Phonotactic Therapy

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ABSTRACT

Words derive their structure not only from the sounds they include but also from the organization of those sounds within the word. This organization is the phonotactic level of the word: roughly, its shape including the sequence of its elements. Often, children with immature or disordered phonologies demonstrate phonotactic as well as phonetic limitations. Sometimes, the child may produce an age-appropriate variety of consonants and vowels but be unable to use them in the configurations required by the language: final consonants, clusters, multisyllabic words, and so forth. In such cases, the most appropriate therapy goals may be phonotactic, rather than phonetic, ones. Studies have shown that clinical focus on a new word or syllable shape may generalize well beyond the specific sound or sounds targeted in that position. These ideas are explored in this article, along with specific therapy results and recommendations for various phonotactic limitations.

KEYWORDS: Phonotactic, syllable, word, treatment

Learning Outcomes: As a result of this activity, the reader will be able to (1) identify six aspects of phonotactics with direct clinical implications, (2) identify appropriate therapy goals for each aspect, and (3) describe how to capitalize upon a child's previously immature phonotactic patterns as a strategy within therapy to decrease a current phonotactic pattern.

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Throughout the history of the field of speech-language pathology, the primary focus of phonological therapy has been on the production of individual sounds or, more recently, classes of sounds. Syllable and word shapes, the *phonotactic* aspects of phonology,* have been targeted only as they relate to target phonemes or classes of phonemes: s- clusters, [θ] in final position, velars in initial position, and so on. As early as 1976, authors such as Grunwell[1] and Ingram[2] stressed that the speech of many typically developing young children and children with severe phonological disorders often demonstrates structural limitations, such as no words of more than one syllable, no final consonants, no clusters of any sort in any position, no occurrences of two different consonants or two different syllables within the same word, and no words with stress on the second syllable. In the terminology of Davis and MacNeilage,[3] the consonants and vowels serve as the *content* of the word, but they must be carried by a language-appropriate *frame*. That frame is the structure of the syllable/word. The highest quality machine parts cannot function unless they are properly combined and connected; similarly, the relationships among the sounds in a word are as important to its meaning as the sounds themselves ("dog" and "god" are very different concepts!). Yet, as recently as 1995, Bleile[4] wrote that "in the future clinicians may be as familiar with . . . syllable- and word-level concepts . . . as we are today with sound and sound class concepts" (p 349). Even such recent texts as Pena-Brooks and Hegde (2000) present almost no information about phonotactic deficits or therapy goals. Certain authors, such as Bernhardt,[5] Bernhardt and Stoel-Gammon,[6] and Velleman,[7] have continued to stress the importance of addressing phonotactic goals directly, in addition to segmental (sound or sound class) goals and goals that combine the two (e.g., production of a particular sound in a particular position).

This historical focus on segments rather than structures in our field has mirrored an earlier, similar focus in phonological theory. During the 1950s and 1960s, "structuralist" phonologists and then generative phonologists emphasized the roles of allophones, phonemes, and phonemic distinctive features (see Barlow and Gierut, this issue). The syllable as a unit was largely ignored.[8] Structuralist phonology focused on the functional roles of phones (as phonemes vs. allophones). Phonological rules as described by Chomsky and Halle[9] provided explicit descriptions of many pronunciation patterns but were not amenable to describing patterns such as consonant harmony, reduplication, and so on. These "generative" rules were designed to best express patterns that applied linearly—that is, one sound affecting the adjacent one, as when the palatal liquid [r] causes the initial [t] in "train" to be palatalized, that is, to sound more like [tʃ] ([tʃreɪn]).

In 1979, Donegan and Stampe[10] proposed what they termed "natural phonological processes"—innate phonological patterns, reflective of human physiological limitations—as an alternative to phonological rules. The processes that they proposed included structural patterns, such as reduplication, harmony, cluster reduction, and final consonant omission. (See Stoel-Gammon et al, this issue.) However, their theory lacked a structural description of syllable and word shapes that could explain or represent the structures to which the processes applied. The patterns that they described were *nonlinear*—they applied to pairs or groups of segments that were not necessarily adjacent to each other—but there was no explanation or description of these nonlinear structures. The development of the theory of "nonlinear phonology" filled this gap.

The basic principles of nonlinear phonology parallel those of nonlinear grammar. For example, the two sentences "Muriel ate the fish with spots" (Fig. 1) and "Muriel ate the fish with chopsticks" (Fig. 2) seem to have the same linear grammatical structure: noun + verb + article + noun + preposition + noun. Yet, "with spots" is descriptive of the fish, while "with chopsticks" is descriptive of Muriel's manner of eating. In this sense, "with spots" is part of the noun phrase "the fish with spots." In contrast, "with chopsticks" is part of the

**This aspect of phonology is also referred to as the "prosodic tier," but we will use the term phonotactic here to avoid confusion between syllable and word shapes versus intonation.*

