Differential Diagnosis and Treatment of Developmental Apraxia of Speech in Infants and Toddlers

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Developmental apraxia of speech (DAS) represents an incompletely understood disorder category presenting important challenges to the practicing clinician in differential diagnosis and subsequent intervention planning. Cautious application of the DAS label should be the norm in the infant-toddler population, as these children are often not using language consistently for communication and cannot be diagnosed easily. Instead, DAS may be more appropriately utilized as a diagnostic label after a period of intervention. Use of DAS as a label for infants and toddlers who are prelinguistic may prematurely label a young child when not all clinical indicators are available for valid differential diagnosis. Differential diagnostic indicators in the areas of general developmental characteristics, phonetic and phonological characteristics, and co-occurring motor characteristics are reviewed to contrast behaviors for diagnosis in older children diagnosed with DAS with those potentially present in infants and toddlers. Suggestions for diagnostic therapy to pursue appropriate differential diagnosis in the infant-toddler population are proposed.

Developmental apraxia of speech (DAS) has been widely studied for over 40 years in preschool and adolescent speakers (e.g., Ferry, Hall, & Hicks, 1975; Morely, Court, & Miller, 1954; Rosenbeck & Wertz, 1972). Although PL-99-452 mandates services for the infant-toddler population, information on differential diagnostic indicators and therapeutic intervention techniques for DAS is not widely available for infants and toddlers. The impor-

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tance of early assessment and treatment is exacerbated by the severity of involvement and relatively poor long-term prognosis traditionally predicted for children in this diagnostic category (Velleman & Strand, 1994). As a result, information on clinical symptoms and diagnostic therapy suggestions for infants and toddlers is crucial to best clinical practice.

Developmental apraxia has been described as a difficulty in programming of sequential speech movements in the absence of neuromuscular pathology (Marquardt, Sussman, & Davis, in press). The DAS label was originally based on apraxia of speech in adults, with the implication that the basis of the disorder was at the premotor planning level rather than in peripheral muscle weakness or incoordination. Neurological etiology was implied by the analogy with adults, but has never been conclusively found in children (Crary, 1991). A variety of terms have been applied including developmental apraxia of speech, developmental verbal dyspraxia, and developmental articulatory dyspraxia. These terms frequently reflect varied views of causality (Davis, Jakielski, & Marquardt, 1998). In this article, we use the term developmental apraxia of speech (DAS), as it has been most frequently employed in the literature on this topic, although we are not inferring causality directly.

Designations of the etiology for DAS include description as a disorder of speech motor control at the level of motor planning (e.g., Caruso & Strand, 1999; Hall, Jordan, & Robin, 1993), a phonological deficit in representation (e.g., Aram & Nelson, 1982), or a deficit in neural tissue with organizational consequences (e.g., Crary, 1984). Marquardt et al. (in press) have suggested that output errors in children with DAS may actually be symptomatic of a more general language deficit compromising the linguistic integrity of underlying phonological structures. They note that attention to strictly performance-level breakdowns ignores possible etiological roots of the disorder that might be more related to competence-level language mechanisms. Velleman and Strand (1994) suggest a common deficit in the generation, storage, and/or retrieval of a variety of hierarchical representations affecting motor or linguistic levels or both. No consensus presently exists regarding etiology, and none of the available theoretical accounts links tightly to clinical behaviors that are frequently described in available research (Davis, 1998).

Generally, the study of DAS has been marked by controversy about salient clinical characteristics and reliable differential diagnosis (Davis et. al., 1998, Guyette & Diedrich, 1981). The focus of much of the work on DAS has been on identifying phonological and phonetic characteristics of the disorder that may be important to reliable identification (e.g., Yoss & Darley, 1974). Ages of subjects vary widely from preschoolers (Bradford & Dodd, 1996) to adults (Ferry et al., 1975). Some studies include control populations of children with functional speech disorders (Dodd, 1995; Stackhouse, 1992), others do not (Horowitz, 1984; Rosenbeck & Wertz, 1972). Some research describes associated motor praxis and language behaviors as aspects of differential diagnosis (Aram & Nelson, 1982; Crary & Towne, 1984; Hodge, 1994). Other researchers explicitly exclude associated language and praxis deficits from differential diagnosis (e.g., Hall et al., 1993). Behavioral criteria for subject inclusion are not consistently reported, and differing criteria are utilized across studies. Severity is not reported consistently. When it is reported, the clinical basis for severity judgments is inconsistent. The consequence of lack of agreement regarding severity is a lack of consensus on what level of disorder is required for the DAS label to be appropriately applied in clinical settings. In some reports, the defining characteristic is severe and persistent disorder (Shriberg, Aram, & Kwiatkowski, 1997b). In other reports (e.g., Hall, 1989; Thoonen, Massen, Gabriels, Schreuder, & de Swart,

