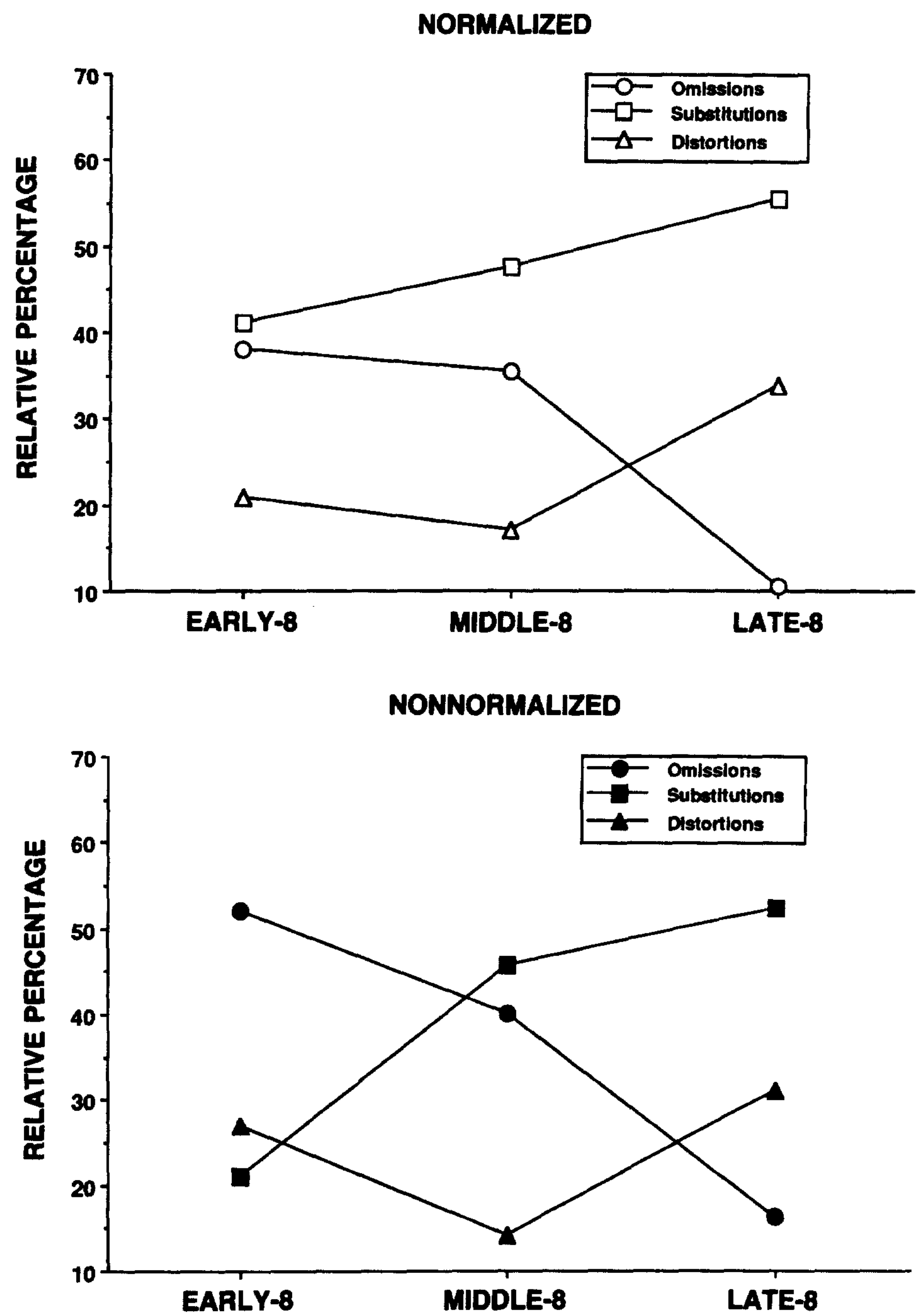


FIGURE 9. Relative error-type comparisons of the 10 children who normalized and the 44 children who did not normalize.