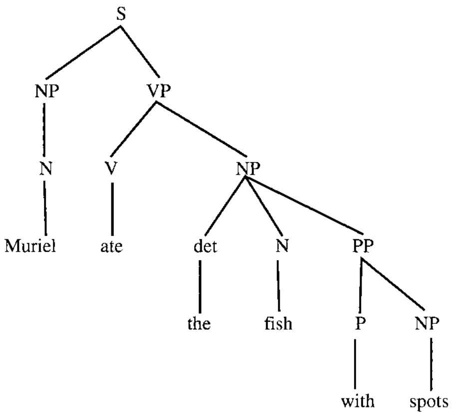

Figure 1 Muriel ate the fish with spots.

verb phrase "ate . . . with chopsticks." If we simply list the elements of the sentence linearly, this distinction is not clear. Therefore, syntacticians instead display the elements on a "tree" structure (which really looks more like a root structure; it grows down, like a family tree), as shown in Figures 1 and 2. These trees illustrate the fact that the prepositional phrase (PP) "with spots" is part of the noun phrase (NP): the PP hangs directly from the NP branch (which itself hangs from the verb phrase [VP] branch). In contrast, "with chopsticks" is part of the VP but not part of the NP within the VP: the PP hangs directly from the VP branch instead of hanging off of the dependent NP.

Another example of nonlinear grammar comes from morphology. If a door cannot be locked, it can be called "unlockable." However, the same term can also apply to a door that *can* be *un*locked. The linear sequence of morphemes "un" + "lock" + "able" is ambiguous

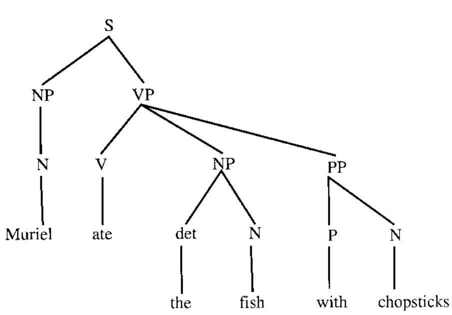

Figure 2 Muriel ate the fish with chopsticks.

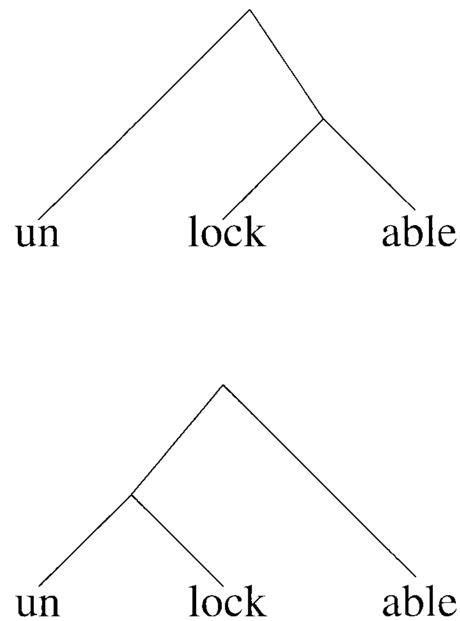

Figure 3 "Unlockable."

with respect to the meaning of this multimorphemic word. Grouping the morphemes hierarchically, as shown in Figure 3, reveals the two different structures: "un" + "lockable" = "not able to be locked;" "unlock" + "able" = "able to be unlocked."

The same principles—of displaying elements hierarchically to differentiate those that are linearly related to each other from those that are elements within larger elements—can be applied to phonology as well. As demonstrated by Yavas,[8] there are sequences of segments that are allowed in some environments in English but not in others. For example, the sequence [bm] is acceptable English in a word like "submarine," but words like [bmlk] or "submstation" are not possible. These words are nonexistent for phonological reasons: [bm] can occur as a sequence only if the [b] closes one syllable and the [m] opens the next. In nonlinear phonological terms, the [b] must be a syllable coda (final consonant) and the [m] a syllable onset; they cannot be adjacent in that order within the same syllable. The same holds true for [tl] versus [tr]: [tr] is a legal sequence within a syllable (as in "train" or "retreat"), whereas [tl] can occur only with a syllable

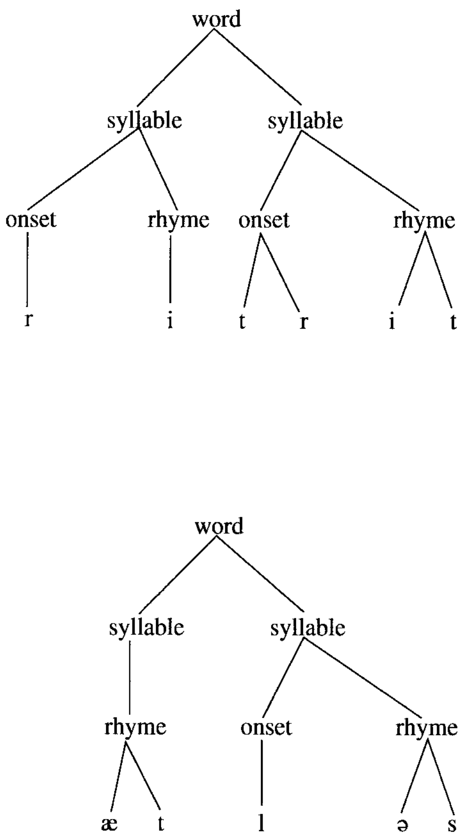

Figure 4 Syllabification of word-medial clusters.

boundary between the two segments, as in "atlas." Therefore, "retreat" can be syllabified as "re + treat," whereas "atlas" must be syllabified as "at" + "las" as shown in Figure 4. "A" + "tlas" is not possible in English, but "a" + "tras" is; it just does not happen to exist as a word.

