Prosodic Patterns in Children’s Multisyllabic Word Productions

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ABSTRACT: This paper reviews results from a series of studies that examined the influence of metrical and segmental effects on English-speaking children’s multisyllabic word productions. Three different approaches (prosodic structure, trochaic template, and perceptual salience) that have been proposed in the literature to account for children’s prosodic patterns are presented and evaluated. An analysis of children’s truncation or syllable deletion patterns revealed the following robust findings: (a) Stressed and word-final unstressed syllables are preserved more frequently than nonfinal unstressed syllables, (b) word-internal unstressed syllables with obstruent onsets are preserved more frequently than word-internal syllables with sonorant onsets, (c) unstressed syllables with non-reduced vowels are preserved more frequently than unstressed syllables with reduced vowels, and (d) right-sided stressed syllables are preserved more frequently than left-sided stressed syllables. An analysis of children’s stress patterns revealed that children made greater numbers of stress errors in target words with irregular stress. Clinical implications of these findings are presented and additional studies that have applied a metrical approach to clinical populations are described.

KEY WORDS: phonology, prosody, stress, syllable deletion, phonological development

Prosody is a general term that refers to several types of speech phenomena such as intonation, stress/accent, and timing. Intonation is the use of pitch across phrases and sentences. Stress/accent is the prominence given to a syllable in a word or a word in a phrase. Timing refers to the overall duration of syllables and pauses in a sentence. One of the most linguistically relevant aspects of timing is phrase-final lengthening, which is the prolongation of the
interchangeably with the term “syllable deletion.” The term “truncation” will be used for the intended adult word and “output” for the child’s production. The term “target” will be employed for the intended adult word and “output” for the child’s production. In addition, children may produce all syllables of a word with equal stress rather than making one syllable stand out or be more prominent than other syllables in the word. Finally, children exhibit a variety of other phonological processes in their productions of multisyllabic words. They may metathesize syllables, that is, alter the order of syllables, and they may reduplicate syllables.

Throughout the article, "S" will refer to a primary stressed syllable, "s" to a secondary stressed syllable, and "w" to an unstressed syllable. Target lexical items will appear in italics with primary stressed syllables denoted by regular uppercase letters and secondary stressed syllables denoted by small uppercase letters. The term “target” will be employed for the intended adult word and “output” for the child’s production. The term “truncation” will be used interchangeably with the term “syllable deletion.”

THEORETICAL APPROACHES FOR EXPLAINING CHILDREN’S PROSODIC PATTERNS IN MULTISYLLABIC WORDS

This section commences with a review of linguistic concepts that will become useful in later discussion of children’s prosodic patterns.

Theoretical Framework

A central notion in recent prosodic theory is that the prosodic behavior of a single word can be described in terms of a hierarchical arrangement of prosodic units (Nespoulous & Vogel, 1986). These units include the mora, the syllable, the foot, and the prosodic word (1).

1. The prosodic hierarchy

<table>
<thead>
<tr>
<th>PW (prosodic word)</th>
<th>Ft (foot)</th>
<th>σ (syllable)</th>
<th>μ (mora)</th>
</tr>
</thead>
<tbody>
<tr>
<td>baLLOON /bolun/</td>
<td>[bolun]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>poTAto /po/terol/</td>
<td></td>
<td>[tero]</td>
<td></td>
</tr>
<tr>
<td>Animal /ænomalm/</td>
<td></td>
<td></td>
<td>[æmɔ]</td>
</tr>
</tbody>
</table>

The lowest level of the hierarchy is the mora, a sub-syllabic constituent that determines syllable weight. Syllable weight is important in many languages of the world for explaining stress assignment. Syllables may be light or heavy, which generally means that they may contain one or two moras. Languages differ, however, in which segments count as moraic. In English, postvocalic consonants, as well as vowels, count as moraic; whereas in certain languages, only vowels count as moraic. A representation of three English syllables according to moraic theory is shown in Figure 1. A symbol containing a lax or short vowel is monomoraic (1a); a syllable containing a short vowel and consonant (1b) or a tense vowel is bimoraic (1c). The moraic representation in Figure 1 captures the phonological

<table>
<thead>
<tr>
<th>Processes</th>
<th>Target word</th>
<th>Child’s production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syllable deletion</td>
<td>Alligator /æləgərə/</td>
<td>[æɡərə]</td>
</tr>
<tr>
<td>Unstressed syllables</td>
<td>BABy /ˈbebi/</td>
<td>[be]</td>
</tr>
<tr>
<td>Word-final</td>
<td>poTAto /po/terol/</td>
<td>[tero]</td>
</tr>
<tr>
<td>Word-initial</td>
<td>Animal /ænomalm/</td>
<td>[æmɔ]</td>
</tr>
<tr>
<td>Word-internal</td>
<td>baLLOON /bolun/</td>
<td>[bolun]</td>
</tr>
<tr>
<td>Syllable epenthesis</td>
<td>poTAto /po/terol/</td>
<td>[tero]</td>
</tr>
<tr>
<td>Word-final</td>
<td>baLLOON /bolun/</td>
<td>[bolun]</td>
</tr>
<tr>
<td>Word-internal</td>
<td>poTAto /po/terol/</td>
<td>[tero]</td>
</tr>
<tr>
<td>Stress shift</td>
<td>gIraFFE /dʒərəf/</td>
<td>[dʒərəf]</td>
</tr>
<tr>
<td>Equal stress</td>
<td>KAN gaROO /ˈkæŋɡəˌru/</td>
<td>[ˈkæŋɡəˌru]</td>
</tr>
<tr>
<td>Other phonological processes</td>
<td>Animals /ænomalm/</td>
<td>[æmɔmɔl]</td>
</tr>
<tr>
<td>Metatheses</td>
<td>Elephant /ˈɛləfənt/</td>
<td>[ˈɛləfənt]</td>
</tr>
<tr>
<td>Reduplication</td>
<td>Animals /ænomalm/</td>
<td>[æmɔmɔl]</td>
</tr>
</tbody>
</table>