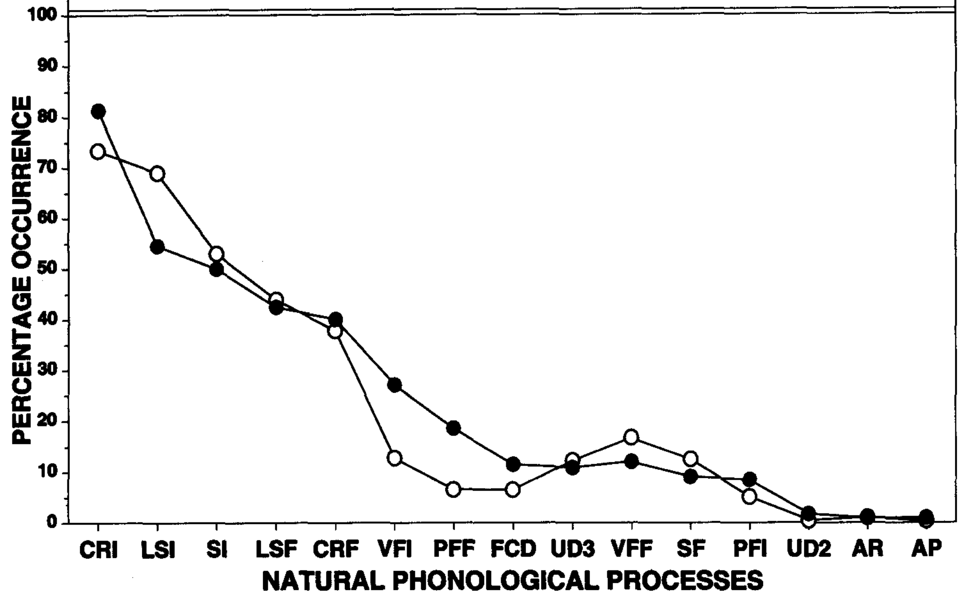
inspected at the phoneme level or at the feature level, as is done in speech profiles.

Figure 10 is a summary of the percentage of occurrence in conversational speech of sound errors divided into the eight natural phonological processes described in Shriberg and Kwiatkowski (1980). For maximum sensitivity the relevant process data are presented separately by word position. Values for the 10 children who normalized are provided as Group 1 in the numeric section of this speech profile and as the open circles in the graphic section. Values for the 44 children who did not normalize are indicated as Group 2 and as the filled circles. As indicated by the lack of statistically significant findings in the graphic section and overlapping standard deviations in the numeric section of this speech profile, the speech error patterns of the two groups did not differ. Overall, the similarity in the two trends in Figure 10 suggests that, at initial assessment, phonological process analyses were not uniquely or especially sensitive to error patterns that discriminate short-term speech-sound normalization outcomes.

Predictor variables: Subject characteristics. The second series of predictive analyses examined whether eventual

NATURAL PHONOLOGICAL PROCESSES

		Assimilat		Clus Reduc		Final	Liq Simp		Palat Front		Stopping		Velar Front		Unstress Del	
		Regr	Progr	Init	Final	Con Del	Init	Final	Init	Final	Init	Final	Init	Final	2 syl	3+ syl
○ 1	*M*	1.0	0.4	73.4	37.7	6.5	69.0	43.8	5.1	6.5	53.0	12.5	12.7	16.7	0.5	12.2
	SD	1.9	0.9	35.5	15.9	4.5	35.2	27.8	11.4	17.2	19.1	21.7	24.4	28.8	1.5	24.4
● 2	*M*	0.9	0.9	81.3	40.0	11.5	54.5	42.4	8.4	18.5	49.9	9.0	27.1	12.0	1.8	10.8
	SD	1.8	2.4	25.7	25.2	7.4	29.6	28.7	21.1	39.6	23.9	13.3	38.2	22.4	3.5	17.8



†$p < .01$, ‡$p < .001$, ∅no test

FIGURE 10. Natural process analyses comparisons of the original conversational speech samples of the 10 children who normalized and the 44 children who did not normalize in the 1-year period. The abbreviations for processes as arranged left-to-right in the graphic section are as follows: CRI: Cluster Reduction-Initial; LSI: Liquid Simplification-Initial; SI: Stopping-Initial; LSF: Liquid Simplification-Final; CRF: Cluster Reduction-Final; VFI: Velar Fronting-Initial; PFF: Palatal Fronting-Final; FCD: Final Consonant Deletion; UD3: Unstressed Syllable Deletion—3 or more syllables; VFF: Velar Fronting-Final; SF: Stopping-Final; PFI: Palatal Fronting-Initial; UD2: Unstressed Syllable Deletion—2 syllables; AR: Assimilation-Regressive; AP: Assimilation-Progressive.

membership in the normalized versus nonnormalized group was statistically associated with subject variables.