1997), a continuum of severity from mild to severe is explored. Similarly, while some researchers search for a single differentiating characteristic of DAS (e.g., Shriberg, Aram, & Kwiatkowski, 1997c), others propose that it is a symptom complex rather than a unitary disorder (Aram 1984; Velleman & Strand 1994). If the latter is the case, "We would not necessarily expect that every child would exhibit every characteristic of the syndrome, nor that any one child's symptoms would remain static over time" (Velleman & Strand 1994, p. 115).

Differential Diagnosis

General Characteristics

Despite the forgoing critiques, the large available literature in developmental apraxia does suggest some consensus on behavioral symptoms that have been listed as typical of children with DAS who are preschool or older. Table 1 lists general characteristics that have been frequently outlined for preschoolers and older children. On the right side of Table 1, general characteristics in corresponding areas used for differential diagnosis that may be found in infants and toddlers are listed.

Exclusionary criteria in the areas of peripheral motor and sensory function, cognition, and receptive language typically have been assessed for differential diagnosis. A basic aspect of definition for DAS as a clinical entity is the absence of peripheral structural or functional organic disorder. Specifically, the presence of DAS does not predict any associated structural deficits in speech production mechanisms or any neuromotor functional deficits such as dysarthria. In addition, no sensory deficits in hearing, tactile, or kinesthetic senses are required for a diagnosis. These indicators are the same regardless of the age of the child. Intelligence Quotient (IQ) is described as being within normal limits in older children. Formal IQ testing may not be possible in infants and toddlers, but play skills may be assessed for developmental appropriateness indicating cognitive function generally. Play behaviors should be generally appropriate to the child's chronological age (e.g., symbolic play should be present in a 12- to 15-month-old child; see Iverson & Thal, 1998, for a review). However, infants and toddlers with speech motor planning problems may show parallel difficulties in planning sequenced, hierarchical play routines. That is, they may pretend to cook, to feed a baby, or to drive a car, but they are less likely to integrate these into one play scheme (in which, for example, someone goes in the car to buy food to cook and feed the baby).

Table 1. General Differential Diagnostic Characteristics for Older Children and for Infants and Toddlers

Older Children	Infants and Toddlers
No peripheral organic disorder	No peripheral organic disorder
No peripheral muscle weakness/dysfunction	No peripheral muscle weakness/dysfunction
No sensory deficit	No sensory deficit
IQ within normal limits	Play may be delayed in putting together elements into a whole play scheme
Receptive language within normal limits	Receptive-expressive gap for vocal communication

A receptive-expressive gap in oral communication skills is characteristic of older children, where expressive language development is expected to be delayed for the child's chronological age. In infants and young toddlers, the receptive-expressive language gap may be more difficult to detect due to lower expectations for language development at their chronological age. However, no receptive or language comprehension difficulties are predicted based on a clinical diagnosis of DAS.

Phonetic and Phonological Correlates

These clinical symptoms have been a major focus area in differential diagnosis. As noted, they have been described across studies with highly varied subject pools and differing exclusionary criteria, and the range of expression of these behavioral symptoms is not established. Some characteristics are in common with functional speech disorders and thus do not constitute differential diagnostic indicators. In addition, not all of the symptoms necessary to a diagnosis of developmental apraxia are consistently reported (e.g., not all clients show groping postures of the articulators). In every instance, these behavioral correlates need to be evaluated against the expected behaviors for the client's chronological age. Differential diagnosis of DAS in infants and toddlers is complicated, as some diagnostic characteristics may be normal aspects of earliest periods of speech and language development (e.g., predominant use of simple syllable shapes or variability in production patterns at the onset of meaningful speech; see Vihman, 1996, for a review of early speech development milestones). Also associated with the behavioral correlates in speech output are frequent reports of long-term persistence of lack of speech intelligibility in spite of intensive therapy. For the infant-toddler population, lack of response to therapy cannot be considered a part of the overall diagnostic protocol, because very young children do not have an extensive therapy history. As a result, clinicians should have at least a 6- to12-month therapy history for an infant or toddler before a DAS label is appropriately applied.