There are two different ways to represent the contents of a syllable nonlinearly, as illustrated in Figures 5 and 6. Both representations agree in dividing the syllable into components called the "onset" (initial consonant, if any) and the "rime" or "rhyme" (the rest of the syllable). In one model, the rhyme is further subdivided into a "nucleus" (usually one or more vowels) and a coda (final consonant, if any). This model, shown in Figure 5, emphasizes the structure of the syllable.

In another model, the portion of the syllable that follows the onset consists of one or more "moras." Each mora is a unit of syllable time or "weight." Typically, the first mora of the syllable is a vowel. The second mora may be another vowel (as in a diphthong), more vocalic material (as in the extra duration and sonority associated with a tense vowel), or a consonant, as shown in Figure 6. This model emphasizes the weight of the syllable and is necessary to explain phenomena such as a constraint against a "light" stressed syllable in English (e.g., syllables such as [bʊ] or [nɪ] can occur only in certain unstressed positions because the nonlow lax vowels [ʊ] and [ɪ] are too short). It has been proposed[11] that children's early words are constrained to contain at least two weight units. Thus, a monosyllabic word must include at least two moras (a long vowel, a diphthong, or a vowel + consonant sequence). Kehoe and Stoel-Gammon[12] have recently con-

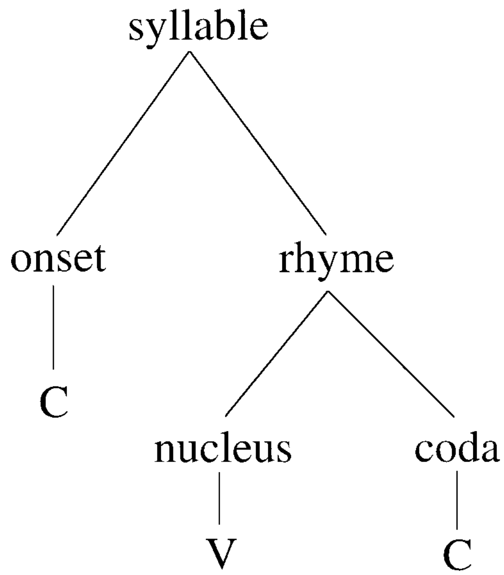

Figure 5 Onset-rhyme syllable tree.

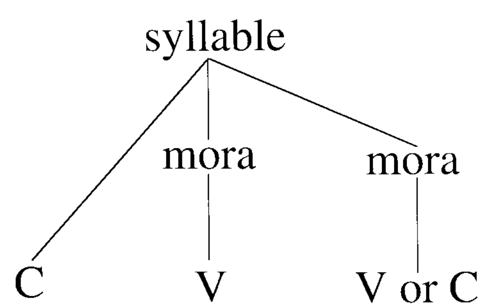

Figure 6 Mora syllable tree.

firmed that children do produce codas more often after short vowels than after long vowels, possibly due to the need for extra syllable weight following a short vowel.

Nonlinear phonology can also be used to describe child consonant harmony. When a child says [pip] for "peek," the first (onset) consonant appears to be influencing the second (coda) consonant. Yet, they are not adjacent. How could the feature "labial" spread from consonant to consonant when there is a vowel in between? This might make sense if a target word such as "boat"—/bot/—were pronounced as [bop]; both consonants are labial and the vowel in between is round. Thus, the effects of lip articulation are seen in all portions of the word. Yet, pronunciations of "beet" as [bip] also occur; in this case the vowel is not labial in any sense. It has been proposed that, in structurally very simple phonologies, consonant (or vowel) features may actually be a feature of the syllable rather than a feature of a particular segment, as shown in Figure 7 for a child who pronounces "bottle" as [bɔbʊ]: the two consonants in the word agree in place of articulation, indicating that the place of articulation is specified for the whole word rather than for the individual consonants.

A similar proposal deals with reduplication phonotactically, by characterizing this process as one of copying one syllable onto another. In a linear model of phonology, each feature of each segment must somehow spread to the corresponding segment in the next syllable until the two syllables are identical. This contrast is illustrated in Figure 8. It simply does not make sense to try to account for reduplication or harmony without some reference to the syllable.

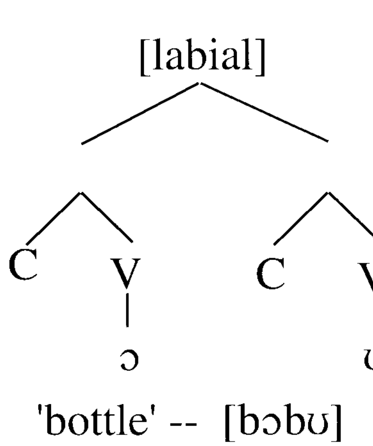

Figure 7 Consonant harmony with place of articulation feature at syllable level.