Demographic comparisons. Table 2 includes summative data on six demographic characteristics of the two groups of children at their initial assessment sessions. Analyses of each variable were performed in several steps, including examination of distributional characteristics from numerical and graphic outputs before selection of an appropriate inferential statistic. None of the six between-group comparisons for the demographic indices (Gender, Age, Birth Order, Number of Children in Family, Father's Education, or Mother's Education) reached statistical significance as indicated in the right-most column in Table 2. Most notably in these data, children in the normalized group were not significantly older than children in the nonnormalized group (confirmed also be nonparametric testing in consideration of the disproportionate cell sizes and standard deviations). Considering the low power associated with sample size, one statistically interesting demographic variable was birth order, with normalization marginally associated with earlier birth order ($p < .07$).

Direct and indirect intervention variables. The most likely source of explanation for the different normalization

TABLE 2. Demographic and summative speech severity characteristics of children whose speech was normalized (Group A) and nonnormalized (Group B) at the one-year follow-up.

	Group A: Normalized				Group B: Nonnormalized				Results				
	n	%	*M*	*SD*	*n*	%	*M*	*SD*	χ^2	*t*	df	*p*	sig.
Gender: M	5	50.0			28	63.6			.63		1	>.30	ns.
F	5	50.0			16	36.6							
Age (months) at initial assessment	10		51.3	3.4	44		51.4	8.4		.07	36	.95	ns.
Birth order	10		1.8	.6	44		2.3	.9		1.96	17	.07	ns.
Number of children in family	10		2.1	.57	44		2.5	.95		1.64	22	.11	ns.
Father's education (years of school)	10		15.2	2.7	42		15.4	2.7		.22	13	.83	ns.
Mother's education (years of school)	10		13.7	1.8	43		14.4	2.2		1.11	15	.28	ns.

TABLE 3. Treatment experiences of the children whose speech was normalized (Group A) and nonnormalized (Group B) at the 1-year follow-up assessment.

Variable	Levels	Group A: Normalized		Group B: Nonnormalized		Results			
		n	%	*n*	%	χ^2	df	*p*	sig.
Direct Intervention									
Duration[a]	None	4	40.0	9	21.0	1.49	1	.23	ns.
	1–6 mos	1	10.0	6	14.0				
	> 6 mos	5	50.0	27	64.0				
Frequency[a]	≤ 1 sess/wk	1	16.7	4	12.5	1.08	1	.30	ns.
	2 sess/wk	5	83.3	23	71.8				
	≥ 3 sess/wk	0	0	5	15.6				
Targets[b]	1–2 sounds	1	16.7	4	12.5	.56	1	.47	ns.
	> 2 sounds	3	50.0	12	37.5				
	sounds and prosody-voice	0	0	8	25.0				
	sounds and lang. prod.	1	16.7	6	18.8				
	sounds, lang. comp., and lang. prod.	1	16.7	2	6.3				
Indirect[c] Intervention									
	none or rarely	1	10.0	2	4.7	1.27	1	.27	ns.
Model words for imitation	often	0	0	7	16.7				
	very often	9	90.0	33	78.6				
Indirect model	none or rarely	8	80.0	27	65.8	.75	1	.41	ns.
	often	0	0	2	4.9				
	very often	2	20.0	12	29.3				
Practice words	none or rarely	4	40.0	9	21.4	.58	1	.46	ns.
	often	1	10.0	14	33.4				
	very often	5	50.0	19	45.2				
Opportunities to talk	none or rarely	1	10.0	12	28.6	1.49	1	.23	ns.
	often	0	0	1	2.4				
	very often	9	90.0	29	69.0				
	none or rarely	7	70.0	17	42.5	2.90	1	.09	ns.
Teach alphabet and sounds	often	2	20.0	10	25.0				
	very often	1	10.0	13	32.5				
	none or rarely	2	20.0	11	25.6	.14	1	.72	ns.
Remind child to speak clearly	often	0	0	3	7.0				
	very often	8	80.0	29	67.4				

[a]The second and third levels were combined for chi-square analysis. [b]The first two levels and the last three categories were combined for chi-square analysis. [c]The second two levels for each variable were combined for chi-square analysis.

outcomes—children's experiences with speech treatment before the original assessment and during the 1-year period—was tested using information obtained from the detailed questionnaire and follow-up interview with each child's caregiver. The percentage breakdowns in Table 3 provide descriptive categorical data. Cell-size requirements for statistical comparisons were met by dichotomizing children's status on each variable (see footnotes to Table 3).