Table 2 shows the most frequently reported phonetic and phonological differential diagnostic indicators for children diagnosed with DAS. Limited consonant and vowel inventory is consistently apparent in older children compared to children of the same chronological age. In the infant or toddler, there may be gaps in the consonant or vowel repertoire if any words are present at all. Some early developing sounds may be missing (e.g., no "b" sound), whereas some late sounds may be present (e.g., use of "s"). Infants and toddlers may also show little variety in the types of consonants and vowels produced. Predominant use of simple syllable shapes is noted in older children diagnosed as having DAS; in infants and toddlers there may be lack of syllable based vocalization (e.g., at least CV combinations like "ba"). Instead, the child may use marginal, nonsyllabic vocalizations (long "ahhh" or "mmm" vocalizations) or few vocalizations at all. Frequent omission errors for consonants (e.g., "_ag" for "bag") are noted often in older children with DAS. In infants and toddlers, consonants or vowels may occur alone, and there may be a restricted set of consonant and vowel syllable combinations (e.g., homonomy where only the "da" syllable is used for many word types). Persistence of errors in producing vowels is considered a hallmark of differential diagnosis in older children and is used to differentiate DAS from functional speech disorders. In infants and toddlers who may not vocalize frequently, early indications of difficulties with vowels may be found in the use of few different vowel types (perhaps even limited to "uh," as in "bug").

A second frequently reported hallmark of differential diagnosis in older children is the presence of altered and/or inconsistent

Table 2. Phonetic/Phonological Characteristics for Older Children and for Infants and Toddlers

Older Children	Infants and Toddlers
Limited consonant and vowel phonetic inventory	Systematic gaps in consonant or vowel repertoire Little variety either of consonants or vowels
Predominant use of simple syllable shapes	Marginal babble, without "true" consonants Lack of consonant-vowel babble Few idiosyncratic, word shapes with consistent meaning
Frequent omission errors	Incomplete syllables, consonant alone or vowel alone Consonants and vowels in repertoire don't combine freely
High incidence of vowel errors	Lack of variation in vowels
Altered suprasegmental characteristics (rate, pitch, loudness, and nasality)	Limited or stereotyped intonation patterns
Variability/lack of consistent patterns of output	Vocal output may be very limited overall Words used then disappear (more than normally expected at this age)
Increased errors on longer sequences	Cannot combine different syllables or has only one movement pattern
Groping/lack of willingness to imitate	Groping/lack of flexibility

suprasegmental characteristics of pitch, rate, loudness, and nasality, which may further compromise their intelligibility. These characteristics give speech its "melody" and are used in English to signal a statement (downward intonation) or a yes-no question (upward intonation) or to change the meanings of words and phrases (a "**hot** dog," the food, versus a "hot **dog**," an overheated pet). Word level stress may be particularly affected (Velleman & Shriberg, 1999). In infants and toddlers, vocal output or words may be characterized by limited or stereotyped suprasegmental patterns. These patterns do not contribute to the intelligibility of the limited words present in a toddler's repertoire. If prelinguistic vocalizations are present, they may not have the musical speech-like quality characteristic of prelinguistic jargon (i.e., where the infant or toddler sounds like he or she is "telling stories" even when words are not discernable).

The third hallmark of differential diagnosis for older children is variability or lack of consistent speech patterning in the ways in which words and sequences are produced. In infants and toddlers, output may be limited overall. Words, if present, may be used and then disappear more than is typical at the onset of first word use. However, it should be noted that variability in productions is highly characteristic of the period of first word use in normally developing children (Ferguson & Farwell, 1975). As a result, this particular differential diagnostic indicator for DAS may be difficult to assess if the infant or toddler is producing between 0 and 50 words. After this early word period, productions of specific word types becomes consistent in typically developing children. The unusual variability in productions of the same word characteristic of DAS can then be used more validly as a differential diagnostic indicator.

One source of variability in productions, an increase in errors on longer sequences of verbal output, is highly characteristic of older children with DAS. In infants and toddlers, this increase in errors with length may manifest as an extremely limited ability to sequence consonants and vowels to make syllables, to combine syllables for two or three syllable words, or to combine words into short sentences. Another source of variability is in automatic versus volitional speech. Adults with apraxia of speech (AOS), as well as children with DAS, demonstrate significantly greater ease in producing automatic utterances (such as the reply "Fine. How are you?" or the song "Happy Birthday to You") than volitional utterances (e.g., novel sentences). Children with DAS, especially young ones, typically find predictable utterances (e.g., "I love you") and unison speech activities (e.g., familiar songs or books) much easier than generating a novel utterance or speaking under pressure (e.g., "Say your new word for Aunt Jane." "You can't have it unless you say it.").