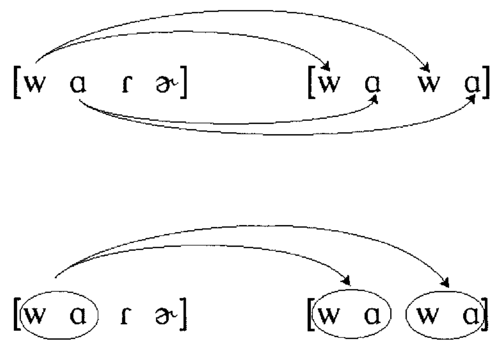

Figure 8 Reduplication: linear versus nonlinear model.

These distinctions have important clinical implications. Grunwell illustrates this with data from a child named Becky, whose production of medial /s/ depends upon the role of that /s/ within the word. In coda position (at the end of a syllable, whether it ends the word or not), Becky pronounces /s/ as [ʔ] or omits it. "Christmas," for example, is produced as [ˈwɪʔmə]. In onset position (either at the beginning of a word or the beginning of a noninitial syllable), /s/ is produced as [t], as in "pencil"—[ˈbɛntəɫ]. Similarly, some children can produce two consonants in a row only if they are intersyllabic, that is, they belong to two different syllables. They may be able to say accurately a word such as "rescue," in which the [s] and the [k] are in different syllables, but not "rescoop," in which [s] and [k] form a complex onset (initial consonant cluster) to the second syllable. Other children who have difficulty with codas (final consonants in syllables) may be able to produce an intrasyllabic onset consonant cluster (as in "rescoop") but not an intersyllabic cluster (as in "rescue"). The linear sequence of the two consonants is not the critical factor; their structural relationship to the syllables of the word is.

Word stress, which is one aspect of prosody, is another area in which the structure of the word is critical. In English, word stress

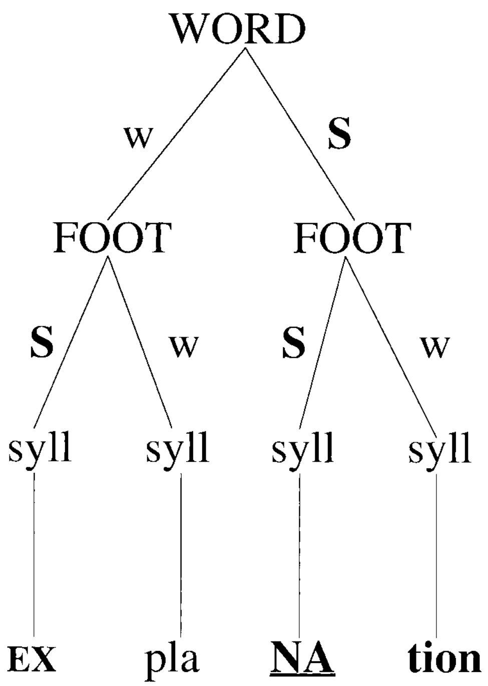

Figure 9 Metrical (stress) tree.

tends to be "trochaic"; that is, the syllables of the word tend to pattern as stressed-unstressed-stressed-unstressed.† This may appear to be a simply alternating linear pattern. However, only one syllable in the word can have primary stress; the other stressed syllables will receive secondary stress. The syllable that receives primary stress is determined by the prosodic "foot" in which it falls. A foot typically consists of two syllables; thus, feet are at a higher level in the tree than the syllables. Each foot is either stressed or unstressed, again typically in an alternating pattern, as shown in Figure 9. The syllable that receives the primary stress will be the stressed syllable within the stressed foot—"na" in the example in Figure 9. The unstressed syllable within the unstressed foot ("pla" in Fig. 9) is highly likely to be reduced to schwa. Despite our trochaic preference, iambic words, in which the first syllable is unstressed and the second stressed, are also fairly common in English (e.g., "giRAFFE," "guiTAR," "preVENT").

†*Other languages have different stress patterns. For example, in French the last syllable of the word always gets the primary stress.*

The major phonotactic patterns with direct clinical implications, then, are the following:

- deletion of onset (initial) consonants
- deletion of coda (final) consonants
- harmony and reduplication
- reduction of multisyllabic words
- reduction or misproduction of word stress patterns
- reduction of consonant clusters: initial, final, or medial (intrasyllabic or intersyllabic)

All of these, with the exception of initial consonant deletion, are quite common in the phonologies of very young children. They become of concern when they persist beyond the usual ages and/or when they interfere with age-appropriate intelligibility. The remainder of this article will address intervention approaches that have been suggested for these syllable or word structures.

