Metrical Analysis of the Speech of Children With Suspected Developmental Apraxia of Speech

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Previous studies have shown that metrical analysis accounts for syllable omissions in young normally developing children better than prior perspectives. This approach has not yet been applied to children with disorders. Inappropriate sentential stress has been proposed as a diagnostic marker for a subgroup of children with suspected developmental apraxia of speech (SD-DAS), suggesting that the application of metrical perspectives to this population may be appropriate. This report extends the goal of identifying diagnostic markers for SD-DAS using analytic procedures from metrical phonology. The lexical metrical patterns of children with SD-DAS were compared to those of a group of children with speech delay (SD) to verify the applicability of metrical constructs to children with disorders while at the same time seeking lexical stress characteristics that might be useful for differential diagnosis. The lexical stress errors of children in both the SD and SD-DAS disorder groups were found to conform to patterns identified in metrical studies of younger normally developing children, confirming the applicability of this approach to children with disorders. Lexical metrical patterns did not differentiate the groups from each other. However, syllable omissions persisted to much later ages in the SD-DAS subjects, especially those children previously identified as having inappropriate phrasal stress. Further metrical studies of the speech of children with suspected SD-DAS are needed, both at the lexical and the sentential level, using both perceptual and acoustic measures.

KEY WORDS: classification, metrical, phonology, prosody, speech disorders

Metrical analysis has recently been shown to account for syllable omissions in young normally developing children and for adult syncope better than prior perspectives. To date, this approach has not been applied to children with disorders. Inappropriate sentential stress has been proposed as a diagnostic marker for a subgroup of children with suspected developmental apraxia of speech (SD-DAS), suggesting that the application of metrical perspectives to this population may be appropriate. In the present study, metrical analysis procedures are applied to children with SD-DAS in an effort to verify the applicability of such procedures to disordered groups as well as to further the search for diagnostic markers for this disorder.

Metrical Phonology and Lexical Stress Information in Young Children and Adult Syncope

Terms and Concepts

The central concerns of metrical phonology are associations between syllable and word structure variables and speakers' suprasegmental

1092-4388/99/4206-1444

production patterns (cf. Goldsmith, 1990; Hayes, 1995; Archibald, 1995). In metrical phonology, syllables are classified as *strong* (S, stressed) versus *weak* (W, unstressed). The syllables in a word (as well as the words in a sentence) tend to alternate between strong and weak, creating a rhythmic base for the word. Some words in English violate this alternating pattern, but those that do so in an extreme manner tend to be notoriously difficult to pronounce (e.g., "indefatigable," which is WWSWWW). If there are two or more strong syllables within the same word, strong syllables may have either primary (Ś) or secondary (S̀) stress.

Strong and weak syllables in English may be further classified as *heavy* or *light* based on their segmental constituents. Heavy syllables contain a diphthong and/or a postvocalic consonant, and light syllables contain only one vowel and no final consonant. Heavy syllables "attract stress"; they may receive either secondary or primary stress, but are not weak. Similarly, weak (unstressed) syllables are light; many vowels in such syllables are actually reduced to schwa or [ɪ] in order to avoid attracting stress. For example, the first vowel in the word "rebellion" is typically pronounced as [ɪ] or schwa rather than [i]. With morphologically related stress changes, many syllables in English words alternate between reduced vowels and full vowels or even diphthongs (e.g., [rɛ́*bəl*] vs. [rə*bɛ́l*jən], [pɚpɛ́tʃu*wəl*] vs. [pɚpɛ́tʃu*wèɪt*]). When the syllable is not stressed, the vowel is reduced to schwa; when the syllable is stressed, the vowel is augmented to a full vowel or a diphthong.

Two or more syllables make up larger units termed *feet*, with the central distinction being between *trochaic* and *iambic* feet. Trochaic feet are composed of a strong syllable followed by a weak syllable (SW; e.g., MONkey), or a primary-stressed strong syllable followed by a secondarily stressed strong syllable (ŚS̀; e.g., FLINTSTONES). Iambic feet are composed of a weak syllable followed by a strong syllable (WS; e.g., baBOON) or a secondarily stressed strong syllable followed by a primary stressed strong syllable (ŚS̀, e.g., TYPHOON). A strong syllable can also stand alone as a (trochaic) foot. In English, the trochaic foot is the preferred stress pattern for words, although iambic words also occur fairly frequently, and iambic phrases are predominant (Vihman, DePaolis, & Davis, 1998).

Lexical Stress in Speech Development

Young English speakers' "preference" for trochaic words is well established, although not universal (Kehoe & Stoel-Gammon, 1997a; Vihman et al., 1998). Children in the initial stages of phonological development (i.e., below 3 years of age) who omit syllables from two-syllable words typically omit weak, rather than strong, syllables. Furthermore, they omit initial weak syllables more often than they omit final weak syllables, especially within trochaic feet. Thus, an SW word such as COOkie will be produced in its entirety, whereas a WS word such as racCOON will be reduced to its strong syllable, COON. A single strong syllable is evidently preferable to an iambic foot. Furthermore, a three-syllable WSW word, such as baNAna, is considerably more likely to lose its first weak syllable, which interferes with the strong-first trochaic pattern. If the initial weak syllable (W_1) is omitted, the remainder of the word represents a trochaic foot: the SW [nǽnə]. Similarly, words with an $S_1W_1W_2S_2$ pattern (such as REintroDUCE) are more likely to lose the second W syllable (W_2) rather than the first (W_1), leaving the first two syllables of the word as an SW trochaic foot, and the fourth standing alone as a foot in its own right. Finally, for children who omit syllables in words with an SWS pattern, it is the weak syllable that is most likely to be omitted (cf. Allen & Hawkins, 1980; Demuth, 1996; Fikkert, 1994; Gerken, 1991, 1994; Gerken & McIntosh, 1993; Kehoe, 1994, 1995, 1997; Kehoe & Stoel-Gammon, 1997a, 1997b; Schwartz & Goffman, 1995; Vihman, 1980).

Stress-shift errors, in which the stress moves from one syllable to another, are far less common than syllable omission errors in young children with typically developing speech (Kehoe & Stoel-Gammon, 1997a). Fikkert (1994) reported more stress-shift errors on iambic than on trochaic words for children learning Dutch. The 11 subjects in Fikkert's study shifted stress in WS words from 0% to 52% of available opportunities (M = 19.6%), and in SW words from 2% to 7% of opportunities (M = 4.8%). Kehoe & Stoel-Gammon (1997a) found that 27-month-olds produced 7% of target WS words with stress shift errors (shifting to SW or ŚS̀) in comparison to 5% stress-shifted productions of SW words in another group of 24-month-olds. However, other iambic target patterns (S̀Ś, S̀WŚ) reflected stress-shift errors in up to 41% of productions in children from 22 to 34 months of age. These authors pointed out that W syllables are more likely to be deleted (from WS words) than S syllables (from SS or SWS words), even if the S syllable only has secondary stress. The frequency of stress shifts in WS words is reduced because the W syllables tend to be eliminated, and there is therefore no possibility of a stress shift. Stress shifts occur more often in other iambic target patterns, presumably as a means of preserving strong syllables while also producing a trochaic stress pattern.

Based upon their studies of children aged 22–34 months as well as upon a review of several other studies of metrical development, Kehoe (1994, 1997) and Kehoe and Stoel-Gammon (1997a, 1997b) proposed that metrical factors alone cannot account for children's syllable omissions in multisyllabic words. They suggest that the sonority of initiating consonants and “edge effects” (the position of the syllable within the word) are additional sources of variance on children’s omissions of weak syllables, especially in SWS words. These authors propose five phonological conditions (phonological *constraints*) governing the occurrence of syllable omissions and stress shifts that are relevant in the present context. The first three are metrical constraints: (a) stressed syllables are preferred (and therefore, preserved) over unstressed syllables, (b) trochaic targets (e.g., SW, ŚS̀, SWS) are preferred over iambic targets (e.g., WS, WSW, S̀Ś), (c) word-final unstressed syllables are preferred over unstressed syllables in word-medial position, even in words with two consecutive W syllables (e.g., SWW, WSWW). Moreover, SWS words, in which the final syllable is targeted for primary stress (S̀WŚ), are more likely to be reduced to one single (final) syllable (e.g., KANgaROO reduced to [wu]) than are ŚWS̀ words. (As above, this is sometimes referred to as the “edge effect.”) The fourth and fifth constraints relevant for metrical analyses reflect the influence of consonant sonority on the status of the syllable. The ideal syllable includes a consonant followed by a vowel, with a maximum phonetic difference between the two segments. Thus, syllables with onsets are preferred over syllables without onsets and syllables with obstruent (stop, fricative, or affricate) onsets are preferred over syllables with sonorant onsets. Preferred syllables are less likely to be omitted in the face of metrical pressure to do so.