Table 1. Examples of common prosodic processes in multisyllabic words.
regularity that syllables containing either a short vowel plus consonant or a long vowel contain equivalent syllable weight, that is, two moras. In English, these syllables are heavy for the purposes of stress assignment and can occur in word-final position under accent.

Moras are not the only way syllables may be subdivided. Some authors represent subsyllabic structure in terms of units such as onsets and rhymes (Selkirk, 1982). The onset contains all prevocalic elements; the rhyme, all other elements. The rhyme is further divided into nucleus and coda. The representation of the same three English syllables presented in Figure 1 according to onset-rhyme theory is shown in Figure 2.

Syllables are grouped into feet, which is the principle unit of stress representation. Generally, feet contain one or two syllables; if two syllables, one syllable is stressed and the other is unstressed. The most important way to classify feet is in terms of where the stressed syllable is situated. Trochaic feet contain the stressed syllable on the left-hand side; iambic feet contain the stressed syllable on the right-hand side, as shown in (2).

Finally, feet are organized into prosodic words. The smallest prosodic word is referred to as the minimal word. In English, the minimal word is bimoraic. This means that no content word can be monomoraic, that is, consist of only a single lax vowel such as the form [be].

**Different Accounts of Children’s Prosodic Patterns in Multisyllabic Words**

When children truncate a multisyllabic word, there are two aspects to be considered (Pater & Paradis, 1996): (a) the size or shape of the resultant production and (b) which syllables of the target form are preserved. Different approaches have given varying degrees of emphasis to these two factors. Three different approaches will be discussed.

**Prosodic structure account.** The first approach is a representational account that focuses on the prosodic shape of the child’s output. Its central claim is that children’s outputs will be constrained by their linguistic representations, which conform to units of the prosodic hierarchy. In particular, it has been argued that children pass through a stage in which all word productions conform to one trochaic foot. One way to conceptualize this approach is as a template that maps on to segmental material in the target form. Material outside this template is not realized. For example, if children’s productions are constrained by a one-foot template, we may expect the following types of prosodic behavior, shown in Figure 3: (a) preservation of syllables in trochaic words (\textit{MONkey} \rightleftharpoons \textit{MONkey}), (b) truncation of stressed and unstressed syllables resulting in trochaic forms (\textit{giRAFFE} \rightleftharpoons \textit{RAFFE}; \textit{avoCAdo} \rightleftharpoons \textit{CAdo}), (c) epenthesis of syllables (\textit{DOG} \rightleftharpoons \textit{DOguh}), and (d) stress shift to trochaic patterns (\textit{giRAFFE} \rightleftharpoons \textit{GIraffe}).

According to this account, children later pass through a stage in which all productions are consistent with two trochaic feet, that is, two strong-weak alternating forms. The same types of prosodic patterns may occur at this stage as at the preceding stage (see Figure 4): (a) syllable preservation (\textit{HEelicoter} \rightleftharpoons \textit{HELicoter}), (b) truncation (\textit{oRANGuTAN} \rightleftharpoons \textit{RANGuTAN}; \textit{catamaRAN} \rightleftharpoons \textit{caTaRAN}), (c) epenthesis of syllables (\textit{caBOOSE} \rightleftharpoons \textit{CAdeBOOSE}), and (d) stress shift (\textit{giRAFFE} \rightleftharpoons \textit{GIraffe}). In the latter example, \textit{giRAFFE}, which is normally produced with one stressed syllable, is now produced with two equally stressed syllables, that is, produced as two stress-feet.

Proponents of this approach include Fikkert (1994), who studied Dutch-speaking children, and Demuth and Fee.

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**Figure 1.** A moraic representation of English syllables.

**Figure 2.** An onset-rhyme representation of English syllables.
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Figure 3. Prosodic patterns consistent with a one stress-foot stage.

One Stress-Foot Stage

Preservation

\[
\begin{array}{c|c}
S & w \\
\hline
MON & \text{key} \\
\end{array}
\]

Truncation

\[
\begin{array}{c|c}
S & (w) \\
\hline
RAFFE & \text{gi} \\
\end{array}
\]

Epenthesis

\[
\begin{array}{c|c}
S & w \\
\hline
CA & \text{do} \\
\end{array}
\]

Stress Shift

\[
\begin{array}{c|c}
S & w \\
\hline
\text{DOG} & \text{uh} \\
\end{array}
\]

Figure 4. Prosodic patterns consistent with a two stress-feet stage.