The phonotactic error pattern that is typically of most concern when it is identified in English-learning children is initial consonant deletion. Although it appears to be a developmentally appropriate pattern in some other languages (such as Finnish[13] and possibly Hebrew[14]), for children learning English this pattern is considered to be a red flag for phonological delay or disorder. Although few children completely lack onsets,[5] some young children with childhood apraxia of speech exhibit a tendency to produce incomplete syllables that consist of a vowel only or a consonant only. For example, Velleman reports that just slightly over half of her subject Holly's syllables included both a consonant and a vowel; the rest were single consonants (such as [tʰ] used to represent any alveolar-initial word) or single vowels rather than complete CV syllables.[15] As far as this author has been able to determine, there have been no controlled studies of treatment for initial consonant deletion. In clinical practice, this pattern has been successfully addressed by targeting the inclusion of initial consonants in CV syllables, giving positive social feedback for any CV shape regardless of the accuracy of the initial consonant. CV words in which the onset is a consonant already in the child's repertoire (although not in that particular word) are typically most successful. Thus, a typical therapy goal for inclusion of onsets would be:

- {Child} will produce target CV words with an initial consonant in X% of trials, regardless of the accuracy of the consonant produced, in imitation/elicited/spontaneous single words.

Sometimes, a child with a phonological disorder will produce VC syllables but not CV syllables, a pattern rarely found in English-learning children who are normally developing. In this case, the repetition of VC syllables can be used as a strategy to induce syllable onsets. For example, "ame-ame-ame" may generalize to "mame-mame-mame" or "ick-ick-ick" to "kick-kick-kick."[5]

Generally, however, final consonant deletion is a more common pattern than initial consonant deletion in young children learning English and in children with disordered phonological systems, although English learners do tend to learn final consonants earlier than learners of some other languages because of the high frequency of final consonants in English words.[16,17] From an onset + rhyme structure point of view, final consonant deletion is a symptom of a phonotactic system in which the coda branch of the syllable is missing. From a moraic point of view, the child may be completing the syllable with a long vowel or a diphthong and therefore have no need, with respect to syllable weight, to add the final consonant.

Although most consonants tend to be mastered first in initial position, certain sound classes—specifically, velars and fricatives—tend to be acquired earlier in final position.[18,19] Traditionally, production of each consonant in final position was addressed individually in therapy. Once treatment for phonological processes became popular, structural processes such as final consonant deletion began to be treated in and of themselves. In such treatment protocols, a few representative words or sound classes are targeted. The child's responses are considered to be correct as long as some final consonant is produced, regardless of its accuracy. For example, a child who differentiates "nose" from "no" by saying [nod] would be given credit for producing the final consonant, despite the fact that she stopped the final [z]. In a study of two 4-year-olds with phonological delay, Weiner[20] showed that addressing the production of final consonants in this way (1) increases the child's ability to close syllables in target words; (2) increases the accuracy of the final consonants that the child produces in those words, despite the fact that this is not emphasized in therapy; and (3) induces generalization of both sorts to words that were not targeted in therapy. Bernhardt[5] suggests that more than one consonant target should be used in therapy intended to increase the child's use of final consonants. However, Bernhardt and Gilbert[21] used the alternative strategy of targeting only one specific final consonant (/p/) and found that this training, also, induced generalization to words with some untrained target final consonants (especially /f/). Thus, an appropriate therapy goal for final consonant deletion would be:

- {Child} will produce target CVC and VC words with a final consonant in X% of trials, regardless of the accuracy of the consonant produced, in imitation/elicited/spontaneous single words.

Again, consonants that are already in the child's repertoire are typically targeted. Alternatively, consonants that are known to be favored in final position (fricatives, velars, voiceless stops) may be chosen. Given Kehoe and Stoel-Gammon's finding that normally developing children produce codas more often following short vowels than following long vowels, words with short (lax) vowels should be early targets (e.g., "bit," "bed," "book," "dog," "cup" rather than "beet," "bait," "kook," "dome," or "coop").

If the child is producing diphthongs in open syllables, but no codas, then producing two moras per rhyme is not the issue. The problem then is the consonantal nature of the coda. One possibility for remediation is to use repeated CVCV sequences, gradually working up to the removal of the second vowel. For example, Bernhardt[5] suggests the "Little Bunny Foofoo" story, with the child being cued to stop before the last vowel, yielding "foof" and eventually "oof." Another possibility is to use the onset slot of the next word to introduce the coda. In casual American English, the final consonant of one word tends to be used as the onset of the next word if the second one has no initial consonant. Thus, "Dad Owl" is produced as [dæ.dɑʊl]. Cases in which the final consonant of one word is the same as the initial consonant of the next can also facilitate production of the coda. For example, in the phrase "Dad Dog," the initial [d] in "dog" should facilitate the child's production of the coda [d] in "Dad" through pronunciations such as [dæ.dɔg] (or, more likely in the case of such a disordered child, [dœ.dɔ]). A pause can be gradually introduced between the two words, such that the [d] comes to be produced in coda position: [dæd.ɑʊ], [dæd.dɔ]. In many cases, the coda consonant is likely to be distorted or only partially produced initially; that is not a problem. Accuracy will come later.