As indicated by totaling the percentages in the second and third rows, 60% of the children who normalized and 78% of the children who did not normalize received some type of direct intervention. The 18% difference, which is opposite from the expected direction relative to normalization, was nonsignificant. Most services were provided by school district personnel, with some children receiving services from speech-language pathologists in local health maintenance organizations or private practice. Table 3 also shows that among those children who received direct intervention there were no statistically significant differences between the normalized and nonnormalized groups in the frequency or targets of treatment. On the latter variable it is notable that speech-sound normalization was not limited to those children whose only direct intervention targets were speech sounds. Additional data on treatment approach and session length also failed to differentiate between children in the two outcome groups.

The six variables listed under *Indirect Intervention* in Table 3 provide descriptive data on the procedures caregivers used to try to help their speech-delayed children before the original assessment and during the following 1-year period. The data in this table are collapsed from more detailed information (as many as 10 individual categories for each procedure) on the type and frequency of each of the six procedures. The descriptive and inferential statistics (*often* and *very often* cells were combined for chi-square analyses) indicated that none of the six indirect intervention procedures was statistically associated with speech-sound normalization by the end of the 1-year period.

Predictor variables: Risk factors. The final series of predictive analyses examined associations between risk factors and short-term speech-sound normalization. Figure 11 is a summary of these data; the Appendix includes a key to each of the numbered descriptors under each risk factor. In each panel the percentage of subjects rated *1* or *2* (*questionable* or *involved*) rather than 0 (*within the normal range*) (cf. Shriberg & Kwiatkowski, 1994) are sorted from