Two Stress-Feet Stage

Preservation

\[
\begin{array}{c|c|c}
S & w & S \\
\hline
HE & li & COP \\
\end{array}
\]

Truncation

\[
\begin{array}{c|c|c}
S & w & S \\
\hline
RANG & u & TAN \\
\end{array}
\]

Epenthesis

\[
\begin{array}{c|c|c}
S & w & S \\
\hline
CA & ta & ma \\
\end{array}
\]

Stress Shift

\[
\begin{array}{c|c|c}
S & w & S \\
\hline
CA & de & BOOSE \\
\end{array}
\]

\[
\begin{array}{c|c|c}
S & (w) & S \\
\hline
GL & RAFFE \\
\end{array}
\]

syllables are acoustically more prominent than unstressed syllables. Word-final syllables are more prominent than nonfinal syllables because they receive acoustic cues related to word or phrase boundaries, such as lengthening and accent effects. Attention and memory factors may make final syllables easier to encode (Slobin, 1973). Researchers such as Echols and Newport, (1992), Snow (1998a), and Kehoe and Stoel-Gammon (1997b) have all argued for such an approach.

Similarities and differences. It should be noted that of the three different accounts, only the prosodic structure approach seeks to explain more than just syllable deletion. A central claim is that children employ a variety of means to satisfy constraints on prosodic shape, including stress shift and epenthesis. In contrast, Gerken’s S(W) template and the perceptual salience approach focus predominantly on which syllables of the target form will be preserved and not on output shape per se. In addition, the prosodic structure approach provides a framework for understanding how phonological representations change over time, whereas the other two approaches say less regarding stages of acquisition.

One larger issue that is relevant to all three accounts is how variability in individual word productions can be explained. For example, a child may produce on the same day or even in the same conversation truncated and non-truncated forms for a given target form (e.g., [tɛ] and [p̩tɛɾo] for the target word poTato). This type of free variation in word truncation argues against the trochaic constraint as a constraint on stored forms or input representation. Otherwise, poTato should be realized consistently as [tɛɾo] if this were its stored representation. Rather, results are consistent with speech production models, in which stored information is transformed into output representations that

(1995), who studied Dutch and English data. Several authors also have provided optimality theory accounts of the prosodic structure approach (Demuth, 1996; Pater & Paradis, 1996).

Trochaic constraint. The prosodic structure approach should not be confused with the production-based trochaic constraint proposed by Gerken (1991, 1994a) to account for children’s unstressed syllable deletions. According to Gerken, children align a trochaic (S(W)) metrical template at the beginning of an intended word. The template works by lining up the first strong syllable of the target word with the strong syllable of the template. Weak syllables that do not fit the template are omitted. Thus, in the novel word, paZAMkaSIS, the first weak syllable is more likely to be deleted than the second, and in the word ZAMpakaSIS, the second weak syllable is more likely to be deleted than the first because, in both cases, the weak syllables fall outside of the trochaic template.

Gerken has applied her trochaic template account successfully to explain children’s omissions of function morphemes in sentences. For discussion of hermetrical analysis at the phrasal level, see Gerken (1991, 1994b, 1996).

Perceptual salience. The third approach, the perceptual salience approach, gives greatest emphasis to the prosodic characteristics of the target form, such as stress and word position (Blasdell & Jensen, 1970; DuPreez, 1974). Its principal claim is that there is a direct relationship between the prominence of a syllable, as determined by its acoustic characteristics, and whether it will appear in the child’s output. The syllables most likely to be produced by children are stressed and word-final syllables. Stressed
apply in a probabilistic manner (Gerken, 1994a; Wijnen, Krikhaar, & den Os, 1994). Acoustic studies by Carter and Gerken (1998), which show that children leave an acoustic “trace” when they delete syllables, also are consistent with the intact representation of unstressed syllables. At first glance, this appears to exclude the perceptual salience approach, which in its strongest form is an account of children’s perceptual or input representations. However, weaker forms of this approach are possible in which perceptual salience may influence production even when representations are complete (Echols, 1993).

RESEARCH FINDINGS ON CHILDREN’S SYLLABLE DELETION AND STRESS ERROR PATTERNS

The next two sections summarize some of the salient findings on children’s syllable deletion and stress error patterns. The research findings pertain specifically to English-speaking children; additional research is required to determine how applicable the three different approaches are to other languages. Although the prosodic structure approach has been applied to both Dutch and English data, research on languages such as Spanish reveal different conclusions (Demuth, 2000; Gennari & Demuth, 1997; Lleó & Demuth, 1999) that may be related to the higher frequency of long words in Spanish (Roark & Demuth, 1999) as well as to differences in the nature of unstressed syllables—unstressed syllables contain non-reduced vowels in Spanish and reduced vowels in English.

Findings on Syllable Deletion Patterns

The findings are based on a series of studies at the University of Washington in which English-speaking children (aged 18 to 34 months) participated in semi-structured elicitation tasks, where they were encouraged to produce real and novel multisyllabic words (see Kehoe, 1995, and Kehoe & Stoel-Gammon, 1997a, for additional information). The multisyllabic words ranged from two to five syllables and varied in stress and segmental pattern. The main results on syllable deletion can be summarized in terms of four generalizations.

Stressed and word-final unstressed syllables are preserved more frequently than nonfinal unstressed syllables. One of the most striking generalizations from an analysis of young children’s truncation patterns is that their productions almost always include stressed syllables and unstressed syllables in word-final position. Considering the stress patterns—wS, sS, sSw, sSw, and wSw—more than 90% of truncation patterns conform to this generalization. Examples of frequent truncation patterns in multisyllabic words are provided in Table 2.