Groping postures and lack of ability to imitate have also been cited as characteristic of DAS in older children. In infants and toddlers, groping postures as well as lack of flexibility may characterize attempts at words, as in older children. However, groping postures are far less common in children with DAS than in adults with AOS (Shriberg, Aram, & Kwiatkowski, 1997a). In addition, imitation ability may depend on how automatic versus volitional the utterance is; automatic may be far better on imitation in some cases.

Co-Occurring Characteristics

These characteristics are listed in Table 3. Co-occurrence of these characteristics with phonetic and phonological symptoms appear to be optional for differential diagnosis, although they have been frequently cited in available studies. In addition, the range of expression of these characteristics required for differential diagnosis is not clearly or consistently specified. Accordingly, they should be considered corollary rather than central to differential diagnosis of DAS.

In older children, the use of gestures for communication has been noted as an associ-

Table 3. Co-Occurring Characteristics for Differential Diagnosis for Older Children and for Infants and Toddlers

Older Children	Infants and Toddlers
Gestures used to communicate	Home signs may develop
Gross and fine motor delays	Uncoordinated feeding patterns/without dysphagia
	May need help with mixed textures
	Drooling is a common issue
Motor clumsiness	Late development of motor milestones
Volitional oral nonverbal skills	Difference between automatic/functional versus elicited gestures
Diadochokinetic rates	Oral motor incoordination, especially for nonautomatic sequences
Syntax	Basic subject-verb-object word order may be in error
Reading and spelling	NA

ated characteristic. This characteristic is held in common with children diagnosed with expressive language disorders and is considered a hallmark of early diagnosis of expressive versus receptive language disorder in young children (e.g., Thal & Tobias, 1994). In this area, infants and toddlers may develop a repertoire of idiosyncratic or "home" signs that are functional for communication. Differential diagnosis of DAS based only on the presence of gestures instead of use of oral language in infants and toddlers is not warranted at this age, as expressive language as well as speech output deficits could be indicated by the use of gestures for communication.

Gross and fine motor praxis problems frequently have also been noted to accompany DAS in older children. It should be noted, however, that some studies specifically exclude children with associated praxis problems, and other studies include them in the DAS subgroup. In infants and toddlers, there may be a history of uncoordinated feeding patterns and excessive drooling, and the child may need help with mixed textures in feeding as well. Motor clumsiness has been noted in some older children with DAS. Hodge (1998) argues in this respect that children with DAS are a subgroup of a larger population of children with developmental coordination disorder (DCD; American Psychiatric Association, 1994) who may exhibit DCD primarily or initially in the speech production system. In this regard, late development of motor milestones or mildly low muscle tone may be reported in infants and toddlers, although motor clumsiness may not be apparent. Volitional oral nonverbal skills have also been reported as deficient in some older children diagnosed as having DAS. In infants and toddlers who show difficulties in oral nonverbal behaviors, function may be assessed by noting the difference between automatic/functional versus elicited gestures (e.g., licking a lollipop vs. pretending to lick a lollipop). Younger children may show a lack of flexibility in accomplishing a task. That is, they may be able to accomplish the task in only one way rather than showing flexibility in achieving a motor goal. This factor may be the basis for the insistence of many younger children with DAS on rigid routines: eating the same food out of the same bowl with the same spoon requires less motor flexibility.

Diadochokinetic rates (i.e., rapid repetition of syllables such as "puhtuhkuh") have been found to be poor in older children with DAS, likely related to the variability noted earlier in producing speech. In infants and toddlers, oral motor incoordination may be present, especially for nonautomatic sequences (e.g., sequences such as tongue protrusion following lip smacking). Syntax is noted as being deviant in older children; in toddlers who begin using multiword sequences, basic subject-verb-object (SVO) word order may be in error (e.g., "Here sit Daddy").

Summary

Based on available differential diagnostic indictors, clinical diagnosis of DAS should be approached with *extreme* caution in the infant-toddler population. Instead, DAS may be more appropriately utilized as a diagnostic label after a period of intervention allowing a larger window of time to (a) view the child's emergence into consistent use of oral communication, (b) observe the presence and persistence of differential diagnostic indicators, and (c) assess the child's response to intervention in areas critical to diagnosis.

Diagnostic Intervention

Initial Goals

Diagnostic intervention should involve several important considerations that will allow establishment of a valid differential diagnosis of DAS in infants and toddlers over a period

of time, as well as increasing their overall communication competence. Two basic sequential goals are initially important: (a) establishment of consistent interpersonal communication and (b) establishment of consistent use of oral communication.