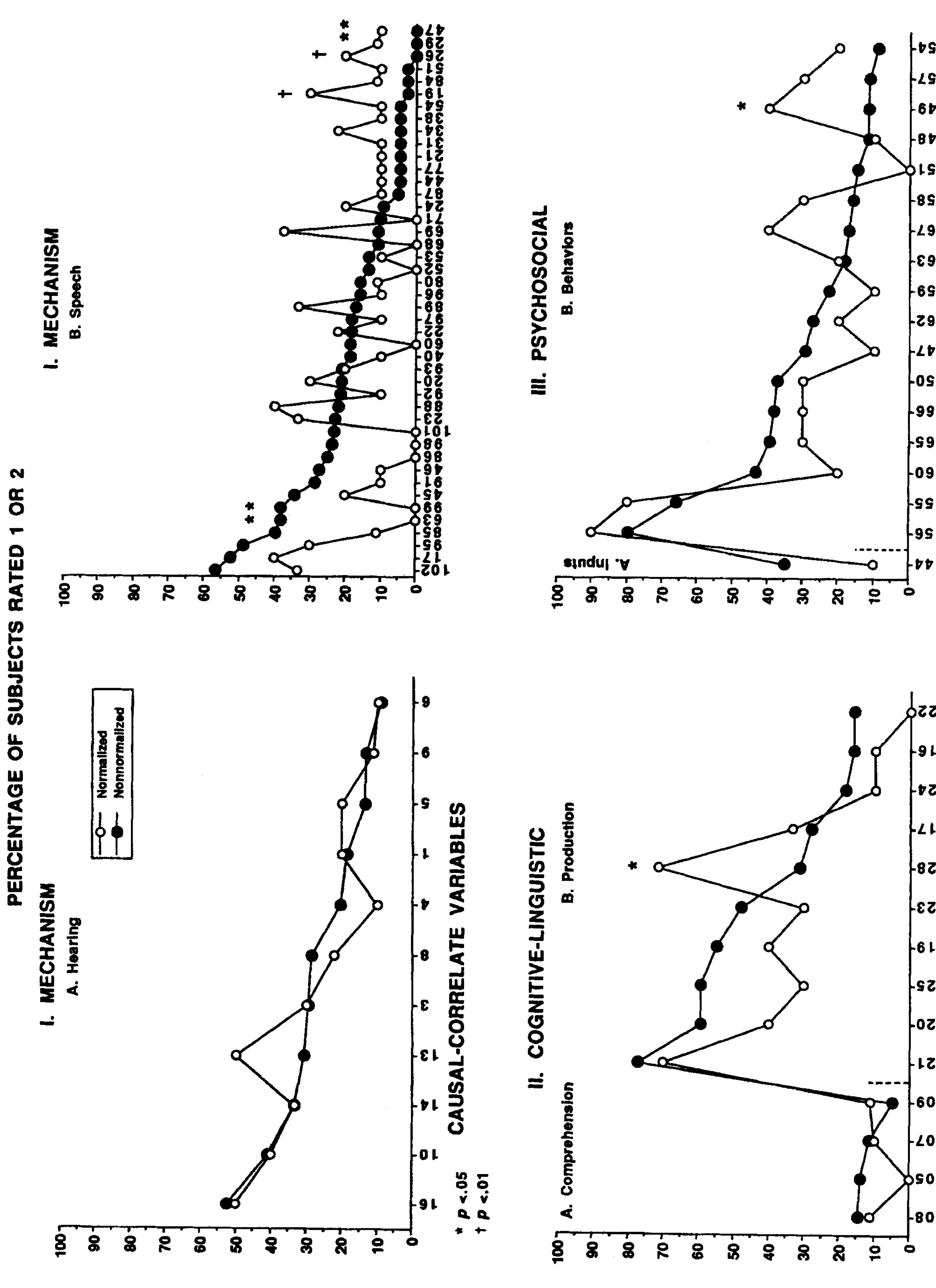


FIGURE 11. Summary of the analyses of causal-correlates and risk factors associated with short-term speech-sound normalization.

highest to lowest, based on the risk-factor data for the 44 nonnormalized children (filled circles). Of the total 146 risk factors on which data were obtained, the numbered variables in Figure 11 are those meeting two criteria: codable data were available for at least 50% of the children in each outcome group, and at least 10% of children in one or both groups were coded *questionable* or *involved.*

The data in Figure 11 do not support a hypothesis that children who normalize have fewer mechanism, cognitive-linguistic, or psychosocial constraints. Only 8 of the 87 risk factor contrasts were statistically significant, and 6 of these significant comparisons indicated more rather than less involvement for children in the normalized group. There is an interesting run favoring the normalized group in the first 12 speech mechanism variables (upper right panel), but only variables 63 (palatine tonsils) and 99 (pharyngeal structure) were statistically significant at the advisory alpha levels. The descriptive and inferential data in Figure 11, as well as individual analyses of the profiles of each of the 10 children who normalized, indicated that no one of these variables is a reliable predictor of speech-sound normalization. Even among the most likely predictor variables, such as the hearing, language comprehension, and language production variables, children's historical or performance status was not strongly associated with speech-sound normalization during the 1-year period.

Discussion

Methodological Issues

The findings of this study are consistent with results from the prediction research to date in developmental phonological disorders: There appears to be no one predictor variable clearly associated with short-term speech-sound normalization. Among the methodological caveats in the present study and all studies to date is the sensitivity of predictor measures to the domains they purport to assess. Especially within the speech and prosody-voice variables, the perceptually based data reduction procedures could have been insensitive to predictive information available with more fine-grained instrumental analyses. Also, some researchers might view the absence of linguistic analyses that purport to yield information on subjects' underlying phonological forms (cf. Vihman, Velleman, & McCune, 1994) as a methodological weakness in an assessment protocol that includes only phonological production data. Finally, any one or more of the array of measures and tasks used to gather information on risk-factor variables could have been insensitive to predictive information available with more elaborated assessment approaches. Thus, from a methodological perspective, it could be argued that the domains assessed in this study might have predictive utility if tested differently and also if cell sizes had allowed for more powerful inferential statistical procedures.

Theoretical Issues

Specificity models. Perhaps the most conventional explanatory-predictive perspective on the origins and persistence of developmental phonological disorders is of a taxonomy of specific etiological factors, any one of which could be a sufficient cause of speech delay or residual error. For example, in the typology proposed by Shriberg (1982), deficits in one of seven etiologic "families" are posited, with subtypes within each family elaborating the typology by site of involvement and phonological stage. For example, in this typology fluctuant hearing loss due to frequent otitis media occurring during stages I and II of phonological development (Ingram, 1989) is deemed sufficient to set in motion a chain of psycholinguistic processes constraining the establishment of the appropriate underlying representations for speech sounds (cf. Shriberg, 1987). To date, however, there is no compelling data to support any one specific causal background for a developmental phonological disorder.

The present findings also suggest that there is ample data to reject the notion that short-term speech-sound normalization is associated with any one specific normalization factor, including the provision of speech services. That is, nowhere in the many reported and unreported analyses did we find evidence linking normalization during the 1-year period to changes in subjects' risk-factor status or intervention histories. This finding was particularly surprising for cognitive and language comprehension factors, which as reviewed have been associated with long-term speech-sound normalization as well as long-term academic needs. As above, these negative findings might reflect either measurement and sample-size needs that are particularly crucial for prediction of short-term speech-sound normalization or they might suggest that the specificity hypothesis is not the correct model for explanatory-prediction research.

Additive models. An additive or "threshold" explanatory-predictive model posits that speech delay may be caused and/or persist because of a constellation of constraints, no one of which is sufficient of itself to prohibit speech-sound normalization. In clinical contexts, the absence of support for a specificity model has led to the additive model as the default explanation for why some children have and/or maintain a developmental phonological disorder.