Adult Fast-Speech Syncope

Hammond’s (1997) analyses of adult English fast-speech syncope indicate that stress reductions pattern themsleves similarly to those observed in speech development. Based upon observed reductions such as “prade” for parade, “choclate” for chocolate, and “respratory” or “respirtory” for respiratory, Hammond proposes that a stressless vowel may be omitted in fast casual speech if it meets one of three conditions: “(a) It is word-initial; or (b) it immediately follows the only stressed syllable of the word and is not in the last syllable of the word; or (c) it is one of two stressless syllables intervening between two stressed syllables” (p. 47). Hammond concludes that “vowels syncopate only when an optimal (= disyllabic) foot would result” (p. 47), and he proposes a metrical constraint against unfooted syllables. This constraint against the production of syllables that do not fit within a trochaic foot is, in his view, prioritized over faithfulness to (preservation of) unstressed syllables, but not over faithfulness to stressed syllables. That is, a syllable may be omitted to optimize the footing of a word only if it is unstressed. However, syncope may be prevented by another constraint that states that the final syllable must be maintained whether it is stressed or not. Thus, the conditions that govern adult fast-speech syncope closely parallel those suggested for young children’s syllable omissions. In the following section, the applicability of these same conditions to the syllable omissions (and vowel augmentations) of children with phonological delays or disorders is considered.

Inappropriate Stress as a Diagnostic Marker for a Subgroup of Children With Suspected Developmental Apraxia of Speech

Background

In a prior study series, Shriberg, Aram, and Kwiatkowski (1997a, 1997b, 1997c) examined segmental and suprasegmental features that might distinguish children whose speech delays were suspected to reflect developmental apraxia of speech (SD-DAS) from children with speech delays of currently unknown etiology (SD). For three independent samples of children with SD-DAS, including one large sample of 53 children with suspected SD-DAS matched with children with SD, there was no segmental feature in conversational speech samples that met customary 90% sensitivity and specificity criteria for all 53 children with suspected SD-DAS. This finding was consistent with suggestions from Grunwell & Yavas (1988) and others, that children with SD-DAS often demonstrate discrepancies between their segmental repertoires, which are *relatively* good, and their phonotactic (syllable and word shape) repertoires, which are comparatively more limited. With respect to prosody, however, as assessed with an auditory-perceptual procedure for suprasegmental analysis (Shriberg, 1993; Shriberg, Kwiatkowski, & Rasmussen, 1990; Shriberg, Kwiatkowski, Rasmussen, Lof, & Miller, 1992), findings indicated that over one half (52%) of the 53 children with suspected SD-DAS had frequent inappropriate stress in conversational speech. The specific type of inappropriate stress, termed *excessive/equal/misplaced* stress, was observed in only 10% of 71 children with SD. Inappropriate stress was therefore proposed as a candidate diagnostic marker for at least one subtype of SD-DAS, hereafter SD-DASi (i.e., speech delay with suspected DAS and inappropriate stress).

Limitations in the Measurement of Stress in the Shriberg et al. Studies

The auditory-perceptual screening instrument used for suprasegmental analysis in the Shriberg et al. (1997b, 1997c) studies provides information on 32 prosody-voice codes (Shriberg, 1993; Shriberg et al., 1990; Shriberg et al., 1992). The code that occurred frequently in over 50% of children with suspected SD-DASi was Prosody-Voice

Code 15: Excessive/Equal/Misplaced Stress. The procedural manual for the prosody-voice coding system indicates that PV15 is an appropriate code for utterances in conversational speech in which the coder perceives either (a) a monostressed pattern characterized by forceful, punctuated stress, (b) misplaced word stress relative to expected phrasal, sentential, or emphatic stress patterns, or (c) blocks or sound prolongations that interfere with the production of the normal prosody of the utterance. Another code is used for utterances that include instances of inappropriate lexical stress (i.e., inappropriate syllabic stress at the word level). Several instances of the latter code attributed to children with suspected SD-DASi (e.g., SidNEY and sisTER) involved vowel augmentation of weak syllables, phonological data that add to the hypothesis that these children have inappropriate representations of stress. Although the quantitative data on the auditory-perceptual procedure did not indicate that children with suspected SD-DAS differed from children with speech disorders of unknown origin on the frequencies of inappropriate lexical stress, the source of the percept of excess-equal phrasal stress was not determined in these studies. One possible method for achieving monostressed sentences is the omission of weak syllables, a pattern that falls outside the PVSP definition of "inappropriate lexical stress." Additionally, strongly overstressed syllables within multisyllabic words could have been perceived in some cases as sound prolongations, eliciting an "excess-equal stress" code rather than an inappropriate lexical stress code. Thus, although children with suspected SD-DAS did not differ from children with SD on lexical stress as defined on the auditory-perceptual measure, analysis of the metrical patterns of syllable omissions and vowel augmentations, as reported above (i.e., SidNEY and sisTER), might indicate that such deficits underlie the percept of excessive/equal/misplaced sentential stress.

Goals of the Study

The present study examined the frequencies of occurrence and metrical effects on syllable omissions and vowel augmentations in words spoken by a subsample of the children with suspected SD-DASi in the Shriberg et al. studies. The goals were twofold: (1) to assess the applicability of metrical phonology to children with phonological delays (SD) or disorders (e.g., SD-DAS), and (2) to assess whether lexical-level changes with metrical impacts (syllable omissions and vowel augmentations) in children with SD-DASi differ from those in children with the common form of child speech disorders, SD, or in children with SD-DASa (i.e., speech delay with suspected DAS and appropriate stress). If these syllable- and sound-level sound changes differ in frequency of occurrence and/or metrical effects from those of children in the other two groups, they may be contributing to the percept of excessive/equal/misplaced stress observed in the utterances of children identified as SD-DASi.

Method

Participants

Table 1 is a summary of the age, sex, and speech severity data for three subsamples of children from the Shriberg et al. (1997b, 1997c) studies. The 8 children in the SD-DASi group were selected from the original sample to have less than 80% Percentage of Appropriate Stress scores, as defined by the number of utterances in the conversational speech sample meeting criteria for Prosody-Voice Code 15: Excessive/Equal/Misplaced Stress on the Prosody-Voice Screening Profile (PVSP; Shriberg et al., 1990). Speech samples for the 7 children in the SD-DASa group had Percentage of Appropriate Stress scores of 90% or higher. Speech samples for the 15 children with speech delay of unknown origin (SD) were selected from a group of 71 children in the same age range as children in the SD-DASi and SD-DASa groups. The goal was to assemble a set of group-matched comparison transcripts that included children who had been scored as having the most PV15 codes in their transcripts. As shown in Table 1, there were 5 children with SD whose Percentage of Appropriate Stress scores ranged from as low as 45.8% to 79.2%. The other 10 children with SD were matched as closely as possible on age, sex, and speech severity based on Percentage Consonant Correct (PCC) and Percentage Consonant Correct-Revised (PCC-R) scores (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997). As shown in Table 1, children with SD averaged approximately 3 years younger (M = 5;8, SD = 2;5) than children in the other two SD-DAS groups (DASi: M = 9;2, SD = 4;4; SD-DASa: M = 8;9, SD = 2;11). Although not dissimilar in average age to children in the SD-DASi group, children in the SD-DASa group averaged approximately 16 points higher on PCC scores than children in both the SD and SD-DASi groups.

Procedures

Transcription and Stress Coding

Shriberg et al. (1997b, 1997c) described the procedures used to gloss, transcribe, prosody-voice code, and assess transcription-coding reliability for the set of 30 conversational speech transcripts included for the present study. Briefly, some of the Shriberg et al. subjects were drawn from a previous study in the Cleveland area. Each subject's hearing and oral mechanism were assessed to rule out subjects with possible hearing loss or dysarthria. Their conversational speech samples

Table 1. Summary of demographic and speech status for 30 children with speech disorders of unknown origin divided into three groups: speech delay (SD), suspected developmental apraxia of speech with inappropriate stress (SD-DASi), and suspected developmental apraxia of speech with appropriate stress (SD-DASa).

