Evolving Views of Children's Disordered Speech Sound Production from Motoric to Phonological

Evolution des vues sur la production désordonnée des sons du langage chez les enfants de l'aspect moteur à l'aspect phonologique

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Abstract

Theory and practice regarding children's disordered speech sound production have evolved over the past 25 years from consideration of peripheral (i.e., auditory and oral sensory-motor) to more cognitive (i.e., phonological) mechanisms. Negative research findings regarding peripheral mechanisms were followed by studies indicating that children's speech production errors were systematic with respect to phonological constructs such as phonemes, distinctive features, phonological rules, and phonological processes. Furthermore, children's speech production was found to interact with higher levels of language organization. These trends suggest that, in the future, children's disordered speech production may be viewed as a synergistic component of children's disordered language.

Résumé

La théorie et la pratique concernant la production désordonnée des sons du langage chez les enfants ont évolué au cours des 25 dernières années. Centrées au départ sur la considération des mécanismes périphériques (c'est-à-dire auditifs et oro-sensori-moteurs), la théorie et la pratique ont évolué vers la considération de mécanismes plus cognitifs (c'est-à-dire phonologiques). Des résultats négatifs de recherches sur les mécanismes périphériques ont été suivis par des études révélant que les erreurs de production du langage chez les enfants sont systématiques en ce qui concerne les constructions phonologiques comme les phonèmes, les traits distinctifs, les règles phonologiques et les processus phonologiques. De plus, la production du langage chez les enfants réagit, on l'a découvert, avec les niveaux plus élevés d'organisation du langage. Ces tendances suggèrent qu'à l'avenir, la production désordonnée du langage chez les enfants peut etre considérée comme une composante synergique du langage désordonné des enfants.

Theory and clinical practice regarding children's disordered speech sound production have undergone dramatic changes in the past 25 years as the dominant view of the etiology of the disorder has evolved from peripheral articulatory processing mechanisms to central phonological knowledge. Students trained in 1965 learned that articulation disorders were recognizable in the misproduction of one or two later developing speech sounds by elementary school aged children. This disorder was contrasted with delayed speech that involved a more pervasive oral language disability. Assessment procedures focused upon the child's ability to produce each consonant sound in a variety of word positions, to produce each error sound when given a model of the sound's production, and to produce each sound in a variety of phonetic contexts. Treatment goals sought to teach the child to consciously describe the nature of his or her error, to correct the production of the error sound, and to teach the child to monitor productions so that the child would be able to take responsibility for future correction of his/her own speech.

In contrast, students of today learn that phonological disorders result from the child's failure to learn cognitive rules governing the pronunciation of abstract word forms. The population of phonologically impaired children includes both the misarticulating elementary school child and the speech delayed preschooler. Assessment and treatment procedures now target the hypothesized abstract rules rather than the production of particular speech sounds, and are progressively evolving toward a treatment approach in which phonological disorder is treated as a synergistic component of the child's overall language impairment.

These changes may make it difficult for speech-language pathologists trained within one framework to communicate with those trained within another, and for students trained in recent times to appreciate the contributions of the older generation of researchers and clinicians. Our purpose in reviewing this history is to mark the major trends in theories of children's disordered speech production and the effects these have had upon clinicial practice. We hope to show that there

is appreciable continuity in both theory and practice that may be obscured by the strong published statements of researchers and clinicians alike. Furthermore, much of the change that has occurred in views of children's speech production errors has resulted from the broadening of the speech-language pathologists' concern for speech sound errors of language-impaired children. We start with a sketch of the traditional viewpoint that existed in 1965 and then trace a path through sensory-motoric, auditory-perceptual, and phonological emphases that have been applied to the study and remediation of this disorder.

Traditional Viewpoint

The concept of phonemes as basic units of speech perception and production dominated linguistic research at the start of this period. Phonemes were thought to be mental units that were realized in speech performance as the distinctive, contrastive, commutative sounds differentiating one word from another (Swadesh, 1934). Each phoneme surfaced in behavior as a set of allophones appearing in particular phonetic contexts. Linguistic research sought to establish phonemic inventories for all languages, including each phoneme's allophonic permutations.