Another strategy that may be used in the course of therapy intended to increase production of codas is targeting words with consonant harmony ("dad," "kick," "pop," etc.). Some children find it far easier to produce the same consonant in both onset and coda position than to produce two different consonants within the same word. Although consonant harmony is not a viable long-term pattern, it can bridge the gap between CV and CVC structures for many children with phonological disorders.[7]

Although consonant harmony can be used as a therapy strategy in some cases, decreasing the use of consonant harmony may be a phonotactic goal in other cases. This corresponds to inducing a change in the child's phonological system such that consonant features are specified at the segment level rather than the syllable or word level. Decreasing reduplication also corresponds to specifying the characteristics of each syllable at a lower level: either at the syllable level (if the syllables are different but both have consonant harmony) or at the segment level (if the individual syllables are differentiated within the syllable as well as from each other). Again, we can use some of the tendencies of normally developing children to inspire our therapy techniques. For example, toddlers have a tendency to produce [i] as the second vowel of a CVCV word (or babble).[22,23] Thus, a change from two identical syllables (such as [dædæ]) to CVCi (i.e., [dædi]) would be a reasonable first target for reducing reduplication, especially as alveolars tend to co-occur with high front vowels in children's babble because the tongue position is so similar for the two.[3] Similarly, children who have preferences for producing places of articulation in a certain order tend to prefer a front-back order, such as labial-alveolar (although many other patterns occur as well). Such patterns can be targeted in order to reduce either reduplication or consonant harmony. For children who are old enough for picture naming-based assessment or therapy, the Test of Syllable Sequencing Skills and Moving Across Syllables are excellent tools for addressing particular place-of-articulation patterns.[24]

For children with consonant harmony in CVC words, it is also important to consider final-consonant preferences. If the child has certain consonants that tend to show up more often in VC words, target CVC words that end (but do not begin) with those consonants may be selected. Similarly, the consonants that tend to show up early in final position in normally developing children's phonologies (nasals, velars, fricatives) may be targeted in final (but not initial) position of CVC words. Again, the accuracy of such consonants is not the concern; the goal is to produce two different consonants within the same CVC word.

Thus, typical goals for children with reduplication or harmony patterns might be:

- {Child} will produce target two-syllable words in which the two syllables differ in some respect (typically consonant or vowel quality) in X% of trials, regardless of the accuracy of the consonants or vowels produced, in imitation/elicited/spontaneous single words.
- {Child} will produce target two-consonant words (i.e., CVC or CVCV) with consonants that differ in place and/or manner of production in X% of trials, regardless of the accuracy of the consonants or vowels produced, in imitation/elicited/spontaneous single words.

- {Child} will produce target two-vowel words (e.g., CVCV) with vowels that differ with respect to height and/or front-back dimensions in X% of trials, regardless of the accuracy of the consonants or vowels produced, in imitation/elicited/spontaneous single words.

In addition to a remediation goal, reduplication (or consonant or vowel harmony) may be a remediation strategy for a child whose output is restricted to monosyllables. Syllable repetition is easy to incorporate into movement activities ("up up up" etc.), daily routines ("bowl bowl bowl" while setting the table), or reading of counting books (repeating the name of the object instead of counting its occurrences, e.g., "ball ball ball" for a page depicting three balls). Words with reduplicated structures (such as the "baby talk" words that we use to simplify the task of new talkers, e.g., "booboo," "mama," "pee-pee") should also be early targets. Gradually, as the child begins to be able to produce these simple disyllables, more change should be introduced within the word. For example, words that are not reduplicated but that do include consonant *or* vowel harmony might be introduced, then words with other early patterns, as described earlier. A typical initial goal for a child whose phonology includes only monosyllables might be:

- {Child} will produce target two-syllable words (e.g., CVCV) with two syllables in X% of trials, regardless of the accuracy of the syllables produced, in imitation/elicited/spontaneous single words.

Such a goal could also be broken down into smaller steps specifying the use of reduplication, harmony, and so forth, as described earlier.

Some children who omit syllables do so only when the target word is iambic. That is, they maintain the first syllable of "monkey" but not that of "giraffe."[25,26] Weak syllables are subject to omission especially when they are word-initial; they tend not to be omitted in final position. This pattern is exacerbated when the word is in a phrase in which an unstressed word comes immediately before an iambic word. Thus, the [dʒɪ] of "giraffe" (and/or the word "the") is more likely to be omitted in "you SAW the giRAFFE" (which has the pattern W–S–W–W–S) than in "you SAW the BIG giRAFFE" (which has the pattern W–S–W–S–W–S).[27] These findings can be used in our selection of strategies for increasing a child's use of longer words: target the words with a trochaic (S–W) pattern. In children who omit only weak syllables from iambic words, our goal will be to reduce the use of this strategy. In these cases, the use of phrases in which a stressed syllable immediately precedes the syllable that is likely to be omitted (e.g., "big giraffe") can be helpful. Goals could include:

- {Child} will produce target iambic two-syllable words with two syllables when they are embedded in a phrase in X% of trials, regardless of the accuracy of the consonants or vowels produced, in imitation/elicited/spontaneous speech.
- {Child} will produce target iambic two-syllable words with two syllables when the words are produced in isolation in X% of trials, regardless of the accuracy of the consonants or vowels produced, in imitation/elicited/spontaneous speech.