Overall Communication

Communication is the top priority for young children with developmental delay, regardless of diagnostic category. Some children will spontaneously generate their own gestural communication system or use idiosyncratic vocalizations to represent certain meanings (e.g., "ah-ee" for "upstairs"). Others are unable to express their ideas, which can lead to withdrawal, frustration, or both. It is necessary to ensure that the child's communication partners:

1. Watch for behaviorally acceptable attempts to communicate, and
2. Respond appropriately to any mode of communication.

Gestural or other attempts to communicate should not be ignored on the premise that the child will not learn to talk unless forced to do so. On the other hand, anticipating the child's every need or giving her free reign to do or take whatever she wants does not further this goal. These strategies remove the need for communication. Some attempts to communicate may be highly idiosyncratic (e.g., the toddler who jiggles her hand in her pocket to signal that she needs to use the toilet) but can be functional for the child and the communication partner while consistent communication is being established.

Motivation is essential, but so is success. A goal for communication partners, both parents and clinicians, is to provide and model appropriate communication strategies whenever possible. These strategies may include use of sign language, pictures, leading, miming, and sound effects or gestures to represent ideas (e.g., "woof" to refer to a dog). It is better for the child to learn semistandard signs or sound effects than to make up her own "words." One message the child should receive (although not to the extent that it interferes with communication exchanges) is that communication is conventional. Unless there is agreement on which gesture, sound, or picture will represent which meaning, communication will not be successful. However, as noted, the communication partner may need to accept the tools the child has to offer and model toward a more conventional communication form (e.g., if the child uses a vowel "uh" to get attention, her mother may want to model "mom" every time she uses her vowel sound).

Oral communication

Oral communication is a second priority. Depending on the child's current status, initial objectives may start at the level of increasing vocalizations of any sort. These can be elicited most easily using the following strategies, which reduce the communication pressure on the child and are as close as possible to "automatic" productions:

- Speech in conjunction with movement (e.g., "whee" while sliding down a slide)
- Sound effects (e.g., "woof," "vroom," etc.)
- Verbal routines (e.g., songs, rhymes, favorite predictable books)
- Speech or singing in unison with another person or a group
- Props that draw the child's attention away from his or her mouth, such as puppets (Velleman 1994)

Any sounds that are already within the child's repertoire should be starting points. Choices should be determined by

- The child's existing repertoire ("b" words if the child can produce "b")
- Functional meanings that will enhance communicative potential ("more" if the child can produce "m")
- "Intelligibility"—sounds that will be recognized as having conventional meanings (e.g., "my" for "mine" if the child can put consonants and vowels together and uses "m")

Sound System Goals

When the child has begun to use vocalization consistently for communication, two additional goals may be added: expansion of sounds and expansion of structures. Initially, the use of these sounds and structures should be encouraged without regard to accuracy

Expansion of Sounds

The goal should be to expand the infant-toddler's repertoire to include a wider diversity of sound qualities. For example:

- Both consonant (C) and vowel (V) sounds produced in different parts of the mouth ("b" and "k," "ah" and "eee")
- Varied pitch and loudness levels (high and low, loud and soft sounds)
- Both short and long utterances ("moo" for the cow, "baa baa baa" for the sheep)

Normal developmental information suggests that early developing consonant sounds are [b], [d], [w], [m], [n], [j] (e.g., Stoel-Gammon, 1985; Vihman, Ferguson, & Elbert, 1986). Earliest vowels are those in the words "father," "ask," "up," and "egg" (e.g., Davis & MacNeilage, 1995). English-speaking children will use high-pitch to low-pitch intonation contours. First words will show stress on the first syllable or have equal stress on both syllables. Children will produce mostly monosyllable word types, because those are common in English phonology. Children in other language environments may not produce the same early intonation and stress patterns and may use longer words if that is characteristic of their language (e.g., Spanish has more multisyllables than monosyllables).

Expansion of Structures

Syllables should be targeted rather than isolated vowels or consonants (Velleman, 1994). Earliest syllable shapes used by normally developing children learning English include CV (e.g., "no"), CVCV, (e.g., "mama"), and a few CVC (e.g., "dad"). When there are two consonants, they are often the same (e.g., "mama"). Establishment of consonants in isolation, although easier to achieve than production of syllables, does not carry over to blending those consonants into larger units (syllables or words). Thus, isolated consonants should only be targeted if they have meaning (e.g., "shhh"; "mmm" for "yum").