Not all word-internal unstressed syllables are preserved equally. The second generalization focuses on preservation patterns with internal unstressed syllables. Given a trochaic template account, the internal unstressed syllable in the three-syllable word Dinosaur should be selected by the trochaic template and should not be deleted, as shown in (3). In fact, children frequently delete internal unstressed syllables (to differing degrees) depending on the segmental content of the target word.

(3) Metrical template account of an Sws word

\[
\begin{array}{c|c|c}
DI & no & SAUR \\
S & w & S (w) \\
\end{array}
\]

Kehoe (1995) observed that words such as Animal and Elephant were almost always truncated to two syllables, whereas words such as Octopus and Crocodile were almost never truncated. Because these are real words, differential rates of truncation may arise from nonlinguistic effects, such as the child’s familiarity with the word or whether the word is produced spontaneously or in imitation. Children tend to truncate less often when the word is unfamiliar or when they imitate the word (Kehoe, 1995). However, this cannot be the sole explanation for the

<table>
<thead>
<tr>
<th>Stress pattern</th>
<th>Truncation pattern</th>
<th>Example target</th>
<th>Example production</th>
</tr>
</thead>
<tbody>
<tr>
<td>wS</td>
<td>S</td>
<td>baLooN</td>
<td>[bun]</td>
</tr>
<tr>
<td>sS</td>
<td>sS</td>
<td>baCCooN</td>
<td>[rækˈkun]</td>
</tr>
<tr>
<td>Sws</td>
<td>S</td>
<td>DI-nosaurus</td>
<td>[dæsəsɜː]</td>
</tr>
<tr>
<td>sSw</td>
<td>S</td>
<td>kangaroo</td>
<td>[kæŋˈwɑː]</td>
</tr>
<tr>
<td>Sww</td>
<td>S, w</td>
<td>Elephant</td>
<td>[əˈfɪnt]</td>
</tr>
<tr>
<td>wSw</td>
<td>S</td>
<td>baNana</td>
<td>[bæˈnænə]</td>
</tr>
<tr>
<td>Swws</td>
<td>S, Sws</td>
<td>Alligator</td>
<td>[æləˈɡætər]</td>
</tr>
<tr>
<td>sSwS</td>
<td>sSw, Ssw</td>
<td>avoCado</td>
<td>[əˈvoʊˌkɑːdə]</td>
</tr>
<tr>
<td>wSsw</td>
<td>Ssw, Sw</td>
<td>pinOchlo</td>
<td>[ˈpɪnəˌoʊ.tʃloʊ]</td>
</tr>
<tr>
<td>sSsw</td>
<td>Ssw, Ssw, Ssw</td>
<td>rinOceroS</td>
<td>[ˈrɪnəˌsɛrəs], [ˈnæsərɪs], [ˈnæsərɪs]</td>
</tr>
</tbody>
</table>

* Numbers refer to which unstressed syllable in the target form is preserved. For example, Ssw refers to the stressed syllable and the second unstressed syllable.
different rates of truncation because the same effect was found in a novel word task, which was controlled for word familiarity effects. The main generalization was that when the word-internal unstressed syllable had a sonorant onset such as /l/ or /r/, this syllable was very vulnerable to deletion. When the word-internal unstressed syllable had an obstructed onset such as /p/ or /k/, this syllable was likely to be produced.

Unfortunately, the limited nature of the stimuli in Kehoe’s (1995) study does not allow for a full understanding of this effect. One explanation is that children syllabify an intervocalic sonorant as the coda of the preceding stressed syllable, resulting in an onset-less internal syllable. Children may syllabify Animal as An-i-mal, but CROcodile as CRO-co-dile. The internal unstressed syllable in Animal may be more vulnerable to deletion than the one in CROcodile because it does not contain an onset. Additional research is needed to explain these results, but overall, the findings suggest that attention should be given to segmental factors in the realization of certain kinds of unstressed syllables.

Unstressed syllables with reduced vowels are deleted more frequently than unstressed syllables with non-reduced vowels. A third generalization observed in the data was that the difference between whether a syllable had full or reduced vowel quality influenced syllable deletion patterns. Consider the two words ballOon and raCCOON. Both words have word-final stress, but in the case of ballOon, the initial syllable is a schwa ([bɔːlən]), whereas in raCCOON, the initial syllable is a full vowel ([rækən]). In a group of children aged 27 months, Kehoe and Stoel-Gammon (1997a) found that the children truncated “balloon-type” words to a single syllable more often than “raccoon-type” words. In English stress classification, the first syllable of raCCOON often is classified as having secondary stress, and the first syllable of ballOon is classified as being unstressed. Therefore, this pattern of behavior also is consistent with the first generalization that children produce stressed syllables and delete nonfinal unstressed syllables. Leaving aside issues of terminology, it is useful to realize, nevertheless, that the difference between the initial syllable of ballOon and raCCOON is one of vowel quality, and this factor seems to play a role in the frequency of syllable preservation.

Right-sided stressed syllables are preserved more frequently than left-sided stressed syllables. The final generalization pertains to the deletion of stressed syllables. In children’s earliest truncation patterns, the most frequently preserved syllable is the stressed syllable closest to the end of the word, regardless of whether it receives primary or secondary stress (Archibald, 1995; Fikkert, 1994; Lohuis-Weber & Zonneveld, 1996). Examples of some of children’s earliest truncation patterns are provided in (4). Even though the stressed syllables closest to the end of the word in CROcodile and HElicopter contain secondary stress, they are preserved more frequently than the stressed syllables with primary stress. That is, forms such as CROC or HEli tend not to occur.