Several studies have addressed the development of consonant clusters in various positions and the remediation of consonant cluster simplification. About one half of typically developing English-learning 2-year-olds produce some combinations of consonants in initial, final, or both positions[28]; 3½-year-olds produce full clusters 75% of the time or more.[29] In development, cluster errors typically progress from complete deletion of the cluster (rare for onset clusters in English-learning children), to deletion of one element of the cluster, to substitution of one element, to correct production.[30] When one element is deleted, this is typically the most *marked* element (i.e., the one that is the most uncommon in the languages of the world; typically more difficult either to pronounce or to perceive). For example, /s/ tends to be omitted from s- clusters, liquids from stop + liquid clusters, and so on.[31] Normally developing children as well as children with phonological disorders[32] occasionally violate this pattern, however. For example, Amahl Smith pronounced "stop" as [sɔp].[33]

Another aspect of markedness relates to the differences in *sonority* (degree of constriction vs. vocalicness of the sound) between the elements in a cluster. If the two consonants are of very different sonorities (e.g., [t], which is highly constricted and un-vowel-like, vs. [w], for which the closure is much less constricted and the sound produced has much more resonance), the cluster is less marked. Typically, the most sonorous elements of a syllable (e.g., the vowel) are in the middle, with decreasing sonority as one moves out to the edges of the syllable (onset and coda). Therefore, [s] + stop initial clusters and stop + [s] final clusters are especially marked because [s] is closer to the edge, even though it is more sonorous than a stop. In some models, these [s]'s are considered to be "adjuncts," consonants adjoined more loosely to the word, rather than elements of a cluster. This special status of some [s] + stop sequences is supported by the finding that treatment of consonant sequences with adjuncts may not generalize to other clusters.[34] Furthermore, some children may acquire adjunct sequences (two-element s-initial clusters) before any other clusters; others may learn these two types of complex onsets (or codas) in the opposite order.[35]

For some children, clusters that can be pronounced in a single word (e.g., the br- in "brush") are reduced when that word abuts another, increasing the total number of consonants in the sequence (e.g., "toothbrush").[32] Other children may use a pattern of epenthesis—inserting a vowel in between the consonants in the cluster—or of pausing between consonants in order to preserve all consonants despite difficulties in producing the sequence.

Treatment research has focused on the prediction that treatment of more marked clusters will cause generalization to less marked clusters even if the latter are not targeted in treatment. Strikingly, one child in such a study who initially produced no clusters of any kind was treated for the cluster bl- and generalized to tw-, kw-, pl-, sw-, fl, sm-, sn-, sp-, and st-![34] In another study, treatment of specific three-element clusters (i.e., an adjunct [s] plus a two-element cluster) did not generalize to other three-element clusters, although some children generalized to untreated singletons (including affricates) and to untreated two-element clusters.[35] From a phonotactic point of view, these studies show that at least part of what children need to learn is to allow consonant sequences within their phonologies. In some cases, once the structure (the consonant sequence) is there, the details (the specific consonants in the sequence) will follow naturally. Thus, a typical initial phonotactic goal for a child with no clusters (or other consonant sequences) might be:

- {Child} will produce target two-consonant sequences with two consonants in X% of trials, regardless of the accuracy of the consonants produced, in imitation/elicited/spontaneous single words.

CASE STUDY

Val came to the University of Massachusetts Speech-Language and Hearing Clinic at the age of 3;4 because of severe unintelligibility. His consonant repertoire at that time, as tested using the articulation screener of the *Preschool Language Scale—3* (PLS-3),[36] included only [b, d, m, n, j]. The consonants [b] and [d] had a heavy functional load, as they were often substituted for other sounds, especially in harmony contexts (e.g., [bɪb] for "pig"). Final consonants were often omitted (e.g., [de ɑʊ] for "take out"). Few two-syllable words were produced. Val's receptive language was within the normal range for his age (36–41 months on the PLS-3); expressive language was somewhat delayed (30–35 months on the PLS-3). His intelligibility ranged from 50% in single words in known contexts (e.g., labeling pictures) to about 20% in unknown contexts. Phonotactic as well as phonetic goals were suggested, including increasing use of final consonants and two-syllable words. For these goals, segmental accuracy was not the target; as long as some final consonant or both syllables of a two-syllable word were present, that production was credited toward that objective.

Six months later, Val had significantly improved his production of two-syllable words, as demonstrated on the *Assessment of Phonological Processes—Revised*[37](APP-R). At this administration of the APP-R, in fact, he omitted no syllables whatsoever. However, syllable preservation came at the cost of consonant preservation. For example, "glasses" was pronounced as [æ.ɪ]. Prevocalic consonant singletons were omitted 20% of the time, and final singletons were omitted 65% of the time. In addition, most final clusters were either reduced or omitted completely (70% consonant sequence reduction overall). His overall Severity Interval Rating was "severe." His consonant repertoire included the following:

Initial position:
Mastered (i.e., produced at least 3 times in that position, regardless of target phoneme): [b, d, m, w, r]
Emerging (i.e., produced 1–2 times in that position): [j, n, h, l, v]
Medial position:
Mastered: [b, d, n]
Emerging: [h, ʔ, j, ʃ, z, v]
Final position:
Mastered: [n]
Emerging: [m, b, d, l, s, v]

Again, his phonotactic therapy goals included increasing his production of CVCs with early sounds/sounds in his repertoire (to 60% of the time, i.e., 40% omission) regardless of actual segmental accuracy. To increase his ability to produce multisyllabic words containing complete CV syllables, syllable sequences with partial reduplication (e.g., [bɑbɑbi]) were recommended as a target.