Sounds and syllables in word structures should be targeted systematically, adhering rigidly to the "old forms, new functions; old functions, new forms" rule. For example, new sounds should be taught only in word positions that are well-established in the child's repertoire. New word shapes (e.g., CVC "*bag*" when a child produces mostly CV words such as "*moo*") should include only sounds that the child can already produce (in some word position). Velleman and Strand (1994) suggest that goals should target *either* structures (e.g., CVC) or sounds (e.g., "k"). Thus, objectives might include:

- **Structural: For a child with final consonant deletion.** The child will produce CVC forms, using *any* consonant in final position ("kik" would initially be accepted for "kiss").

- **Segmental: For a child who does not produce fricatives.** When producing words that contain fricatives, the child will produce any fricative in any position in the word ("fit" or even "fif" for "sit").
- **Structural and Segmental: For a child who produces final consonants and fricatives, but not fricatives in final position.** The child will produce any fricative in final position of the target words that end with fricatives ("yeth" for "yes").

Movement Sequencing Goals

These principles address the child's need for communication via conventionally understood productions of words. However, it is vital to remember that, while improving the child's interactive function, these goals do not address the core problem of DAS: the ability to flexibly plan—and produce—new sound sequences (Velleman, 1994; Velleman & Strand 1994). The brain and the oral musculature must be involved collaboratively in producing output so that the child can produce (a) new words and (b) old words in new contexts. Speech "aerobics," (i.e., "same syllable," "change at the end") assist with this process by encouraging the neurological sensorimotor planning systems to work together in order to

- Recognize the current state of the vocal tract: "What is the current position of my tongue? lips? velum? vocal folds?"
- Identify the articulatory targets required for the next segment: "Which articulators need to move, to where, and in what sequence?" "How can I get them there from where they are now?"

Ayres (1985) stresses that sequencing involves not only determining the order in which individual (articulatory or other motor) postures will occur, but—even more critically—establishing appropriate strategies for transitioning between these postures. A trapeze artist's challenge provides an appropriate analogy: The order of the swings or rings is obvious to every member of the audience; determining their order is not what impresses the crowd. The true skill involved is the ability to transition from each swing to the next, without over- or undershooting. Flexibility training can provide this skill. This flexibility training for children involves asking the child to reproduce sequences of syllables in series, supporting establishment of feedback loops between the articulators and the brain. Thus, planning can be based on accurate information about the current state of the articulators, and appropriate motor commands can be issued for transitioning from that state to the next. At older ages, we ask children to repeat CV syllables, first in response to pictures representing these syllables (a sheep to represent "baa," a ghost for "boo," a bee for "bee," etc.), and later, in response to printed nonsense syllables. The following sequence is recommended:

- **Same syllable** repeated ("ba ba ba ba ba ba")
- **One change at the end** of the series ("ba ba ba ba ba boo" or "bee bee bee bee bee dee")
- **Alternating** series ("ba boo ba boo ba boo" or "bee dee bee dee bee dee")
- **Varied** series ("ba bee boe boo bye")

The child is required to (subconsciously) recognize the current state of the vocal tract, identify articulatory targets, and—crucially—to repeat these steps for every transition between two segments (or syllables or words) in the target sequence. The sequence expands from known transitions ("b" + "a") to new transitions ("b" + "oo").

Clearly, drilling with a row of picture cards is not an option for a toddler. However, this type of repeated sequence can be practiced in more toddler-friendly ways. Counting books are especially appropriate for this activity. Rather than counting, one may simply point to each object while saying its name (e.g., "em em em em" with McGrath's [1994] The *M & M's Counting Book*) or the sound it makes (e.g., "wow, wow, wow" with Boynton's [1995] *Doggies*). Other relevant sound effects ("yum yum yum" for Cheerios; "ow ow ow" for pictures of bees; etc.) may also be used. These drills are quite adaptable to play or other daily routines, as well. For example, while setting (or pretending to set) the table, "plate, plate, plate, plate; spoon, spoon, spoon, spoon; cup, cup, cup, cup" can be repeated. Again, not accuracy, but consistency is the goal. Surprising to those who witness it for the first time is the difficulty that many children with DAS have in just repeating the same syllable over and over. As repetitions continue, consonant or vowel quality—or both—tend to change significantly. The goal of this type of activity is consistency in use of consonants, vowels, and CV transitions. Suprasegmental flexibility can also be built into the drills in systematic ways, such as using a rising pitch while pushing an object up and using a falling pitch while pushing an object down or speaking quietly while a "baby" is sleeping, but speaking loudly when she is awake.