Although multivariate analyses could not be performed because of the sample size of the normalized group, the data gathered in the present study also fail to support an additive explanatory-predictive model of speech-sound normalization. Compared to profiles for the 10 children who normalized in the 1-year period, profiles of the 44 children who did not normalize were not more negatively weighted by constraints across mechanism, cognitive-linguistic, or psychosocial factors. Moreover, additional analyses to derive weighted indices were not informative; we could discern no additive scheme by which the nonnormalized children "scored" higher on risk factors than the normalized children.

A two-factor model. A fundamental issue in the present discussion is whether speech-sound normalization outcomes are ever likely to be predictable from only the types of variables assessed in the current study and those illustrated by the citations in Table 1. Explanatory-predictive research in developmental phonological disorders must actually address two questions: Why do some speech-delayed children—even those with only mild involvement—fail to normalize within 2 years? Why do others—even those with relatively poor speech—normalize? In the present study, for example, the severity levels of the 10 children who normalized ranged from percentages both below and above the standard deviation of the severity levels of the 44 children who did not normalize in 1 year.

The present findings, as well as other findings indicating that neither severity of speech-language involvement nor other risk factors are sufficient predictors of short-term speech-sound involvement in specific or additive models, have prompted the development of a two-factor framework for explanatory-predictive research in developmental phonological disorders (Kwiatkowski & Shriberg, 1993; Shriberg et al., 1992). The core notion in the two-factor framework is that, for explanatory-predictive purposes, there is a need for measures that index a subject's *motivation* for speech-sound normalization. Briefly, the two-factor framework subsumes all variables relevant for phonological learning under two-factor domains titled *Capability* and *Focus*. Capability reflects the child's current potential for speech change, indexed by status on all of the speech and risk-factor variables assessed in the present study (i.e., as listed in the Appendix). Focus, which subsumes the constructs of motivation and effort, reflects the child's modal and momentary (i.e., trait and state) disposition toward effecting speech change. A minimal level of both capability and focus is presumed necessary at each stage of normal phonological development as well as for speech-sound normalization. In a retrospective study of short-term outcomes for 75 children who had received intervention programming at one university clinic, a quantitative index of the focus construct added statistically significant discriminant power to the prediction equation. Specifically, adding a retrospectively determined estimate of children's focus to the discriminant function significantly increased the correct prediction of children who made minimal, rather than maximal, progress in one or two semesters of intervention. Thus, the construct of focus may have promise to address successfully one of the most clinically puzzling predictive questions: Why do some children with even mild to moderate speech involvement fail to achieve short-term speech-sound normalization. Such questions have been posed in a series of longitudinal case studies of the capability-focus predictive framework in children with developmental phonological disorders.

Conclusions

Findings from this study of short-term speech-sound normalization in developmental phonological disorders suggest the following four conclusions:

1. Considerable speech-sound normalization occurs in the 1-year period following the initial classification of a child as having a developmental phonological disorder, subclassed as a speech delay of unknown origin. Of an overall 1-year gain averaging 8% on the Percentage of Consonants Correct metric, the greatest improvement (approximately 22%) occurs on Late-8 consonant sounds.

2. The pattern of improvement over a 1-year period is consistent with "across-the-board" processes in which speech changes occur proportionally in all phonetic classes of consonants and vowels-diphthongs. Such findings support the construct of *speech delay,* with the sequence of short-term speech-sound normalization mirroring the normative acquisition sequence (cf. Shriberg et al., 1994; Shriberg & Kwiatkowski, 1994).

3. Short-term speech-sound normalization, which occurred for 10 of the 54 (18.5%) children during the 1-year period of this study, was not associated with specific or additive speech, risk-factor, or intervention histories. The most statistically significant predictor of continued speech delay was the occurrence of omission errors in the original assessment, particularly on the Early-8 and the Late-8 consonant sounds. As observed in a retrospective study in which original consonant inventories were significantly associated with treatment progress (cf. Kwiatkowski & Shriberg, 1993), the absolute and relative percentage of omission errors appears to provide the strongest predictive power for both short-term and long-term speech-sound normalization.

4. More sensitive, multivariate measurement of speech and risk-factor variables may increase the accurate prediction of short-term and long-term speech-sound normalization. However, as is currently being pursued in associated studies, an instrument with clinically acceptable sensitivity and specificity may require additional measures indexing a child's motivation to effect speech change.