Group	Child	Age (year;month)	Sex	% Appropriate Stress[a]	PCC[b]
SD	1	3;3	F	45.8	61.1
	2	4;4	F	91.7	68.2
	3	4;11	F	66.7	62.8
	4	5;7	F	100.0	50.6
	5	7;5	F	83.3	83.5
	6	3;11	M	79.2	66.8
	7	4;0	M	70.8	52.5
	8	4;0	M	52.2	60.9
	9	4;4	M	95.8	49.1
	10	4;8	M	100.0	47.1
	11	5;5	M	95.8	63.2
	12	6;1	M	100.0	72.2
	13	7;1	M	87.5	70.9
	14	7;9	M	83.3	88.9
	15	12;10	M	91.7	90.5
	M	5;8	—	82.9	65.9
	SD	2;5	—	17.2	13.7
SD-DASi	1	4;9	F	66.7	68.8
	2	5;4	F	33.3	52.5
	3	14;4	F	70.8	68.1
	4	5;7	M	52.6	42.8
	5	5;10	M	4.2	44.6
	6	9;11	M	40.0	68.8
	7	12;11	M	54.2	80.5
	8	14;11	M	70.8	82.3
	M	9;2	—	49.1	63.5
	SD	4;4	—	22.8	15.2
SD-DASa	1	9;2	F	91.7	89.9
	2	11;11	F	91.7	84.8
	3	5;2	M	91.7	77.4
	4	6;1	M	91.7	62.7
	5	6;3	M	100.0	76.1
	6	10;2	M	95.8	89.4
	7	12;4	M	100.0	89.1
	M	8;9	—	94.6	81.3
	SD	2;11	—	4.0	10.0

[a]percentage of appropriate stress (Shriberg, Kwiatkowski, & Rasmussen, 1990). [b]percentage of consonants correct (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997).

were initially transcribed using narrow phonetic transcription by consensus by two of the authors of the 1997 Shriberg et al. studies. Later, their samples were subjected to prosody-voice coding by a research transcriptionist who had previously met the reliability standards described in Shriberg et al. (1992). Interjudge agreement figures for this transcriber on previous samples had ranged from 85% to 99%. Interjudge reliability with two of the authors of the Shriberg et al. (1997) studies for these particular speech samples ranged from 74% to 96%.

Other subjects were drawn from samples provided by six persons with clinical research programs in DAS, with sites in Iowa, Massachusetts, Ohio, Ontario, and Texas. These researchers had been asked to provide conversational speech samples of children who: (a) met that individual researcher's criteria for a diagnosis of developmental apraxia of speech, (b) had cognitive abilities within the normal range, and (c) had "no known developmental or acquired disorder affecting the speech-hearing mechanism, cognitive functioning, or psychosocial processes" (Shriberg et al. 1997c, p. 314). These conversational speech samples were transcribed, again using narrow phonetic transcription, and coded using PVSP procedures by the transcriber described above.

For the present study, the first author and an assistant coded the metrical contexts for all syllable omissions and vowel augmentations occurring in each of the transcripts. Intelligible words and syllables in the transcripts were first sorted by (a) word type (monosyllabic, disyllabic, multisyllabic), (b) foot type (trochaic, iambic), (c) syllable strength (strong, weak), (d) syllable onset type (consonant onset, no consonant onset), and (e) consonant-onset manner type (obstruent, sonorant). These target syllables and segments were then classified as either retained, replaced, or omitted based upon the phonetic transcripts. Following Kehoe and Stoel-Gammon (1997a, 1997b), rhymes (with or without onsets) were used as the criterial information for syllable preservation. For example when "SARgeant" was produced as [ɑrt], the first syllable was considered to have been preserved because its nucleus was. In keeping with previous studies, multiple exemplars of the same word spoken by the same child were each counted separately. Truncations that occur in casual speech in American dialects (as documented by Hammond, 1997) were counted as correct (e.g., "prob'ly" for probably, one-syllable versions of "gonna"). Spondees, reduplications, and other words with inconsistent stress were not included in these analyses (e.g., upstairs, okay, outside, night-night), whereas those with consistent (usually ŚS̀) stress patterns (e.g., baseball) were included.

As reviewed previously, because vowel augmentation (increasing the segmental salience of a vowel, e.g., by tensing a lax vowel; see below) might also underlie the percept of excessive/equal/misplaced stress coded in the study of children classified as SD-DASi, procedures were developed to identify the linguistic contexts for vowel augmentation. Several additional rationales could be proposed to motivate vowel augmentation in children with any type of speech disorder: (a) to exaggerate the difference between weak and strong syllables as a means of facilitating the production of the stress contrast, maintaining the alternating stress metrical *contour* of the language (achieved by augmenting strong syllables); (b) to preserve syllables that otherwise would be omitted, maintaining the metrical *structure* of the word with respect to the target number of syllables (augmenting weak syllables, especially in word-initial position and between two strong syllables; augmenting strong syllables with secondary stress); or (c) to equalize strong and weak syllables as a means of avoiding the production of alternating stress (again, by augmenting weaker syllables). That is, vowel augmentations could be used either to enhance prosodic contrast or to maintain the syllabic foundation for stress. Each is a metrical goal; one highlights the English alternating stress pattern metrical contour, and the other maintains the metrical structure of the individual word.

On consideration of the above alternatives, our hypothesis was that children (especially those with speech disorders) would use vowel augmentation to increase the segmental weight of certain syllables. As heavier syllables—including those with more vocalic content—are more likely to be stressed, they are less likely to be omitted. Vowel augmentation then could be used to preserve syllables that would otherwise be vulnerable to syllable omissions due to metrical influences. That is, they would maintain the metrical structure of the word (number of syllables) at the expense of the metrical contour (stress pattern). Thus, in speech disordered children we expected to observe augmentations that might reflect the phonological conditions suggested by Kehoe (1994, 1997) and Kehoe and Stoel-Gammon (1997a, 1997b), with the predicted metrical consequences. Specifically, we expected a deemphasis on stress contrasts (i.e., reduced faithfulness to prosody) while reducing syllable omissions (i.e., increased faithfulness to syllables). The predictions were as follows: (a) vowels of weak syllables will be augmented, (b) vowels of syllables in iambic target words will be augmented (to shift stress toward the preferred pattern), (c) vowels of non-final syllables will be augmented, (d) vowels of syllables without onsets will be augmented, and (e) vowels of syllables with non-obstruent onsets will be augmented. Each of these strategies would have the outcome of making those particular syllables easier to preserve.

In the transcription coding procedures, vowel augmentations were defined as (a) a vowel replaced by a diphthong (e.g., [*tɛk*nɪ́ʃən] produced as [te*ɪ*khɪ́pɪ]), (b) a central vowel replaced by a peripheral vowel (e.g., [əbɑ́ʊt] produced as [ébɑʊt]), or (c) a lax vowel replaced by a tense vowel (e.g., [dɪ́fɛns], as pronounced trochaically in sports, produced as [dɪ́f*i*ns]). Syllables closed by liquids (/l/, /r/) were excluded from the vowel augmentation analysis because they may have influenced the phonetic transcription of vowel augmentation. Specifically, the influence of postvocalic /r/ or /l/ on a preceding vowel, especially when the liquid was vowelized (typically to [o] or [ʊ]), could have made them too difficult to transcribe reliably. Earlier literature reports on such errors (Klein, 1984; Hochberg, 1988) are unclear on whether these sound changes should be considered phonological stress errors. Kehoe (1997) implies that they should not; she states that unstressed rhotic vowels tend to receive increased duration due to articulatory effort, but they do not receive pitch accent.

Statistical Analysis

To retain the maximum sensitivity to the contribution of each child in a group to the central tendency statistic, group-wise percentages were calculated by dividing the sum of the percentages for all children in the group by the number of children in the group. Recall that the SD-DASa group included 7 children, the SD-DASi group 8 children, and the SD group 15 children. Similarly, the group-wise percentage across all three groups was obtained by summing the percentages for the 30 children and dividing by 30 (except for the calculations in Figure 1, Panel A, and Figure 1, Panel B, which required that a child included in the calculation have at least one occurrence of the sound change).