General Intervention Considerations

Types of Goals

Children with DAS often do not follow the expected developmental sequences, especially with respect to order of acquisition of phonemes. Therefore, it is even more difficult to determine which objectives the infant or toddler is likely to respond to most quickly or effectively. Thus, several goals/objectives should be identified and cycled, including both structural goals (CV syllables, final consonants, two-syllable words, etc.) and segmental goals (e.g., glides, stops, fricatives, velars). Frequent sampling of the child's productions is required to identify and respond to changes in the child's system. Flexibility is required on the part of the therapist as well, being a target for the child's motor-planning system. Even changes in the therapy situation that may seem quite slight to the speech-language pathologist may cause changes in performance (Velleman & Strand, 1994). Similarly, changes in child status (e.g., fatigue) may have a major impact on performance. When a new form or a new function is introduced, a child may appear to "lose" some old ones. For example, the child who appears to have mastered the "sh" sound may "lose" it (usually temporarily) when the "s" sound is introduced. This is why only one new goal in each realm should be addressed at a time.

Nonspeech Symptoms

Some infants and toddlers exhibit both oral nonverbal and speech apraxia. They may also exhibit mildly reduced oral motor tone or oral hyposensitivity, sometimes accompanied by marked drooling. Coordination, especially sequencing, for feeding and the ability to handle challenging (chewy or crunchy) or mixed textures may be affected. If these symptoms are more than mild, dysarthria rather than dyspraxia may be the primary diagnosis or may form an additional diagnosis. There is presently no research available to support the efficacy of oral-motor therapy for improvement of speech production skills per se. Thus, it is appropriate to work with children with DAS on nonspeech oral-motor skills in order to improve these skills themselves, but improvement in speech should not necessarily be expected as a result. For remediation of

oral apraxia, again it is important to focus more on sequences than on stable postures. As with all treatment, intervention should be dynamic rather than static.

System Fatigue

System fatigue is an important consideration for children with DAS. Speaking, especially volitionally, is a physically taxing activity. Therefore, frequent short individual therapy sessions should be augmented by group activities involving verbal routines in which the communication pressure on the individual child is markedly reduced and contextual, rhythmic, multimodal, or other types of support are enhanced.

Stair-Step Progress

Children with DAS, much more than other children with functional speech delay, even severe delay, seem to progress in spurts. Plateau periods are common in which no progress is apparent or the child even appears to regress. During these periods of no apparent progress or even regression, the child may be integrating various pieces of new skills into the whole required for an overt change in speech production skill.

Play

As we have seen, children with speech motor planning problems may show parallel difficulties in planning sequenced, hierarchical play routines. In some instances, starting to build sequencing ability in the area of play routines may be less threatening to the child than in the area of oral communication, where lack of success or ability may have produced secondary symptoms of resistance or withdrawal. Particularly for young infants and toddlers, who may not be developmentally ready for structured oral activities, play may provide an entry activity for building sequencing into the intervention program. Later, aspects of the play may be paired with sounds to move into oral communication, even before oral sound production is used interactively.

Other Motor Symptoms

Limb and/or whole-body apraxia frequently accompanies DAS. Coordinating therapy techniques—or even providing co-therapy—with occupational and/or physical therapists is extremely helpful for these children. Such difficulties will of course impact on augmentative communication choices (e.g., sign language).

Structure of Sessions

There are many issues pertinent to the structure of intervention sessions. These issues include motivation, goal setting, instructions, and modeling. Two issues derived from the motor learning literature especially relevant to treatment of DAS are (a) the use of repetitive practice and (b) the concepts of mass versus distributed practice (Strand, 1995). These issues must be mediated for use with infants and toddlers, as they were originally designed for use with adults and older children.

Repetitive Productions

Infants and toddlers need enough productions in a session in order to allow learning to occur, to become habituated toward more automatic sequential processing, and to form a foundation for flexibility in sequencing speech movements. This repetition involves using reinforcements that do not take time and developing activities that facilitate repeated opportunities for production of the target utterance (e.g., "toe, toe, toe, toe, toe" while counting toes). Decisions must be made regarding

scheduling of sessions as well as how many targets to include in treatment. Massed practice (i.e., many repetitions) yields quick acquisition of the skill, but poor retention and generalization for incorporating it into other motor skills. Distributed practice takes longer, but results in better motor learning (Magill, 1998; Schmidt, 1991). For a very young child, two activities with the same goal rather than one longer activity may be appropriate. For example, saying "toe toe toe toe toe" while pasting toes on a foot then "moo moo moo moo" for a cow, may be better practice than one long activity with the same number of repetitions.