Nature of the Disorder

Against this phonemic background, Van Riper (1963) defined children's articulation disorder as the substitution, omission, addition, or distortion of speech sounds within words. This disorder was contrasted with delayed speech in which children had failed to acquire the use of speech as a functional tool. The clinical population of misarticulating children was defined as children who continued to misproduce one or a few of the developmentally later appearing sounds beyond age eight or nine years. Thus, much of the research effort at that time was applied to defining the normal progression of speech sound development (Templin, 1957) and the types of speech sound errors produced by misarticulating school age children (Snow, 1961) that might distinguish them from the normal population.

Articulation disorder was suspected of having a variety of potential causes: developmental, environmental, emotional, defective oral anatomical structure, defective auditory processing, and defective motor coordination. With the exception of specifically oral-motor causes, delayed speech was given a similar list of potential causes.

A strong research emphasis was placed upon describing the articulation of children with known oral structure abnormalities (i.e., dental malocclusion, restricted lingual frenum, Down Syndrome, and cleft palate), oral-motor differences (i.e., reverse swallow), and known neurological disorders (i.e., cerebral palsy) (Bernthal & Bankson, 1988). In general, it was found that each of these conditions may result in specific misarticulation patterns that are predictable from the structural or neurological deficit (e.g., nasalization of vowels among children with repaired palatal clefts or children exhibiting velar paralysis) and that other speech errors represented a general delay in speech development (e.g., misarticulation of /r/ as [w] by a child with a repaired cleft palate).

The relationship between error patterns of children with known neurological impairment and children with functional misarticulation led to the the positing of a neurological impairment in processing of speech sound production called childhood verbal apraxia. This proposed disorder was defined with respect to behavioral characteristics of speech production without a prerequisite diagnosis of neurological damage. These behavioral characteristics overlap in large degree with the definition of severe functional misarticulation or phonological disorder (Guyette & Diedrich, 1981). The traditional emphasis upon motoric aspects of articulation was further developed in McDonald's (1964a) sensory-motor theory of misarticulation. Concern for the potential causal factors related to children's misarticulation was diminished during the ascendency of cognitive theories but is again making an impact (Shriberg & Kwiatkowski, 1982).

Clinical Practice

Diagnosis of articulation and delayed speech disorders was a process in which etiological factors, both intrinsic and environmental, were fully explored. Articulatory ability was described by identification of the individual speech sounds produced in error (i.e., phonemic targets), the error types used for each (i.e., allophones produced), and the position of these errors relative to word boundaries. This form of analysis became available in the form of picture articulation tests, such as the Templin Darley Tests of Articulation (Templin & Darley, 1960). In addition, Van Riper (1963) suggested the use of: (1) deep testing in which many words containing a misarticulated sound were probed for potential correct sound productions; (2) phonetic assimilation testing in which the error speech sound was embedded in sentences so that it could be preceded or followed by a variety of other speech sounds; and (3) stimulability testing in which production of a sound was cued by a clinician-produced model of the sound. While primarily focused upon description of the individual speech sounds, Van Riper's (1963) examples of summary reports provided a precursor to the use of linguistic features to describe multiple phoneme misarticulation, for example, when he described a child who produced k/g, t/d, f/v, and s/z as confusing voiced and unvoiced sounds.

Reflecting the influence of behavioral learning theories, Van Riper (1963) described a therapy regime that was systematically structured with respect to length of utterance (i.e., isolated sounds, syllables, words, and sentences). Developmentally appropriate speech sounds were targeted according to a child's age. At each utterance length, the child was trained to auditorily recognize the sound, compare it to the standard sound, vary and correct the error sound, and stabilize correct productions. Clinician-supplied instructions for production were based in cues regarding the place and manner of articulation of the sound with a focus upon the child's proprioceptive feedback. The ability to analyze the characteristics of the error sound and to manipulate the physiological patterns that produced the sound were to be used by the child to maintain appropriate production after therapy ceased.