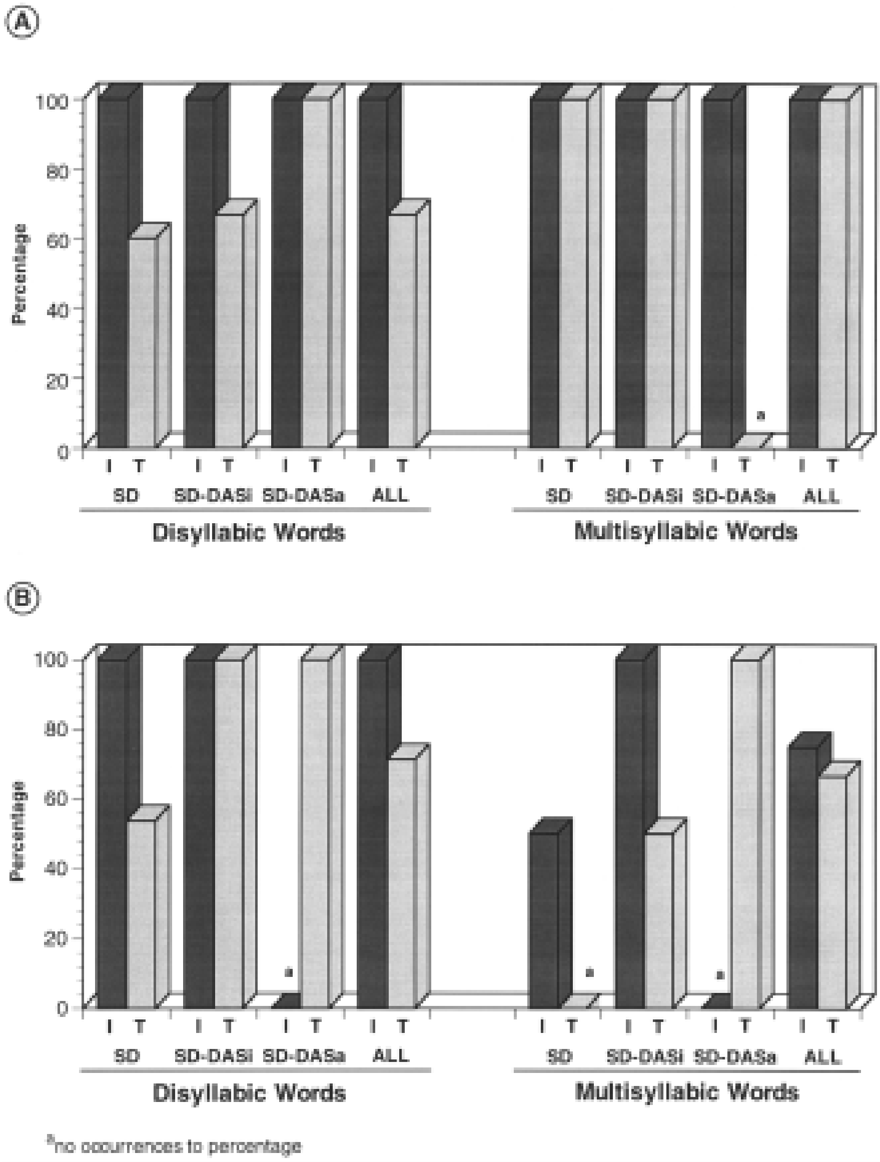
The total number of disyllabic words attempted by all subjects together was 876; of these, 786 were trochaic. Twenty-two of these disyllables were truncated (subject to syllable omission), and 26 contained vowels that were augmented. The total number of multisyllabic words attempted by all subjects together was 91. Of these, 49 were trochaic. Twenty-five syllables were omitted from these words (including two cases in which two syllables were omitted from the same word), and eight syllables included vowels that were augmented.

The relatively small subgroup sample sizes and low frequencies of occurrences of syllable omissions and vowel augmentations prohibited use of inferential comparison statistics. Therefore, the occurrence of replicated trends across the 10 dependent variables described in the next section was the criterion used to draw conclusions from the data.

Results

The following sections summarize findings for syllable omissions and vowel augmentations as identified in the transcripts of conversational speech for the 30 children. Dependent variables included five phonological comparisons, each with potential metrical effects on the occurrence of syllable omissions and of vowel augmentations (yielding 10 dependent variables), as described above. Figures 1–5 provide graphic comparisons of the syllable omission and vowel augmentation data

Figure 1. Percentage of occurrences in which a deleted syllable was the weak (Panel A) and a strengthened syllable was the weak (Panel B) syllable in iambic (I) and trochaic (T) disyllabic and multisyllabic words. See text for description of the three speech disorder groups.



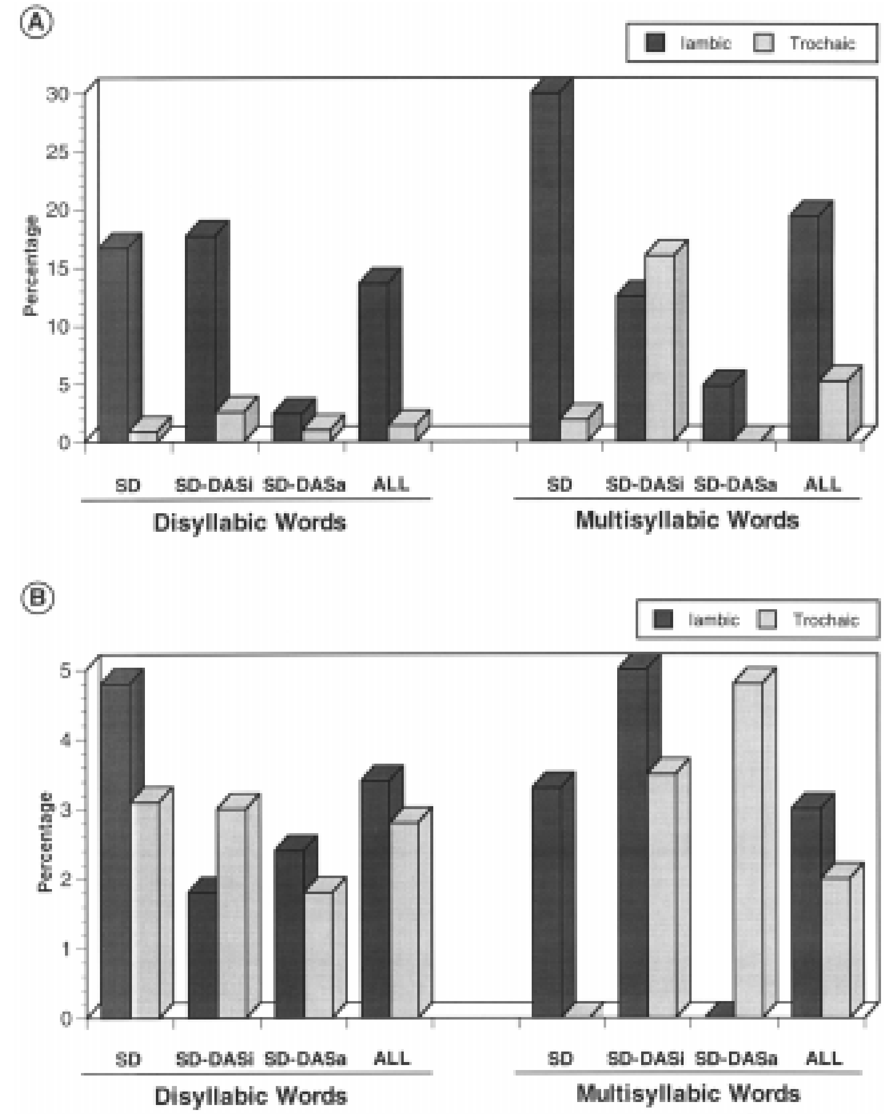
from each subject group and from all subjects grouped together for each of the five comparisons. In each case, it was predicted that the findings for both omissions and augmentations would be consistent with the findings reported above for children developing normally and for adult syncope. Specifically, it was expected that omissions and augmentations would be more frequent in: (a) weak versus strong syllables, (b) iambic versus trochaic words, (c) non-word-final versus word-final syllables, (d) syllables without versus with consonant onsets, and (e) syllables with sonorant-initial versus obstruent-initial-consonant onsets. The data are presented in sections that correspond to these predictions. Subsections within each section describe (a) whether the pattern of sound changes for children with speech delays/disorders is similar to patterns reported for typically developing children and adult fast-speech syncope and (b) whether these sound changes for children with SD-DASi differed in frequency or pattern of occurrence from those of children in the other two groups.

Metrical Patterns: Weak Versus Strong Syllables

Omissions

Beginning with the first of 10 predictions, the data in Figure 1, Panel A, are consistent with the metrical