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Appendix

TABLE A. Causal-correlate descriptors for the data points in Figure 11.

Item	Rating definitions 0	1	2
I. Mechanism			
A. Hearing			
1. Wax buildup	None	Periodic wax buildup warrants medical attention	Frequent; excessive wax buildup warrants medical attention
3. P.E. tubes	None	P.E. tubes considered by physician	P.E. tube(s) placed in ear(s)
4. Allergies	None	Mild; controlled with mild medication	Severe; persistent; strong medication
5. Adenoids; size	Normal	Slightly enlarged	Significantly large or removed
6. Asthma	Not present	Mild	Severe
8. Hearing; observationally	Normal	"Does not always seem to hear; is sometimes indifferent to sound."	"Seems to always have trouble hearing."
9. Pure tone screening	Passed	Failed at one frequency	Failed at more than one frequency
10. Pure tone thresholds	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
13. Tympanometry	Normal	Negative pressure of at least −200 in one ear on at least one occasion	Negative pressure of at least −200 in both ears on at least one occasion
14. Acoustic reflex	Present in both ears	Absent in one ear on at least one occasion	Absent in both ears on at least one occasion
16. Middle ear problems	Fewer than four episodes between 0–18 months	Four-plus episodes between 0–18 months but none later	Four-plus episodes between 0–18 months and later episodes
B. Speech			
17. Heredity factor	Not present	Single family member with same speech problem	More than one family member with same speech problem
19. Gestational age	Full term	One month premature	Greater than one month premature
20. Delivery position	Normal	Complications, such as breech position, but normal delivery	Complications requiring a C-section
21. "Blue"	Not present	Blue at birth; oxygen not required	Blue at birth; oxygen required
22. Jaundice	Not present	Jaundice at birth lasting no more than 3 days	Jaundice at birth lasting 4 days or more
23. Gross motor development	Within age level	20%–30% below age level (MCDI) or delayed up to one year	Greater than 30% below age level (MCDI) or greater than one year delay
24. Walking; onset	15 months or earlier	16–19 months	20 months or later
26. Gross/fine motor skills; quality	Normally coordinated	Somewhat uncoordinated	Very uncoordinated
29. Neuromotor	Normal	Medically affiliated person suspects dysarthria or dyspraxia	Confirmed dysarthria or dyspraxia
31. Chewing	Normal	Noticeably slow, but coordinated	Significant difficulty coordinating movements
34. Pooling of saliva after infancy	None	Periodic	Frequent
38. Eye spacing	Normal	Questionable	Involved
40. Nasal obstruction	Normal	Questionable	Involved
44. Lips; position at rest	Normal	Questionable	Involved
45. Teeth; occlusion	Normal	Questionable	Involved
46. Teeth; condition	Normal	Questionable	Involved
47. Teeth; condition of gingiva	Normal	Questionable	Involved
51. Tongue; appearance of surface	Normal	Questionable	Involved
52. Tongue; length of frenum	Normal	Questionable	Involved
53. Hard palate; height	Normal	Questionable	Involved
54. Hard palate; coloration	Normal	Questionable	Involved
60. Uvula; description	Normal	Questionable	Involved
63. Pharynx; palatine tonsils	Normal	Questionable	Involved
68. Respiration and phonation; loud voice	Normal	Questionable	Involved

Continued

TABLE A. Continued.