Knowledge of Results

It is important to give infants and toddlers who are using words frequent information about results (was the production right or wrong) as well as movement performance (what did they do or what should they do such as "open bigger, make your tongue tighter"). The cognitive motor literature shows, however, that although adults benefit from increased specificity of feedback, too much specificity can actually decrease performance in children (Schmidt, 1991). Strand and Skinder (1999) note that while feedback (whether verbal, tactile, or gestural) from the clinician can be beneficial to all children, it may be extremely beneficial to children with inadequate internal sensory mechanisms. In addition, however, for infants and toddlers, social feedback may be equally important (e.g., "understanding" following feigned confusion) to reinforce the social importance of use of vocal communication and of success in making their communication attempts intelligible to their listener.

Strand (1995) has suggested that the "Eight Step Continuum," a treatment program for acquired apraxia (Rosenbek, Lemme, Ahern, & Wertz, 1973) can be adapted for infants and toddlers with DAS who show delays and deviance in phonological development. Integral to the method is the use of a specific hierarchy of temporal delay (i.e., simultaneous production, immediate repetition, repetition after delay, etc.). This principle is just as applicable for toddlers with DAS, as it allows an opportunity for the young child to take increasing responsibility for assembling and retrieving motor plans with progressively less cueing. In addition to the repeated attempts of repetitive (or simultaneous or delayed repetitive) production, techniques such as phonetic placement, tactile cueing, prosodic cueing, and so forth, can be incorporated as needed or appropriate. Again, strategies that take some of the child's focus off his or her mouth (such as hand gestures or other movement, music, etc.) can be very helpful for getting the very young child started with this type of activity. Table 4 contains a plan for modification of Rosenbeck and colleagues' eight-step continuum.

Note that multiple repetitions of the same item may only teach that one thing, which can be an important goal for functional communication. However, generalization to other words should not be expected. Also, it is important to address word shapes (e.g., final consonants, two-syllable words), sound classes (e.g., any fricative in any position), and word patterns (e.g., front to back vs. back to front; stop to fricative vs. fricative to stop) rather than only focusing on production of particular sounds. Segmental accuracy is often not the goal until the child is older. For toddlers, the goal is a variety of word shapes, features, and movement patterns.

Conclusions

Clearly, DAS is a clinical diagnostic category in preschoolers and older children that is challenging for both researchers and clinicians. Although the disorder has long been a focus of research efforts and, more recently, has been a subject of intense interest to clini-

Table 4. Modification of "Eight-Step Continuum" for Therapeutic Intervention

1. Therapist says the utterance while the child watches the clinician's face; the child repeats
   a. If the child is unsuccessful, move to simultaneous production (therapist with client), varying rate and adding tactile or gestural cues as necessary
   b. Maintain both auditory and visual stimuli
   c. Continue productions until the child can easily produce the utterance with the therapist; then slowly fade the simultaneous cue by reducing volume to the point where there is a simultaneous mime only
2. Move to immediate repetition
   a. Therapist provides auditory model (again making sure the child is watching the therapist's face)
   b. Child repeats (therapist mouths the gesture during the response if additional support is needed; then fade)
3. Addition of delay
   a. Therapist says target utterance
   b. Insert a delay (1 to 3 seconds) before imitative response
   c. After the child is successful at repeating the utterance after a 2- or 3-second delay, have the child repeat the target several times without intervening stimuli
4. Work to elicit the utterance spontaneously
5. Teach the child how to transition within a sequence
   a. From a certain consonant to varied vowels (babibabibo, etc.)
   b. From varied consonants to a certain vowel (badagaba, etc.)

cians, little consensus exists on definition, etiology, and characterization of clinical behavioral correlates. Despite the lack of consensus on either theoretical motivation, neural etiology, or any clear empirical evidence precisely defining clinical symptoms, there is some consensus among practicing clinicians that developmental apraxia exists (e.g., Williams, Packman, Ingham, & Rosenthal, 1980). It thus represents an incompletely understood disorder category that presents important challenges to the practicing clinician in differential diagnosis and subsequent intervention planning. Because infants and toddlers are often not using language consistently for communication, cautious application of the DAS label should be the norm, founded on a clear understanding of (a) the positive benefits to family and to the infant-toddler in discerning long-term prognosis and (b) making appropriate decisions with the family regarding intervention programming. Use of developmental apraxia of speech as a label for infants and toddlers who are prelinguistic may prematurely label a young child when not all clinical indicators are available for valid differential diagnosis. This particular issue relates to both research and clinical practices in assessment and treatment for infants and toddlers with delay in the onset of meaningful speech or with severe intelligibility problems in the earliest periods of speech and language development.

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