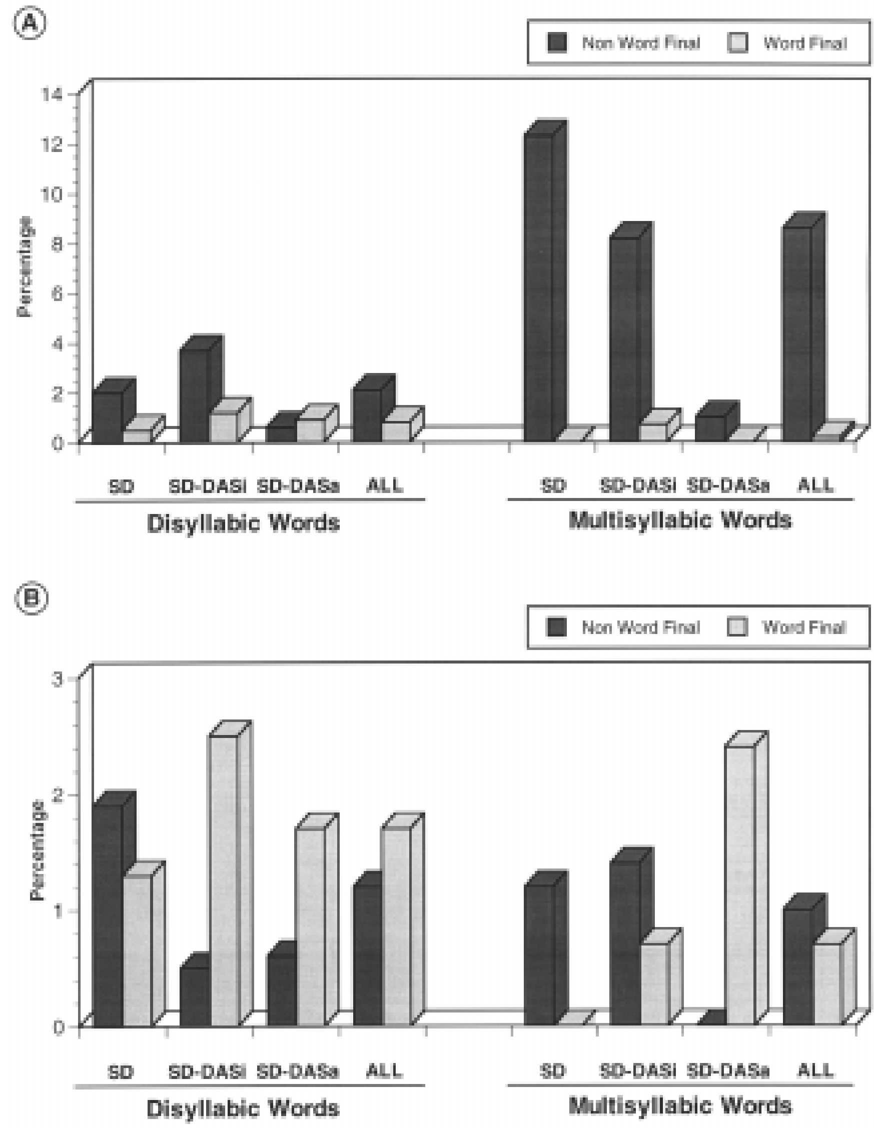
Figure 2. Percentage of syllable omissions (Panel A) and strengthenings (Panel B) in iambic and trochaic disyllabic and multisyllabic words in children with speech disorders (see text).



prediction that weak syllables were more likely to be omitted than strong syllables. For iambic word targets, 100% of the syllable omissions were weak syllables in both disyllabic and multisyllabic words for all three disorder groups (e.g., [wɑɪ] for "July"; [mɑwoʊ] for "toMORrow"). Within trochaic targets in disyllabic words, 60% of the syllable omissions of children with SD were of weak syllables and 66.7% were of weak syllables for children with SD-DASi (e.g., "OVer" produced as [oʊv][1]; "BAby" as [beb]). The few cases in which strong syllables appeared to have been omitted were ambiguous, requiring invocation of the "nucleus rule" (e.g., "SARgeant" produced as [ɑrt]). From multisyllabic trochaic words, omissions were all of weak medial syllables from SWS words (e.g., "DInosaur" produced as [bɑɪsɔrz]), as has been reported for children with typically developing speech in studies cited previously. There was only one example in the present data of a multisyllabic iambic word that began with a secondarily stressed strong syllable (S̀ŚWS) rather than with a weak syllable (WŚWS̀): rhiNOceros. The initial syllable of this word is a heavy, and therefore, strong syllable because it contains a diphthong. It receives only secondary stress in this word, however, with the following syllable receiving primary stress. One child produced the word as [ʔɑɪ.ɔ.sɪs], omitting the weak syllable and preserving all strong syllables, even though the stress pattern of the first two syllables was nonoptimal (i.e., the weaker syllable precedes the stronger).

[1]This production of this word may have been influenced by its presence in the SWSW phrase, "over there." The entire phrase as produced was SSW: [oʊv vɛə].

Figure 3. Percentage of syllable omissions (Panel A) and vowel strengthenings (Panel B) in non-word-final versus word-final syllables in disyllabic and multisyllabic words in children with speech disorders (see text).



Thus, the findings in Figure 1, Panel A, are generally consistent with those reported in Fikkert (1994) and Kehoe and Stoel-Gammon (1997a, 1997b) for children who were normally developing, in which there apparently were no omissions of a strong syllable from any target word.

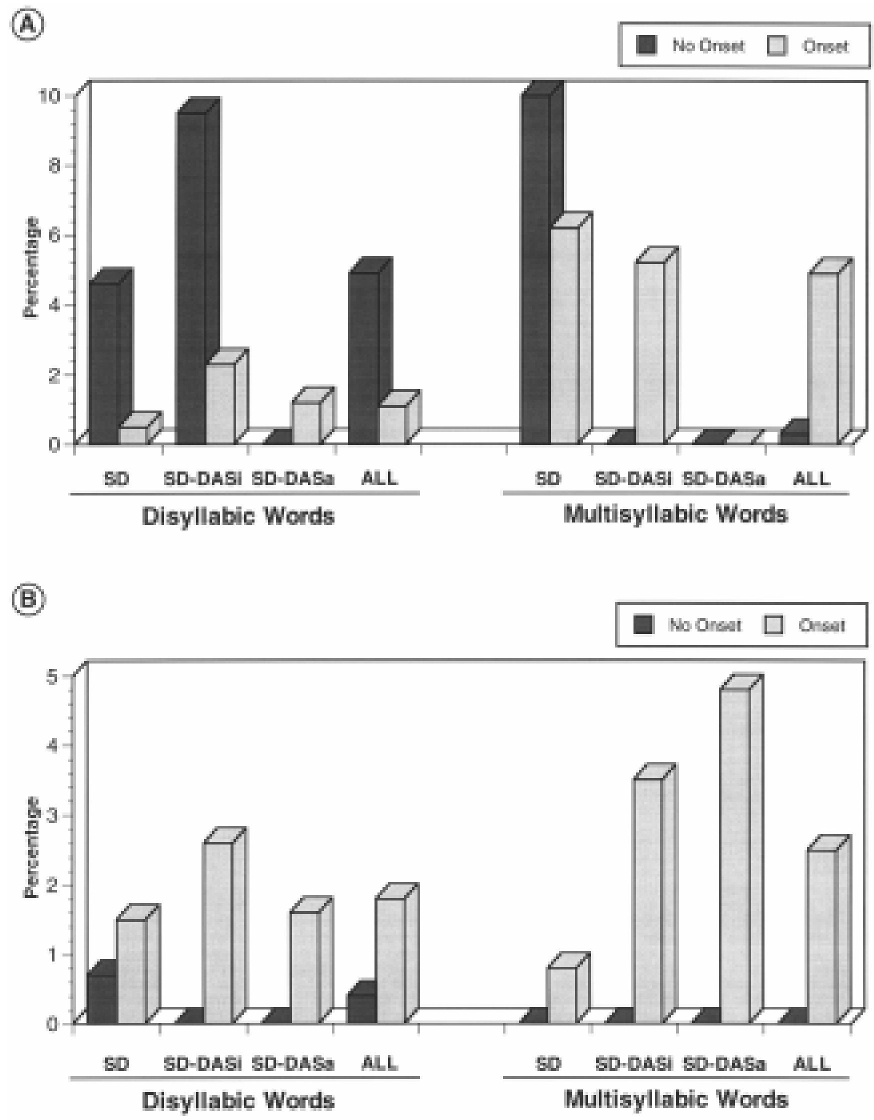
The findings illustrated in this panel also indicate that the syllable omissions of children classified as SD-DASi on the basis of the auditory-perceptual prosody-voice procedure did not differ in frequency of occurrence or metrical characteristics from those of children in the other two groups. Although only 66.7% of their syllable omissions in trochaic disyllabic words were of weak syllables, an essentially similar pattern of weak syllable omissions in trochaic disyllabic words (60%) was also observed in children with SD.

Vowel Augmentations

As shown in Figure 1, Panel B, the vowel augmentation data are also generally consistent with the prediction from metrical theory. There were no occurrences of vowel augmentation for 3 of the 12 percentage calculations, but where they did occur, 50%–100% were augmentation of the weak syllable (e.g., [b^{w}ɔ.um^{b}] for “baLLOON”; [teɪkhɪpɪ] for “techNIcian”).

The frequencies of occurrence and metrical patterns of vowel augmentations in disyllabic and multisyllabic words for children with SD-DASi did not differ from those of children in the other two groups. For the SD-DASi group, 100% of the occurrences of vowel augmentations were on the weak syllable in disyllabic words

Figure 4. Percentage of syllable omissions (Panel A) and vowel strengthenings (Panel B) in syllables with and without consonant onsets in disyllabic and multisyllabic words in children with speech disorders (see text).



and iambic multisyllabic words; 50% were on the weak syllable in trochaic multisyllabic words.