(4) Preservation of right-sided stressed syllables

a. CROcodile /krəkəˈdoɪl/ [dəl]
b. HElicopter /ˈheləkɒptər/ [kəptə]

Now we turn to another prosodic process, stress shift.

Findings on Stress-Shift Patterns

Stress errors do not occur frequently in early prosodic development. Children seem to be highly sensitive to the prosodic roles of stressed and unstressed syllables in the target form and tend to reproduce these patterns in their own productions. A principal question that has been posed in the stress acquisition literature is whether stress is learned according to a rule or whether it is learned on a word-by-word basis (Hochberg, 1988b; Klein, 1984). Support for lexical learning comes from the fact that, when learning stress, children have heard all the words that they will produce, correctly stressed. In principle, they need only memorize the stress pattern of each individual word.

Because stress learning often is complicated by large numbers of exceptional forms, memorization may be the simplest route for the learner to take. One way to address this question is to compare children’s prosodic patterns of words with regular and irregular stress. If children are guided by stress rules, then there should be a tendency for words with irregular stress to be made regular, but the reverse should not be seen. That is, words with regular stress should not be made irregular. If children memorize individual stress patterns, stress errors should be inconsistent and random. Several studies that have examined children’s stress errors with regular and irregular target words indicate that children make greater numbers of stress errors with irregular stress patterns and display a strong tendency to regularize irregular forms (Hochberg, 1988b; Kehoe, 1997; Nouveau, 1993). This suggests that stress is not simply memorized on a word-by-word basis but displays systematic effects, consistent with rule-based learning.

What types of stress error patterns do children display in development? Fikkert (1994) proposed several stages of stress development for Dutch-speaking children. These stages are presented in Table 3 using the English words Dinosaurs and kangaroo as examples. Note that Dinosaurs has primary stress on the initial syllable and is consistent with the regular pattern of English stress. Kangaroo, in contrast, has primary stress on the final syllable and is an exceptional form. In English nouns, word-final syllables generally do not receive primary stress. According to Fikkert’s model, at Stage 1, children have access to a

Table 3. Stages of stress development.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Dinosaurs</th>
<th>Kangaroo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trochaic stress</td>
<td>[ˈdɛnəs]</td>
<td>[ˈkæŋgrəu]</td>
</tr>
<tr>
<td>2. Level stress</td>
<td>[ˈdɛnəsər]</td>
<td>[ˈkæŋgrəu]</td>
</tr>
<tr>
<td>3. Main stress</td>
<td>[ˈdɛnəsər]</td>
<td>[ˈkæŋgrəu]</td>
</tr>
<tr>
<td>4. Exceptional stress</td>
<td>[ˈdɛnəsər]</td>
<td>[ˈkæŋgrəu]</td>
</tr>
</tbody>
</table>

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single trochaic template and target forms that do not fit this template are altered. In particular, target forms with final stress will be produced as trochaic forms. At Stage 2, the template expands to two trochaic feet, but because children have not learned the prominence relationship between feet, they place equal stress on both stressed syllables. Finally, children learn that one stressed syllable receives greater prominence than another stressed syllable in the word. At first, they follow the pattern of English stress, which is to avoid the final syllable for stress placement. They place primary stress on the initial syllables of both DInoSAUR and KAN gaROO. Later, they must learn that KAN gaROO is an exception to the English stress rule and that they should place primary stress on the word-final syllable.

Kehoe’s (1998) findings with English-speaking children (aged 22, 28, and 34 months) offered some support for Fikkert’s (1994) developmental stages. Among the youngest children, there was a tendency for words such as KAN gaROO to be produced either as single syllables or as trochaic forms (e.g., [wu],[wuwa]). In the middle group, there was a tendency for two- or three-syllable forms to be produced with level stress (e.g., [kæn[wu], [kɪˈɡɪrʊ]). The oldest group of children frequently produced nontruncated forms with initial stress (e.g., [ˈtɛndəʒru]).

Nevertheless, although many of the stress errors supported Fikkert’s (1994) theory, some of the stress errors reflected nonrepresentational factors, such as the influence of articularatory focus (e.g., shift of stress for articulatory reasons; see Hochberg 1988a) or lack of control of the acoustic/phonetic parameters (i.e., fundamental frequency (F₀), duration, and amplitude) that underlie stress. Approximately 20% of children’s attempts at multisyllabic words received low confidence ratings for stress transcription. “Unreliable” or “low confidence” productions were characterized by minimal acoustic differentiation between syllables and trading effects between phonetic parameters. For example, instead of F₀, duration, and amplitude coming together on a single syllable to make it more prominent, one syllable received a higher F₀ value and another syllable was longer in duration. As a result, listeners were unable to decide on which syllable was more prominent. The difficulty of obtaining reliable stress transcription in children implies that caution must be exercised when interpreting all children’s stress errors in terms of the development of prosodic structure.

A final factor that may influence children’s stress patterns is whether their productions are spontaneous or imitated. In the discussion of syllable deletion patterns, it was mentioned that children tend to truncate less often in imitated productions as compared to spontaneous productions. In the analysis of stress errors, the opposite pattern occurs: Children produce greater numbers of stress errors in imitated speech (Hochberg, 1988b; Kehoe, 1997). This finding appears to reflect the influence of word familiarity because words that are less familiar to children are more likely to be produced as imitations. One explanation is that when the word is familiar, children memorize the target stress pattern and any of its individual exceptions. When the word is unfamiliar, children are more likely to employ a stress rule, leading to stress errors when they encounter irregular target forms.