This therapy strategy was recommended for the elementary school child who misarticulated one or a few phonemes. Suggested treatment for the speech-delayed child was more indirect. The child was stimulated to produce and respond to speech sound production within a communicative context. Modelling of individual sounds was followed by the recognition and production of words as a sequence of speech sounds and the expansion of the child's use of words in conversation.

Research regarding the efficacy of this treatment strategy as a whole was and still is lacking. There were no studies that compared a traditional treatment group to a control group to demonstrate that the treatment was effective. However, certain components of the process were assessed in limited studies. For example, Powell & McReynolds (1969) trained children to produce [s] in isolation and then in syllables. Correct production of [s] in words appeared only after the children had practiced production in syllables. However, continued practice through the sentence level was questioned by the results of Hoffman (1983) who found that practicing [r] production in phrases and sentences added little to the gains made through syllable and word practice.

Sensory-Motor Emphasis

As advances in instrumentation allowed, phoneticians studied the acoustic-perceptual (Fletcher, 1953) and articulatory (Stetson, 1951) realizations of phonemes in adult speech. Phonemes and word units were found to be too abstract to be seen in the continuous flow of speech movements and their resultant smoothly changing acoustic characteristics. The concept of coarticulation was advanced as a process by which discrete phoneme-size units could be mapped unto continuously changing motoric and acoustic features.

Coarticulation of gestures across phoneme boundaries within syllables was regarded as a process by which consonants and vowels were telescoped, or shingled, yielding the extraordinarily efficient and smooth stream of speech. The central issue in constructing models of speech production has been to convert the timeless, static units of phonological analysis (i.e., phonemes, allophones, and features) into the well-timed, dynamic units of motor control (i.e., muscle contractions and articulator movements). Typically, this has been done in hierarchically-arranged models that translate strings of phonemes within words at one level into gestural features organized into syllables at another level (Kent & Minifie, 1977). Such models use feedback correction systems to adjust muscular contractions related to a particular articulator's movements and feedforward mechanisms that make adjustments in muscular contractions affecting one articulator using feedback from another articulator (Abbs, Gracco, & Cole, 1984).

Nature of the Disorder

McDonald (1964a) focused upon the motoric aspects of speech production when he rejected Van Riper's notion of mislearned word units and stated that a misarticulated sound represented arrested sensory-motoric development. This focus resulted in research being directed toward studying the sensory-motoric abilities of children with articulation errors, and the relationship between articulation disorders and the presumed units of motoric organization. As a group, functionally misarticulating children have not been shown to display coordination differences compared to normally articulating children (Winitz, 1969). Deficits in oral sensory-motor tasks that are specifically related to an error phoneme have been demonstrated for some older (i.e., post-pubescent) misarticulating children who misarticulate /s/ or /r/ (McNutt, 1977). However, no sensory-motor differences have been demonstrated for misarticulating children who have not been grouped by phonemic error (Dworkin & Cullatta, 1985). However, the search for oral-sensory problems in combination with other deficits may yet bear fruit in correlational data showing that subgroups of misarticulating children are definable via patterns of performance on a variety of psychological and physiological measures (McNutt & Hamayan, 1984).

Numerous studies have demonstrated relationships between syllabic shape, phonetic context, and rates of misarticulation among elementary school-age children who misarticulate one or a few consonant sounds. In general, the frequently misarticulated sounds /r/ and /s/ were produced correctly more often in stressed syllables and consonant clusters, and when preceded or followed by lingual consonants (Kent, 1982). These studies have been interpreted as suggesting that aspects of phonetic and syllabic context enhance the misarticulating child's apparent motor control for misarticulated sounds. However, preliminary acoustic studies of misarticulating children's control of temporal (Weismer & Elbert, 1982) and spectral

(Daniloff, Wilcox, & Stephens, 1980) characteristics of fricatives suggested that cluster contexts may be less, not more, well-articulated. Physiological studies of children's speech production will be required to address this issue in the future.