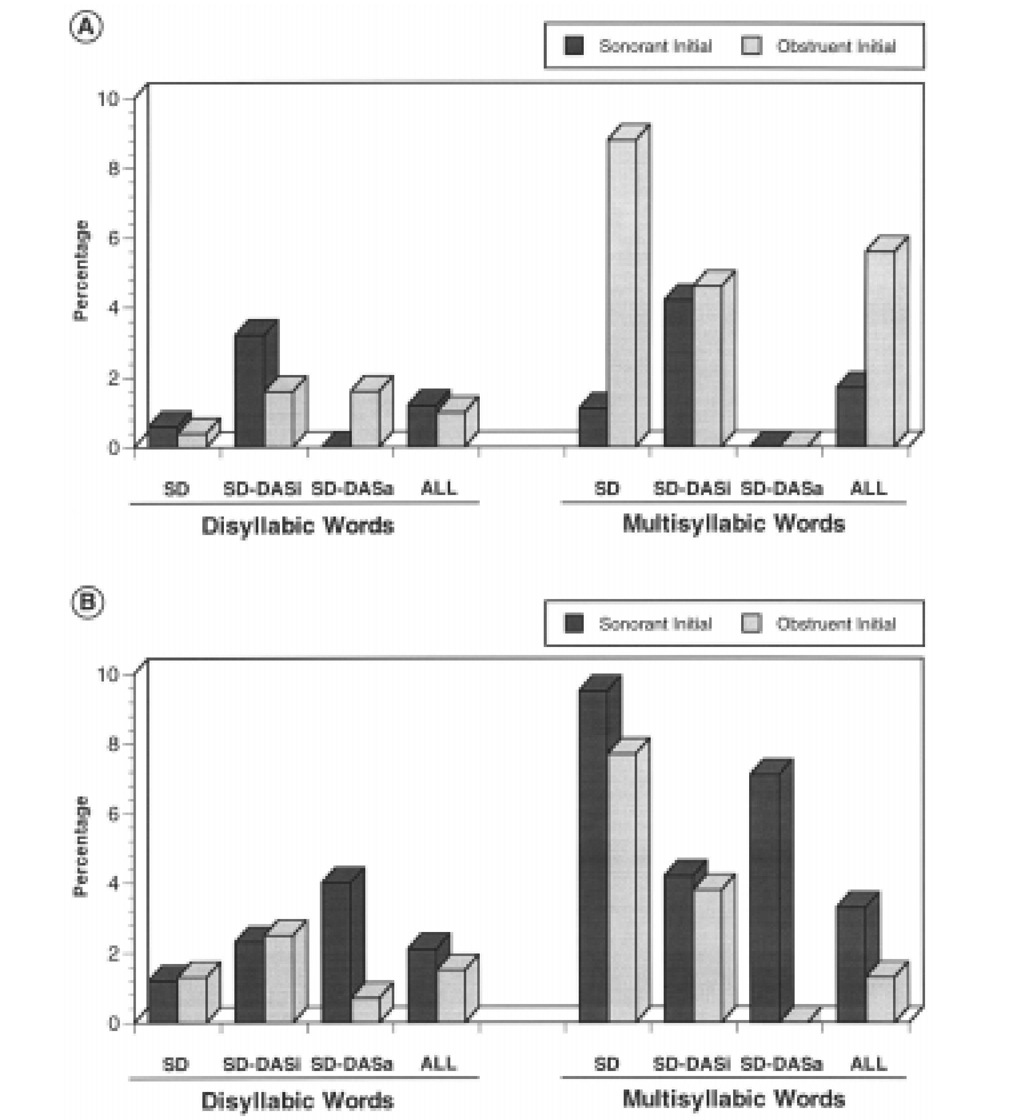
Metrical Patterns: Iambic Words Versus Trochaic Words

Omissions

The data in Figure 2, Panel A, are consistent with patterns in metrical theory and data on the typically developing children in the Fikkert (1994) and Kehoe and Stoel-Gammon (1997a, 1997b) studies. Averaging over all 30 children with speech disorders, syllable omissions occurred on 13.6% of the 90 attempted iambic disyllabic words. For example, one child made four attempts at communicating the word “afraid.” He was able to improve his production of the second syllable from [twe] and [teɪd] to [treɪd], but none of his attempts included the initial weak syllable. In contrast to the iambic data, omitted syllables occurred on only 1.4% of the 786 attempted trochaic disyllabic words. For multisyllabic words, the 30 children averaged 19.4% syllable omissions on iambic word targets and 5.2% omissions on trochaic targets. Half of the 24 trisyllabic trochaic truncations were SWS target forms reduced to SS, the others being WSW forms reduced to SW. These percentage data for the trisyllabic words are similar to those reported for the typically developing 22- to 34-month-old speakers in Kehoe & Stoel-Gammon (1997a).

Once again, the findings indicate that the frequencies of occurrence and patterns of omissions in iambic

Figure 5. Percentage of syllable omissions (Panel A) and vowel strengthenings (Panel B) in syllables with sonorant-initial versus obstruent-initial onsets in disyllabic and multisyllabic words in children with speech disorders (see text).



versus trochaic words for children with SD-DASi were relatively similar to the patterns of children in the other two speech disorder groups in disyllabic words. In multisyllabic words, however, they had slightly more syllable omissions in trochaic (16%) compared to iambic (12.5%) word targets, the reverse of the pattern predicted by metrical theory. However, this is due to the large percentage of weak syllables omitted from SWS words (e.g., [æmo] for "AniMAL"; [bɪhoʊ] for "BillyGOAT"). This pattern is also exhibited by younger children with typically developing speech, as described above.

Vowel Augmentation

As shown in Figure 2, Panel B, and noted in the prior section on statistical analysis, there were relatively few occurrences of vowel *augmentation*s across the three speech disorder groups, ranging from 1.8% to 4.8% occurrence in disyllabic words and from 0% to 5% in multisyllabic words. Overall, there were relatively more augmentations in iambic words than in trochaic words within this narrow rate of occurrence. This pattern held true for many but not all of the group-specific comparisons as well. For example, children in the SD-DASa group had 0% occurrence of vowel augmentation in multisyllabic iambic words, but 4.5% vowel augmentation in multisyllabic trochaic words. Similarly, the SD-DASi group augmented more vowels from iambic multisyllabic words, but fewer from disyllabic iambic words.

It is interesting to note that syllable omission and vowel augmentation may be alternative strategies for the same child for the same word in two different sentential situations. One subject from the SD group, for example, articulated "balloon" once via omission (as [bwun]) and once via augmentation (as [bʷɔ.umᵇ]).

Additionally, there is mixed support for the similarity or difference between vowel augmentation patterns of children in the SD-DASi group compared to patterns in the other two speech disorder groups. Within disyllabic words, vowel augmentation patterns of children in the SD-DASi group differed from those in the other two groups, with 1.8% vowel augmentations on iambic targets (e.g., [mʌʃeɪ] for "mache"—[məʃeɪ]—as in "papier maché") and 3% on trochaic targets (e.g., [bɑɪdət] for "RABbit"). These findings compared to iambic and trochaic patterns of 4.8% and 3.1% in children with SD and 2.4% and 1.8% in children with SD-DASa, respectively. In multisyllabic words, however, their pattern of augmentations was essentially similar to those in the other two groups.

Edge-Effect Patterns: Non-Word-Final Versus Word-Final Syllables

Omissions

The data in Figure 3, Panel A, are strongly consistent with the edge-effect prediction that non-word-final syllables are more likely to be deleted than word-final syllables. Five of the six comparisons are in the expected direction, with the largest difference in the expected direction occurring in the multisyllabic data for children in the SD group (12% omissions of non-word-final syllables and 0% of word-final syllables).

The frequencies and patterns of syllable omissions of children with SD-DASi were similar to those of children in the other two groups relative to the influence of the location of the syllable in the target word.

Vowel Augmentations

The few occurrences of vowel augmentation summarized in Figure 3, Panel B, are insufficient for clear interpretation. However, the pattern of findings does not appear to be consistent with the predicted pattern. Children in the SD group had proportionally more vowel augmentations in non-word-final position than in word-final syllables, but the opposite obtained for children in the SD-DASa group for both disyllabic and multisyllabic words and for children in the SD-DASi group for disyllabic words.

Children in the SD-DASi group did not consistently differ from children in the other two speech disorder groups relative to the influence of the syllable in the word on the occurrence of vowel augmentation. The SD-DASi children's patterns of vowel augmentation were essentially similar to the patterns for the SD-DASa children in disyllabic words and similar to those of the SD children in multisyllabic words.

Sonority Patterns: No-Consonant-Onset Syllables Versus Consonant-Onset Syllables

Omissions

Within the relatively low occurrence rates ranging from 0% to 10% shown in Figure 4, Panel A, the overall findings were consistent with sonority effects in both disyllabic and multisyllabic words for the children with SD. The SD-DASi group's frequencies of syllable omissions in disyllabic words also confirmed the patterns reported in the Kehoe and the Kehoe and Stoel-Gammon studies relative to syllables without and with consonant onsets: Syllable omissions occurred on 9.5% of syllables with no consonant onset (e.g., [bɑʊʔ] for "aBOUT"), compared to 2.3% omissions of syllables with a consonant onset. The data for the children with SD-DASa on disyllabic words that were not consistent with the predicted pattern involved differences of small magnitude (0% omissions of syllables with no consonant onsets and 1.6% omissions of syllables with consonant onsets).