### SUMMARY OF CHILDREN’S PROSODIC PATTERNS IN MULTISYLLABIC WORDS

The findings will now be summarized, with reference back to the claims made by the three different approaches to prosodic development—the prosodic structure approach, the S(W) production template, and the perceptual salience approach. Kehoe (1999/2000) examined the truncation patterns of 48 English-speaking children to determine whether their patterns were consistent with the prosodic structure account or with alternate accounts of prosodic acquisition. She found that children’s earliest truncation patterns were consistent with the claims made by the prosodic structure account. That is, children’s outputs conformed to a single trochaic foot. Although it frequently is claimed that this stage occurs around the age of 2 years, Kehoe (1999/2000) found that the majority of 2-year-old children produced words of more than two syllables, suggesting that this stage occurs even earlier in speech development.

Children’s later truncation patterns were not consistent with the claims of the prosodic structure account, that is, children’s outputs did not display uniformity of output shape, consistent with two stress-feats. Rather, children produced stressed and word-final unstressed syllables, consistent with the perceptual salience account. The inclusion of nonfinal unstressed syllables was not explainable by a single trochaic template. The preservation of unstressed syllables in word-initial position was influenced by segmental effects that related to syllable structure, the main one being whether the internal unstressed syllable contained a sonorant or obstruct onset. The preservation of unstressed syllables in word-initial position remains more difficult to explain. The following observation suggests that it simply is not a rhythmic production problem. Frequently, children truncate a word such as baNAna to [ˈnæna] but produce a four-syllable word such as avoCado as [əkˈkədo]. If children can produce the rhythmic form wSw for avoCado, we may wonder why they do not produce the same form for baNana, that is, produce [baˈnæna] (see Gennari & Demuth, 1997, for a similar observation in Spanish). Again, we must appeal to the acoustic prominence of stress and consider how the target form is perceived and represented by the child. In baNana, the initial syllable contains a reduced vowel, whereas in avoCado, the initial syllable has secondary stress or contains a full vowel. Perceptual salience appears to interact with syllable and metrical structure to determine which syllables are selected for production. The next section examines clinical implications of the current findings.

### CLINICAL IMPLICATIONS

When comparing the amount of attention given to segmental versus suprasegmental speech disorders in the clinical literature, it is apparent that much greater attention has been given to segmental disorders. To some extent, this reflects the perspective taken in the theoretical literature, because suprasegmental development has been studied only
recently in normally developing populations. Furthermore, linguists have had the tools to study prosodic behavior for only a short period of time. Finally, it reflects the prevalence of the disorder. Prosodic disorders are far less common than segmental disorders. This would be predicted developmentally because children’s suprasegmental skills are generally in advance of their segmental skills. For many clinical populations, prosodic behavior may remain one of their residual strengths and serve as a basis for the exploitation of therapy techniques. This is suggested in a study by Snow (1998b), who found no evidence of impairment in two prosodic correlates of syntax (phrase-final-lengthening and the pitch range of the boundary tone) in children with phonologic-syntactic type of specific language impairment (SLI). Snow (1998b) suggested that such children may benefit from therapy techniques that present morphosyntactic and segmental information within a salient suprasegmental envelope.

Despite Snow’s (1998b) findings of intact prosodic skills in one group of children with SLI, prosodic disturbances have been implicated in the speech of other subjects with SLI (Carter, 1999; Pigott & Kessler-Robb, 1994), hearing impairment (Miccio & Kehoe, 1996), and apraxia of speech (Kent & Rosenbeck, 1982; Velleman & Shriberg, 1999). The next two sections discuss clinical implications of the research finding and describe other studies that have applied a metrical approach to clinical populations. Again, the main emphasis is on prosodic patterns in word productions. Research that has focused on phrasal-level prosodic patterns or employed instrumental techniques to study speech movements during the productions of metrical patterns will not be discussed, but see Gerken and McGregor (1998), Goffman and Malin (1999), Goffman and Smith (1999), and McGregor and Leonard (1994) for additional information. See also an acoustic study by Carter (1999) that documents similar prosodic patterns between children with SLI and young normally developing children.

Clinical Implications from the Current Research Findings

Prosodic shape constraint. Given the claims of the prosodic structure approach—that children’s outputs conform to prosodic units in development—it is possible that some subjects may present with prosodic shape disorders. This would be suggested by children who display uniformity of prosodic shape regardless of the target form. These children reduce long words (i.e., words of three syllables or more) to one stress-foot or expand short words (i.e., words with one stressed syllable) to two stress-feet. Kehoe (1999/2000) observed a two stress-feet shape constraint in a 28-month-old child. Patterns particularly suggestive of an output template were his productions of words such as toMate, Elephant, and TÉlePHONE. Whereas other children of this age tended to truncate these words, this child preserved all syllables of the target form or added a syllable to his truncated production, resulting in a three-syllable output. This child definitely appeared to be striving to produce all output forms with two stressed syllables and with a consistent prosodic shape. Examples of this child’s productions are displayed in (5).