Clinical Practice

Inasmuch as the syllable was assumed to be an important speech-motor planning unit, McDonald (1964a) focused assessment procedures upon syllabic position rather than word position. Acknowledging the coarticulation of gestures across phonemic units, McDonald (1964b,c) expanded Van Riper's deep test to search for phonetic contexts in which error sounds were appropriately produced, first in two word naming responses and then in sentence reading or repetition tasks. This clinical procedure continues today in the publication of similar test procedures using multisyllabic words (Kenney & Prather, 1984).

McDonald (1964a) described therapy procedures in which the clinician acted as counselor. Therapy goals were structured to heighten awareness of tactile-kinesthetic feedback of motoric features and provide for a spread of acceptable productions from one phonetic context to the range of possible phonetic contexts. It was assumed that as a child learned to describe and manipulate motoric patterns, he/she would be able to actively work on constructing therapy materials and monitoring performance. Studies tracked the spread of appropriate articulation across syllabic and phonetic contexts in untreated (Stephens, Hoffman, & Daniloff, 1986) and treated (Elbert & McReynolds, 1978) development. But these studies showed little effect of syllabic shape or phonetic context upon the development of appropriate articulation. Specifically, once most misarticulating children produce a speech sound in any syllable or phonetic context, it appears to be appropriately produced in a variety of contexts within words.

Emphasis upon the oral motor characteristics of children's misarticulation has waned over the past 25 years as cognitive theories have ascended. However, further development of theories accounting for the realization of phonological units and rules in the speech of children may ultimately require a return to the study of children's speech motor control.

Auditory-Perceptual Emphasis

Coproduction of gestures across phoneme units results in spreading the acoustic features of one phoneme into others. Thus, a particular phoneme is represented by differing acoustic features depending upon phonetic and syllabic context. However, listeners perceive the speaker's intended phonemic sequence, not the acoustic differences between a phoneme's production in one context as opposed to another. This phenomenon is referred to as categorical perception. It provided the motivation for development of the motor theory of speech perception (Lieberman & Mattingly, 1989). This theory suggested that perception of speech is not purely an auditory process. Rather, perception of phonemes is acomplished with reference to the gestures that produced the acoustic characteristics of the sounds being perceived.

Nature of the Disorder

It was considered intuitively obvious that children learn the words and phonemes of their language largely through auditory inputs. Thus, a continuing research effort has been applied to the relationship between children's misproduction of sounds and their auditory perception abilities. Researchers found that hearing impaired talkers most often correctly produced visible speech sounds (i.e., labials, labiodentals, and dentals) and those with relatively low frequency spectra (Nober, 1967). Both of these generalizations are predictable given that the importance of visual features will be enhanced relative to a poor auditory input mechanism and the fact that sensorineural hearing impairment more often affects the perception of high frequency information. Furthermore, both tendencies are similar to patterns of normal development in which the visible labials are typically acquired prior to the linguals, and the more visible alveolars are acquired before velars. The speech sounds that tend to be acquired latest (i.e., fricatives and affricates) are those associated with higher frequency spectral representations. Functional misarticulation may prove to be related to intermittent otitis media. Shriberg and Kwiatkowski (1982) found that over a third of the preschool children identified as speech delayed have histories of intermittent otitis media.

Since the 1930's researchers have been amassing evidence that there is a correlation between the number of speech sounds a child misproduced and the number they would misperceive on identification and discrimination tasks. One interpretation of this relationship was that nonstandard abstract phoneme units mediate both misperception and misproduction (Winitz, 1969). Evidence for this hypothesis is seen in the specificity of the relationship between misarticulated and misperceived phonemes. The possibility of a specific relationship between phonemes misproduced and misperceived was documented by Monnin and Huntington (1974) who found that children who misarticulated /r/ as [w] appropriately perceived other phonemic contrasts but made more perceptual errors when asked to discriminate productions of /r/ and /w/. Locke (1980) has furthered investigation into the specificity of misarticulating children's perceptual errors by demonstrating difficulties in perception of self-produced speech sounds.