As shown in Figure 5, Panel A, the SD-DASi group's frequencies of syllable omissions in disyllabic words were more than twice that of children with SD. In multisyllabic words, however, the frequencies of occurrence for children in the SD-DASi group were not greater than those for children in the SD groups. Also, the direction of their metrical effect was not consistent with the pattern for children with SD. In fact, subjects in the SD-DASi group did not omit onsetless syllables from multisyllabic words, but did omit several syllables that had target onsets. Thus, findings were mixed for this variable.

Vowel Augmentations

As indicated in Figure 4, Panel B, occurrence rates for vowel augmentation in all groups were below 5%. Within these small frequencies of occurrence, the data in Figure 5, Panel B, are inconsistent with the metrical pattern predicting that vowel augmentation would be proportionally more frequent in non-consonant-onset syllables compared to consonant-onset syllables. All six comparisons, including the data for children in the SD-DASi group, were in the opposite direction.

As shown in Figure 4, Panel B, the pattern percentages for children with SD-DASi were not different from those obtained in the other two speech groups.

Sonority Patterns: Sonorant-Initial Syllables Versus Obstruent-Initial Syllables

Omissions

The findings in Figure 5, Panel A, were inconsistent with the prediction that syllables with sonorant-consonant onsets would be more likely to be omitted than syllables with obstruent-consonant onsets. Although patterns were generally not discrepant in disyllabic words, counter findings were evident in multisyllabic words in which children in the SD group had a 1.5% omission rate for sonorant-onset syllables, but an 8.8% omission rate for obstruent-onset syllables.

Furthermore, the syllable omissions of children in the SD-DASi group were not clearly different in frequency of occurrence or metrical effect from those of children in the other two speech disorder groups based on comparisons of effects associated with the manner class of the initial consonant in the syllable.

Vowel Augmentations

The vowel augmentation data in Figure 5, Panel B, were generally consistent with the predicted sonority pattern relative to effects of manner class of the initial consonant in the syllable. Findings were less clearly consistent with the expected metrical effects for children in the SD group, but for children in the SD-DASa group, findings were clearly consistent with the sonority prediction.

Together with the low overall rates of occurrence of vowel augmentation for the children in the SD-DASi group, the complex vowel augmentation patterns in Figure 5, Panel B, are difficult to compare to those of the children in the other two groups. For disyllabic words, the pattern of vowel augmentation was relatively similar to findings for children in the SD group, but comparisons to children in the SD-DASa group were mixed. Compared with both the disyllabic and multisyllabic findings for children in the SD-DASa group, children in the SD-DASi group had less pronounced differences between rates of vowel augmentation in sonorant-initial versus obstruent-initial syllable targets.

Discussion

Metrical Phonology in Research Speech Pathology

The present findings suggest that, in addition to its applicability to the speech of young, typically developing children, metrical phonology also is a useful analytic framework from which to organize and describe the syllable omissions of children with phonological delays or disorders. In the attempt to integrate linguistic analyses into clinical contexts, the phonological structures and patterns proposed for children must relate well to previous and future phonological states. Pinker (1984) has referred to this concept as the *continuity assumption* (see also Fee, 1991; Menn & Matthei, 1992): If the same principles apply to child and adult phonology, development is appropriately described as a continuum. In a related discussion, Goad (1992) notes that a theory that posits grammatical mechanisms that are constant over the course of development would significantly reduce the amount of grammatical restructuring a child's system must undergo as grammar develops. Similarly, if children with disorders can be shown to have the same underlying phonological structures and patterns (e.g., constraints) as those who are normally developing, then there is also a continuum from normalcy to disorder. If common underlying structures and patterns can be identified for children with disorders, then the task that clinicians face in intervening with such children becomes one of elaboration and accommodation, rather than of eliminating one system and helping the child create a new one. The clinician can identify and build upon those metrical structures and contours that the child has mastered, systematically addressing new structures (e.g., longer words) or contours (e.g., iambic and other exceptional forms), rather than attempting undifferentiated treatment goals such as "the production of multisyllabic words."

The present data seem to support the normalcy-disorder continuity assumption relative to metrical principles. In the present study, the contexts associated with higher probabilities of syllable omissions and vowel augmentations were generally applicable as well to the speech of children with speech disorders. Of the five metrical comparisons examined, most of the more widely discussed patterns were supported in these data. Metrical predictions regarding omission patterns were supported completely for strong versus weak syllables, trochaic versus iambic word shapes, and word-final versus non-word-final syllables. The omission prediction regarding onsetless versus onsetted syllables was also confirmed for disyllables, but not for multisyllabic words. One of the syllable omission patterns reported by Kehoe and colleagues for young, typically developing children, based on the manner feature of the initial consonants in the syllable, was clearly not supported in the present data. Kehoe and Stoel-Gammon (1997a) suggested that sonorants are more likely to be integrated into coda-like roles in the preceding syllable, rather than retaining syllable-onset status, and are therefore more susceptible to omission. For young, typically developing children, these authors found that weak syllables beginning with sonorants were deleted on 48%–77% of target occurrences (M = 61.3%), whereas targets beginning with obstruents were omitted on only 16%–36% of occurrences (M = 25%). In the present study, omitted syllables more often were initiated by obstruents than by sonorants. Differences in findings might, in part, be due to the conversational speech samples in the present study compared to the elicited speech samples controlled for onset sonority, equal numbers of trochaic and iambic tokens, and syllable weight in the Kehoe and Stoel-Gammon analyses. Alternatively, the differences might be due to the segmental production difficulties that are, after all, among the symptoms of SD and SD-DAS, especially with respect to the difficulty of production of particular obstruents (fricatives and affricates).

Vowel augmentation patterns provided much weaker support for the application of metrical theory to disorders. Findings here were quite mixed, especially with respect to the presence versus absence of an onset consonant. It may be that segmental characteristics of vowels, such as sonority, have a larger impact on augmentation than on syllable omissions, obscuring predicted results based upon metrical factors.

Another potential hypothesis regarding the present vowel augmentation data is a possible interaction between metrical structure and metrical contour. Although the present data are too few to attempt such a careful analysis of individual results, it is possible that some children attempt to enhance their intelligibility by preserving syllables (as predicted here), whereas other children attempt to maintain the "default" (trochaic) prosodic contour of the language at the cost of syllable omissions. The former children would use vowel augmentations to augment the most vulnerable syllables (weak, non-final, and/or onsetless syllables). The latter children would use vowel augmentations to highlight the alternating stress pattern, thereby augmenting the syllables that are least vulnerable to omission (strong, final, and/or obstruent-initial syllables). The use of one strategy or the other might also depend upon the metrical structure of the word (e.g., an even vs. odd number of syllables). Such different patterns in different children or different metrical circumstances might account for the inconsistency of the vowel augmentation findings. Potential constraints in the measurement of lexical stress differences and in the conceptual links between lexical and sentential stress processing render all such speculation premature.

The general similarity in findings for children with typically developing speech and speech disorders also supports the conceptual and nosological perspectives underlying use of the term *speech delay*. If the present children's speech acquisition is best characterized as a delay, their error patterns should resemble those of younger, typically developing children. On this issue, although the age-matching procedures yielded children with SD ranging from 3;3 to 12;10, no syllable omissions were produced by any of the 5 children with SD over the age of 6;0. (The parallel issue as it applies to children with SD-DAS will be addressed below.)

Correlates of Inappropriate Stress in SD-DASi

The secondary goal of the present study was to examine the frequencies of occurrence and metrical effects on syllable omissions and vowel augmentations in children with suspected SD-DASi. A constraint on the data analysis was the need to limit comparisons to descriptive trends. Small cell sizes and low frequencies of occurrence for most dependent variables prohibited the use of inferential statistics. These limitations notwithstanding, the trends of the data in Figures 1–5 suggest that the frequencies of occurrence and metrical effects on syllable omissions and vowel augmentations of children with SD-DASi are not dissimilar to those of children with SD and, to a lesser extent, to those of children with SD-DASa. Some of the five comparisons differed in frequencies of occurrence or pattern, but most of these occurred primarily in variables with very low frequencies of occurrence and/or on only disyllabic targets or multisyllabic targets, but not both.

It is notable that children in the SD-DASi group did not consistently have more syllable omissions or vowel augmentations, regardless of the phonological basis for the metrical effects. As described previously, all of the children identified as SD-DASi had inappropriate sentential stress on at least 20% of utterances, whereas only 5 of the 15 children in the SD group had rates that low. Yet the present metrical analyses indicated essentially similar averaged rates of syllable omissions and vowel augmentations as those produced by children in the other two speech disorder groups. Indeed, as indicated in data such as the percentages in Figures 2–5, there were comparisons in which children with SD-DASi had fewer syllable omissions and vowel augmentations than children in the other two speech disorder groups. Thus, although syllable omissions and vowel augmentations might underlie the percept of inappropriate sentential stress, such lexical stress changes were not more frequent in the transcripts of a subsample of SD-DASi children identified in the Shriberg et al. (1997b, 1997c) studies, nor did they differ from the predicted patterns.