(5) Productions of a 28-month-old child suggestive of a two-feet output template

<table>
<thead>
<tr>
<th>Word</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>toMate</td>
<td>[twə'merə]</td>
</tr>
<tr>
<td>Elephant</td>
<td>[ˈɛləfænt]</td>
</tr>
<tr>
<td>TÉlePHONE</td>
<td>[ˈteləfən]</td>
</tr>
</tbody>
</table>

Because prosodic shape uniformity may be a transient stage in the speech of normally developing children, clinicians should be alert to its manifestation in children with phonological disorders. Therapy should include exercises that expand children’s repertoires of prosodic shapes by including words with different numbers of syllables and stress patterns.

Truncation and syllable preservation patterns. Syllable deletion is a common process in the speech of normally developing children. It is difficult to provide precise normative data; however, some rough guidelines can be extracted from Kehoe’s (1995) study. In this study, children between the ages of 22 and 34 months deleted unstressed syllables in three-syllable words approximately 50% of the time. Word-initial position posed particular difficulty for children in that 22- and 28-month-old children deleted unstressed syllables in the word-initial position approximately 70% of the time. Only the very youngest age group (22 months) displayed a tendency to delete stressed syllables. The overall findings suggest that after 2 years of age, deletion of stressed syllables is relatively infrequent, and after 3 years of age, deletion of unstressed syllables is less frequent. These values pertain to multisyllabic words elicited in isolation or in short phrases, so truncation rates may be greater in conversational speech. High truncation rates in children aged 3½ years and older may be diagnostic of prosodic difficulties.

Close scrutiny of children’s syllable preservation patterns should offer useful information regarding clinical intervention. Given the claims of the perceptual salience approach—that children preserve stressed and word-final unstressed syllables—children’s output patterns should be studied to determine whether they comply with this regularity. An important question to ask is: Which unstressed syllables are deleted—word initial, word final, or word internal? Kehoe (1999/2000) observed several stages in the acquisition of unstressed syllables: (a) word-final position; (b) word-internal position, when they were produced with nice strong onsets (e.g., obstruent onsets); (c) word-initial position; and (d) word-internal position, when they were produced with less strong onsets (e.g., sonorant onsets).

If children display variability in their realizations of unstressed syllables, segmental factors should be examined to determine whether they play a role. Kehoe (1999/2000) observed that when children realized an unstressed syllable in target words that were highly susceptible to truncation (e.g., TÉlePHONE, Alligator), they often did so by being segmentally unfaithful to the onset of the unstressed syllable. That is, they realized the unstressed syllable with an obstruent rather than sonorant onset. Hence, they produced TÉlePHONE as [tʰɛldədɒn] and Alligator as [ˈædɡərə]. As well, do children produce unstressed syllables more frequently when they contain a full vowel or...
additional segmental material? As mentioned earlier, children tend to delete the initial syllable of a word more frequently when it contains a reduced vowel than when it contains a full vowel. Attention to these factors may shed light on syllable deletion patterns that initially appear unsystematic.

**Stress errors.** Because stress errors do not occur frequently in normal development, a high prevalence of stress errors may be diagnostic of prosodic difficulties. Kehoe and Stoel-Gammon (1997a) observed one child in their group of normal subjects who produced a high number of stress errors and who appeared to operate with an iambic rather than a trochaic template. His productions of two-syllable words (6a) and his truncations of longer words (6b) all involved deformation to a wS (weak-strong) pattern. This child was the same subject described in (5), who produced many words with a two-stress-fleet output template. Even his two-feet patterns conformed to an iambic template, either a wS S (Elephant was produced as [uˈfɪt ˈhɪt]) or a wS wS pattern (Alligator was produced as [ˈhædə ˈædrɪ]). Unfortunately, no follow-up was able to be conducted with this child to determine when and how he rectified this unusual prosodic style. If this child had manifested these prosodic patterns at a later age, therapeutic intervention may have been required to introduce a trochaic stress pattern and to teach the child to produce word-initial rather than word-final stress.

(6) Productions of a 28-month-old child suggestive of an iambic template

a. PlIcuture /pɪkˈtʊr/ [pɪkˈtʊr]
   Apple /æpl/ [æˈploʊ]

b. baNAna /bəˈneɪnə/ [ˈneɪnə]
   HEllicoter /ˈhelɪkəpˈtər/ [ˈheɪlɪkəpˈtər]

This 28-month-old child’s stress errors are consistent with the incorrect representation of stress. Other children’s stress errors may be more suggestive of a lack of phonetic control. In these cases, acoustic analysis can be a useful diagnostic tool. Kehoe (1997) noted that one 28-month-old child showed a strong tendency for medial syllable prominence in Sws and Sww words. For example, TELEPHONE was produced as [tɛləˈfoʊ] and OCtopus was produced as [ˈɔskʊpəs]. Acoustic analysis revealed that the medial syllable was produced with higher than expected F0 and amplitude, but not with increased duration. This confirmed the perceptual impression that his productions were not the same as the regularly stressed target wSw words (e.g., baNAna) in which the medial stressed syllable is cued by amplitude, F0, and duration. This child was unable to coordinate the phonetic features of stress so that one syllable was consistently longer, louder, and higher in pitch. Although this pattern was seen in a young child, phonetic control difficulties may be typical of older children with speech disorders.