Item	Rating definitions 0	1	2
69. Respiration and phonation; pitch	Normal	Questionable	Involved
71. Velopharyngeal function; velar movement	Normal	Questionable	Involved
77. Articulation; nonspeech lip retraction	Normal	Questionable	Involved
80. Articulation; lip strength	Normal	Questionable	Involved
84. Articulation; tongue protrusion	Normal	Questionable	Involved
85. Articulation; tongue movements (highest score)	Normal	Questionable	Involved
86. Articulation; tongue strength/force (highest score)	Normal	Questionable	Involved
87. Diadochokinesis	Normal	Accurate, but slow and/or arrhythmic	Significantly slow and/or arrhythmic
88. Volitional oral movements; isolated	Normal	Between 15th and 30th percentile	Below one standard deviation
89. Volitional oral movements; sequenced	Normal	Between 15th and 30th percentile	Below one standard deviation
91. Syllable sequencing; nonsense syllables	Normal	Between 15th and 30th percentile	Below one standard deviation
92. Syllable sequencing; multisyllabic words	Normal	Between 15th and 30th percentile	Below one standard deviation
93. Facial structure scales	All zero scores	Highest scale score = "1"	Highest scale score = "2"
95. Teeth and mandible structure scale	All zero scores	Highest scale score = "1"	Highest scale score = "2"
96. Tongue structure scale	All zero scores	Highest scale score = "1"	Highest scale score = "2"
97. Hard palate structure scale	All zero scores	Highest scale score = "1"	Highest scale score = "2"
98. Soft palate structure scale	All zero scores	Highest scale score = "1"	Highest scale score = "2"
99. Pharynx structure scale	All zero scores	Highest scale score = "1"	Highest scale score = "2"
101. Velopharyngeal function scale	All zero scores	Highest scale score = "1"	Highest scale score = "2"
102. Articulation function scale	All zero scores	Highest scale score = "1"	Highest scale score = "2"
II. Cognitive-Linguistic			
A. Comprehension			
105. General development	Within age limits	20%–30% below age level (MCDI) or up to one year delay	Greater than 30% below age level (MCDI) or greater than one year delay
107. Preschool Language Scale; Auditory Comprehension	Age appropriate	Up to one year delay	Beyond one year delay
108. Concept learning	Within age limits	20%–30% below age level (MCDI) or up to one year delay	Greater than 30% below age level (MCDI) or greater than one year delay
109. PPVT-R	Standard score 75 or more	Standard score < 75, age equivalent one year or less below actual age	Standard score < 75, age equivalent greater than one year below actual age
B. Production			
116. Amount of babbling	Normal	Limited	None/very little
117. Talking onset; first word	14 months or less	15–18 months	Later than 18 months
119. Mean length of utterance (MLU)	Within expected range for chronological age	Marginal (between 15th and 30th percentile)	Predicted chronological age equivalent below one standard deviation of expected age
120. Structural stage	Emerging stage consistent with expected stage	One stage gap between emerging and expected stage	Two or more stage gap between emerging and expected stage
121. Grammatical morpheme use stage	Consistent with expected stage	One stage gap between overall grammatical morpheme stage and expected stage	Two or more stage gap between emerging and expected stage
122. Formulation	Within normal range	Marginal (15th–30th percentile)	Below one standard deviation
123. Percentage of word types	46% or greater	45%–46%	Less than 45%
124. Lexical retrieval	Within normal range	Marginal (15th–30th percentile)	Below one standard deviation
125. Pronoun production	Normal	Only one error type	Two or more error types
128. Talking onset; two word combinations	22 months or earlier	23–31 months	Later than 31 months

Continued

TABLE A. Continued.

Item	Rating definitions 0	1	2
III. Psychosocial			
A. Inputs			
144. Acceptance by peers	Readily accepted	Accepted after initial period of nonacceptance	Never fully accepted
B. Psychosocial Behaviors			
147. Nervous habits	None	Limited to some situations	Consistently in many situations
148. Maturity	Within age limits	20%–30% below age level (MCDI) or somewhat immature behavior	Greater than 30% below age level or considerably immature behavior
149. Social responsiveness; new situations	Normal	Somewhat shy, quiet, fearful	Considerably shy, quiet, fearful
150. Social responsiveness; reinforcement	Normal	Needs somewhat more external reinforcers	Needs considerably more external reinforcers
151. Social responsiveness; questions	Normal	Somewhat unresponsive to direct questions	Generally unresponsive to direct questions
154. Need for approval	Normal	Somewhat high	Considerably high
155. Sensitivity to others	Normal	Somewhat over-concerned about others' feelings	Considerably over-concerned about others' feelings
156. Sensitivity to self	Normal	Somewhat too sensitive; feelings easily hurt	Overly sensitive; feelings very easily hurt
157. Dependence on adults	Normal	Somewhat too dependent	Overly dependent
158. Separates from adults	Normal	Separates from parents only after encouragement	Cannot be encouraged to separate from parents
159. Aggression	Normal	Periodically over-aggressive	Consistently over-aggressive
160. Compliance	Normal	Compliant when expectations are made clear	Compliant only in highly structured situations
162. Requests for clarification	Normal	Often unwilling to repeat an utterance	Consistently unwilling to repeat an utterance
163. Willingness to talk	Normal	Hesitant in many situations	Hesitant in most situations
165. Attention in treatment	Normal	Somewhat distractible; can attend for short periods	Highly distractible
166. Manipulative behavior in treatment	Not overmanipulative	Periodically over-manipulative	Constantly over-manipulative
167. Speech-related avoidance	Normal	Some avoidance of difficult speech tasks	Frequent avoidance of difficult speech tasks

Developmental Phonological Disorders II: Short-Term Speech-Sound Normalization

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