These findings for both frequencies of occurrence and metrical effects on lexical stress in children with SD-DASi have implications for an eventual account of the relevant correlates of the perceived stress deficit. One possibility is that syllable omissions and vowel augmentations are not significant or even relevant correlates of the inappropriate sentential stress coded in the Shriberg et al. studies. Weak syllable omissions, in particular, have been observed in all forms of speech acquisition and performance, including typically developing speech, speech disorders, casual speech forms, adult fast-speech syncope, and second-language speech. As before, vowel augmentation might be functional for any type of speech disorder in which augmentation aids in either prosodic or segmental contrastivity, hence intelligibility. Thus, the present data might be interpreted as evidence against the hypothesis of a metrical stress deficit in children who were identified as SD-DASi using a perceptual measure of sentential stress. However, there are several conceptual and methodological issues that warrant consideration.

First, unlike the analysis of sentential stress which involves any or all words or combinations of words in an utterance, the analysis of lexical stress is constrained to words of two or more syllables. Words of two or more syllables account for only approximately 15% of all words in the conversational speech utterances of 3- to 6-year-old children with speech delay (Austin & Shriberg, 1996). Conversational speech samples such as these do not control for the possible avoidance of metrically difficult word targets. In contrast to sentential stress, lexical stress analysis deals with fewer and grammatically different word forms (e.g., function words are more frequently monosyllabic). Moreover, lexical stress analysis does not address the cognitive-linguistic processes associated with the processing of the larger phrasal and clausal units that are included in measures of sentential stress. Thus, conclusions based on the present findings are constrained by the sampling restrictions inherent in these lexical stress data.

A second set of perspectives on the present findings for lexical stress is that the measurement approach may have been insensitive to the correlates of inappropriate stress identified in the Shriberg et al. studies. The narrow-phonetic transcription procedure used to identify children's syllable omissions and vowel augmentations does not include symbolization categories to quantify the subphonemic features of intensity, frequency, duration, and spectra (quality) of speech sounds. Although phonetic transcription captures phonemic and certain allophonic aspects of vowel augmentation (e.g., SIDney [sídni]) vs. sidNEY [sɪdní]; SISter [sístɚ] vs. sisTER [sɪstɝ́]), transcription cannot quantify the percept of excessive/equal/misplaced stress (sometimes termed a "robotic" register) that is conveyed by changes in the frequency, intensity, duration, and quality of vowels. To quantify such changes reliably, metrical and narrow- phonetic analyses of lexical stress must be aided by acoustic analyses. Acoustic-aided analyses of the syllable omissions of children with SD-DASi may identify acoustic differences in the non-omitted, or preserved, syllables that correlate with the percept of excessive/equal/misplaced stress. As well, acoustic analyses could be used to characterize the acoustic topography of vowel augmentations that are perceived by the ear as the "robotic" register. Specifically, measures of duration, pitch, and loudness could be used to determine whether the three vary together or independently in syllables or utterances that are perceived as overstressed. Differences in vowel quality associated with excess stress could also be explored.

To summarize, the frequencies of occurrence and metrical effects on syllable omissions and vowel augmentations of a subsample of children with SD-DASi were not substantially different from those of children with SD or SD-DASa. Conceptually, these findings might be taken to suggest that inappropriate sentential stress may not be attributable to a deficit in acquiring or adhering to the lexical stress patterns of the ambient language. In contrast, omissions persisted in the children who were characterized as having SD-DAS to much older ages: within the SD-DASa group up to the age of 10 years, and within the SD-DASi group up to almost 14 and a half years. This provides support for the distinction between children with speech delay (SD) versus children with suspected developmental apraxia of speech (SD-DAS) made here and as pursued in other research groups attempting to characterize developmental apraxia of speech. One possibility is that children with SD-DAS may develop the same metrical systems as younger children (delayed or not), but be unable to elaborate these systems as their phonologies become more complex in other respects. They may be unable to accommodate to more complex or to exceptional forms as their multisyllabic vocabularies increase with age. Using optimality theory terminology it could be posited that children with SD-DAS may have difficulty deranking immature metrical constraints (such as "the trochaic bias") and/or allowing metrical contour faithfulness constraints to rise to the top of the ranking. The limited data presented here preclude further speculation on such linguistic constructs.

Although the participants in this study produced close to 1,000 words of two syllables or more, the majority were trochaic (86%), and few were multisyllabic (9%). Further studies of lexical stress errors using elicited word productions are clearly needed. In addition, given that the Shriberg et al. studies indicated phrasal stress differences and that, in contrast to single words, most phrases in English are iambic (Vihman et al. 1998), metrically based studies of sentential stress errors are warranted. Gerken and McIntosh (1993) illustrated the impact of metrical factors on production versus omission of function words in phrases. As with the lexical studies extended in the present study to children with SD-DAS, studies similar to those of Gerken and McIntosh also should be applied to children with phonological and other language disorders. Unfortunately, a metrical sentential analysis such as that of Gerken and McIntosh was not possible with the present data, due to the spontaneous conversational nature of the samples. Children's utterances ranged from one up to as many as 17 words, and their sentence structures from telegraphic to complex. In the Shriberg et al. (1997) studies, these entire utterances were given one code for excess-equal stress (and/or other prosody characteristics). Thus, specific portions of longer utterances that were responsible for this percept were not identified by the transcriber. Additional studies identifying the locus of perceived prosody differences remain to be completed.

Conclusions

Research Implications

Metrical analysis of the speech of children with phonological delays and disorders would appear to have the potential to provide important clinical and theoretical information. The applicability of linguistic theory to deviant linguistic systems strengthens claims of psycholinguistic reality for the theory. The bases for apparent differences between clinical groups (such as inappropriate sentential stress) may be fruitfully explored using a metrical perspective. Although the present study did not reveal quantitative differences in lexical stress error patterns among the three selected clinical groups, it did confirm the applicability of metrical concepts to their errors. It also highlighted age differences in the persistence of these error types among children with speech delay versus those with SD-DAS. Future research directions are clear: At a very basic level, the gradual normalization of metrical stress errors among children who are developing normally has not been studied beyond the age of three. Detailed normative data, specified in terms of the parameters studied above, are not yet available. With respect to clinical research, controlled speech protocols must be compared to studies of conversational speech, and lexical stress error patterns must be further explored in contrast to sentential stress error patterns. Acoustic validation of findings in both typically developing and clinical populations is vital.

Clinical Implications

Preliminary speculation on implications of the present findings for clinical perspectives is warranted. Some treatment techniques commonly used with children with suspected apraxia may encourage clear articulation at the cost of robotic prosody. Modeling equal stress should be avoided, as suggested by two independent case studies, both observed—at different times within different school systems—by the first author. In both cases, a child diagnosed with SD-DAS had appropriate prosodic contours, although he did exhibit the syllable omission patterns described above. As each child was exposed to procedures using equal stress as a means of preserving or counting syllables (as one component of a literacy-preparedness program), he shifted to an equal-stress register. Intelligibility was enhanced, but listeners (especially peers) immediately characterized each child as a deviant speaker. Although anecdotal, these cases suggest that activities that encourage the production of robotic speech should be avoided with children with suspected SD-DAS. For this group, syllable-counting and other activities may be modified to make children aware of stress patterns as well as of other aspects of word structure. For example, rather than arranging a row of equal-sized blocks to represent the syllables in a word, the child could be asked to include larger blocks to represent stressed syllables.

Finally, as a preventive measure, prosody activities might be incorporated early in the treatment plans of children with SD-DAS. Appropriate activities range from finger plays and clapping songs (loud vs. soft claps) to explicit prosodic awareness tasks at word, phrase, or sentence levels. The metrical awareness of children with possible speech apraxia could be heightened by training them to answer such questions as:

> "Tell me which part of this word is the loudest: 'El-ePHANT.'"
>
> "Tell me which word in this sentence is loudest: 'He RAN to the store.'"
>
> "If I asked you '*Who* ran to the store?', which word in your answer would be loudest?"

Although much remains to be learned about the stress errors of children with SD-DAS, it does appear that these children are at increased risk for both robotic sentential stress and a pattern of syllable omission that may persist into the teen years.

Acknowledgments

Preparation of this report was supported by the National Institute on Deafness and Other Communication Disorders, National Institutes of Health (DC00496). We thank the following people for their significant contributions to this paper: Chad Allen, Heather Dunn, Jane McSweeny, and Erin Peterson.

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Received June 19, 1998

Accepted April 30, 1999

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