### Prosodic Disturbances in Clinical Populations: Other Studies

Several recent studies in the literature have focused on prosodic disturbances in clinical subjects. Velleman and Shriberg (1999) examined the speech of children with suspected developmental apraxia of speech (SD-DAS) and with regular speech delay (SD) in order to determine whether a metrical analysis constituted a viable diagnostic tool to differentiate the two groups. Their analysis included the study of syllable omissions and vowel augmentations (akin to stress errors) in the conversational speech samples of these children. Although some of the children in the SD-DAS group had been identified previously as having inappropriate sentential stress (based on the Prosody-Voice Screening Profile, see Shriberg, Kwiatkowski, & Rasmussen, 1990) the metrical analysis did not distinguish the SD-DAS and SD groups in a major way. The metrical analysis indicated essentially similar averaged rates of syllable omissions and vowel augmentations across groups, although syllable omissions persisted in the SD-DAS group in the older age ranges. Their findings suggest that the percept of inappropriate sentential stress involves more than word-based metrical effects and that more sensitive diagnostic techniques may be required to characterize children with apraxia of speech effectively.

Another clinical group that may be at risk for prosodic disturbances are people with hearing impairment. Miccio and Kehoe (1996) reported a high prevalence of stress errors in an adolescent boy with a mild-moderate hearing impairment. In this subject, stress pattern acquisition most likely was compounded by a fragile auditory system and a difficult period of academic learning, during which a large number of multisyllabic words were introduced. Examples of the subject’s stress errors, provided in (7), reveal that primary stress often was assigned to the penultimate (or second-to-last) syllable rather than to the initial syllable of the target word. Stress shift was accompanied by segmental changes that resulted in the newly stressed syllable becoming heavier (e.g., diphthongization or tensing of vowels). A subsequent metrical analysis revealed that the stress errors were not aberrant nor unsystematic but displayed awareness of many aspects of a normal metrical system, such as stress shift to heavy syllables and avoidance of word-final syllables.

(7) Stress errors in an adolescent with hearing impairment

a. parlIament /ˈparlɪmənt/ [ˈparlɪmənt]
   b. syllable /ˈsɪləbl/ [ˈsɪləbl]
   c. swastIka /swəˈstɪkə/ [swəˈstɪkə]

Finally, Fikkert and Penner (1998) reported on prosodic “stagnation” or delay in two Swiss-German children with language disorders. One child they studied produced predominantly multisyllabic forms in which CV syllables were reduplicated and in which both syllables contained equal stress (8a). The examples below refer to German pronunciations. The child also preserved the last syllable of the word rather than the stressed syllable (8b), the latter being observed more often with normally developing children. For example, although an English-speaking child may truncate the word BAh by to [bi], the form [beː] is observed more frequently. Fikkert and Penner (1998) queried whether Child 1 may have been focusing on the
wrong prosodic cues in the input. Instead of focusing on stressed syllables, the child focused on word-final syllables. For example, the child had to learn to give the greatest prominence to the final syllable (whether the syllable was bimoraic or more than bimoraic) result in a difference in stress. The English, although superheavy, does not receive main stress. For example, the final syllable of the word *elephant* in English, which has many exceptions to the stress rule.

A second child had difficulty assigning main stress. Many of his multisyllabic forms contained level stress (9). Fikkert and Penner (1998) hypothesized that Child 2 had stagnated at the stage prior to learning the main stress rule. Therapy consisted of working with a structured set of data designed to highlight stress differences between syllables. For example, therapy materials contained items such as *eleFANT* /ˈeɪləfænt/ “elephant” versus *TEleFON* /ˈteləfən/ “telephone.” These words are in quantity differences in the final syllable (whether the syllable was bimoraic or more than bimoraic) result in a difference in stress. The child had to learn to give the greatest prominence to the heaviest syllable. For example, the child should stress the final syllable of *eleFANT* and NOT the final syllable of *TEleFON*. Unfortunately, this technique may not always work for English, which has many exceptions to the stress rule. For example, the final syllable of the word *Elephant* in English, although superheavy, does not receive main stress.

Prosodic stagnation (Child 1) (Fikkert & Penner, 1998)

<table>
<thead>
<tr>
<th>Target</th>
<th>Gloss</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. <em>TEleFON</em> /ˈteləfən/ telephone</td>
<td>[ˈfoʊˈfoʊ]</td>
<td></td>
</tr>
<tr>
<td>b. <em>VElO</em> /ˈvelə/ bicycle</td>
<td>[ˈloʊˈloʊ], [ˈlo]</td>
<td></td>
</tr>
</tbody>
</table>

Regarding the child’s overall prosodic pattern, Fikkert and Penner (1998) posited that this child was operating at the syllable and not the foot level and had not yet established the salient trochaic pattern of the language. Therapy techniques included inventing nicknames (e.g., *MICkey, SUSie*) to stimulate the development of trochaic forms.

Clinical Implications: Conclusion

This section has shown how different sets of investigators have applied a metrical approach to clinical subjects. All studies underscore the importance of having an accurate linguistic model of prosodic acquisition on which to base clinical intervention. Although these findings are preliminary, they suggest that a metrical analysis may lead to greater insights into changes in the prosodic structure of speech that result from speech and language disturbances. Vellman and Shirberg’s (1999) findings, nevertheless, offer a note of caution. The label of “inappropriate stress” in children with suspected developmental apraxia of speech appears to reflect more than just syllable omission and stress shift. Consequently, more fine-grained analyses procedures (e.g., acoustic analysis) are required before we can fully understand and describe all forms of deviant prosody. It is clear that there is more work to be done in the area of prosodic disorders, but a detailed account of some areas of normal prosodic acquisition and its application to some clinical populations, as presented in this paper, should serve as an important addition.

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