Unfortunately, insurance issues intervened and Val received no therapy for a period of almost a year. When he was finally retested, at the age of 5, Val's APP-R severity interval rating had worsened to the "profound" level (only partly due to the fact that he received extra penalty points for his age). He had made a little bit of progress phonetically. His consonant repertoire now included:

Initial position:
Mastered: [b, d, m, n, w, j, l, r, h]
Emerging: [p, t]
Medial position:
Mastered: [b, m, n, w]
Emerging: [p, t, d, j, r]
Final position:
Mastered: [p, m, n, ʔ]
Emerging: [d, l]

However, many of these consonants were not produced in the appropriate target words. The early-emerging voiced stops [b] and [d], in particular, were overused, replacing many other consonant targets (e.g., [dɛɚ] for "chair," [bʌv] for "glove," and [bʌm] for "jump"). Labial harmony (as in "glove," "jump") was common. Phonotactically, open (CV) syllables continued to predominate, with postvocalic consonant singletons omitted on the APP-R 71% of the time. In his case, contrary to Kehoe and Stoel-Gammon's finding, the status of the vowel (long or diphthong vs. short) did not seem to affect his final consonant deletion pattern. One-syllable words also continued to predominate, with syllable reduction increased to 32% on the APP-R. When he omitted a syllable, it was always the weak (unstressed) syllable of the word, but this occurred in trochaic as well as iambic words (e.g., "music" pronounced as [mu]). Furthermore, certain phonotactic structures (e.g., consonant clusters, which were reduced 90% of the time) were essentially not in his repertoire. It seemed as if Val had difficulty producing more than one place of articulation feature per word. He got around this by using partial consonant harmony (e.g., [b] and [v] in [bʌv] for "glove" share the same place of articulation, despite the difference in manner) or, more often, by deleting any "extra" consonants in final position or in clusters. For these reasons, Val was not able to use appropriately even the consonants that he could produce. Therapy goals for the next 6 months continued to emphasize:

- Increasing his phonotactic repertoire (final consonants, two-syllable words, consonant clusters), and
- Increasing his appropriate use of the consonants already in his repertoire (a) rather than substituting for them and (b) in new phonotactic contexts such as final position.

Twice-weekly therapy was much more successful than Val's involuntary hiatus had been. Within 6 months, syllable reduction was once again down to 1%, with final consonants included when targeted 52% of the time. Val's severity interval rating had again improved to the "severe" level, although he continued to reduce consonant clusters 85% of the time. The few clusters that he did produce were mostly word- or syllable-initial, although one final cluster (-mp in "jump rope") and one intersyllabic cluster (-nt- in "Santa") were preserved. At this time, Val's CVC goal was divided into two: (1) the production of CVCs with consonant harmony and (2) the production of CVCs without consonant harmony. The particular segment targeted in final position was beginning to be a determining factor in his success: [m, n, b, p, d] were now produced in this position with 50% accuracy, while other consonants continued to be omitted. A new therapy strategy, of targeting the final consonant initially in a VC before adding the initial consonant (e.g., "am," then "pam"), was used. This approach divorced the two confounding issues of producing final consonants versus producing two different consonants within the same word, and it appeared to facilitate his production of CVCs. Through this process, he was able to produce final [p, m, n] in final position of CVCs with 60% accuracy.

Now, as he approaches kindergarten and the age of 6, Val is beginning to show explicit awareness of final consonant targets. He can correct the therapist if she omits a target final consonant and is beginning to attempt to self-correct as well. He is more stimulable for affricates (e.g., [tʃ]) in final position than in initial. The consonants [p, m, n] are now included in final position with 80–100% accuracy; [l] is inconsistent from word to word; and final [t, d, f, s] continue to be omitted at all times. Val imitates two-syllable words with 80% accuracy.

Val has a significant phonological disorder, and he clearly regressed when his therapy was discontinued for a lengthy period of time. However, the parallel goals of increasing his phonetic repertoire and his phonotactic repertoire are finally beginning to merge, as his limitations are no longer absolute in either respect. That is, he can produce CVC structures except where certain consonants are targeted in final position. He can produce several later phonemes, except in certain positions. He can produce consonant clusters, with some substitutions and a few omissions. Few absolute phonotactic restrictions (e.g., no three-element clusters) and few absolute phonetic restrictions (e.g., no affricates) remain. The separation of phonotactic goals from phonetic goals, with ongoing focus on both, has allowed him to reach the point at which they no longer need to be separate for most targets.

CONCLUSION

A word consists of phones or phonemes within a frame; deficits in either the frame or its content or both are possible roadblocks to a fully functional phonology. When phonotactic constraints on a child's phonological system are absolute or near-absolute, as when a child produces very few final consonants, or clusters, or multisyllabic words of any type or produces frequent reduplication or harmony, it is important to address these deficits explicitly, in the absence of concern about segmental accuracy. Once the structures are established within the child's phonology, it becomes reasonable to set a goal of accurate phonetic production within that structure, but not before.

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