A second interpretation suggested that misarticulating children did not possess adequate abilities to detect basic auditory features. In a series of studies conducted throughout the 1970's, Tallal and her coworkers (Tallal & Stark, 1981) found that children identified as language disordered evidenced difficulties in the ability to process auditory cues with rapidly changing spectral components. It was argued that such a difficulty would make all receptive language organization tasks more difficult, including organization of phonemic units.

The issue of misarticulating children's abilities to perceive phonemic and feature contrasts will receive more attention in the future as investigators seek to define the phonological concepts learned by children. Phonological concepts, such as phonemes and word forms, must be organized with respect to some perceptable attributes of spoken words.

Clinical Practice

Van Riper's (1963) prescribed stage of perceptual training prior to production practice was intended to make the child aware of the auditory characteristics of the error sound as produced by the community so that it could be compared to the child's error production. The child's ability to compare self-produced speech sounds to standard productions was to be used by the child to monitor self-produced sounds during all stages of therapy. Van Riper's suggested training for speech perception abilities related to children's misarticulation has evolved from relatively peripheral to cognitive. Van Riper focused upon discriminating the correct production of the speech sound produced in error from the child's own production of that sound, a tactic that was supported by the findings of specific relationships between sounds misarticulated and those misperceived. Later attempts to measure the efficacy of a stage of therapy devoted to speech sound discrimination suggested that it was unnecessary because production practice improved both perception and production (Williams & McReynolds, 1975). However, the ability to judge the appropriateness of one's own speech productions appears to be a crucial link in achieving lasting production changes (Koegel, Koegel, & Ingham, 1986).

Phonological Emphasis

The study of children's speech disorders has progressed from the study of peripheral causal mechanisms regarding sensory-motor and auditory-perceptual processing to higher-level cognitive processing. Throughout this time period, researchers and clinicians have rapidly adopted a series of concepts derived from theories of phonology and applied them to the study and treatment of children's disordered speech production. These concepts have included distinctive features, phonological rules, and phonological processes.

Distinctive Features

While the traditional model of articulation intervention was developing around word forms and phonemes, phonologists and phoneticians were positing different critical units of analysis. The publication of *Preliminaries to Speech Analysis* by Jakobson, Fant, and Halle (1952) spread Trubetskoy's (1939) concept of distinctive features far and wide. By positing distinctive features as the underlying phonological universal for all languages, research on perception, production, and competence focused upon feature performance and structure. Jakobson et al. (1952) proposed a set of bipolar acoustic features that were used to distinguish phonemes within a particular language. Chomsky and Halle (1968) incorporated distinctive features as abstract articulatory entities in their generative phonology. Because vocal tract shape determines its acoustic properties, the two feature sets often overlap. Distinctive features were used extensively in describing adult perceptual errors (Singh & Woods, 1971; Singh, Woods, & Becker, 1972) and children's productive development (Prather, Hedrick, & Kern, 1975).

McReynolds and Huston (1971) analyzed the multiple phoneme misarticulations of a group of children, demonstrating that their errors could be described more compactly using a bipolar feature system than through the use of a traditional phonemic analysis. This was a formalized version of the feature analysis suggested by Van Riper (1963). These investigators proposed a theoretical distinction between *phonetic* problems in which a feature specification was never produced and *phonological* problems in which all feature specifications were produced. This distinction represented a refinement of the earlier organic-functional division, with functional misarticulation now defined as a mislearning of part of the phonology of the parent language. It also moved the description of children's speech production disorders into the cognitive domain inasmuch as the phoneme is thought to be a cognitive organizational unit.

Early attempts to utilize distinctive features in clinical assessment procedures resulted in unwieldy counts of the percentage of correct feature use (McReynolds & Engmann, 1975). Furthermore, it was rapidly appreciated that a feature could not be taught without the use of a phoneme-sized rehearsal unit. As a result, the proposed feature analysis required the clinician to procede from phonemic substitution analysis to the feature level and back before therapy was planned.

The rising viewpoint that development of phonemic contrast arose from refining feature contrasts offered an explanation for the generalization of training (a concept derived from behavioral learning paradigms) that occurred when a child was taught to produce one speech sound and apparently learned other speech sounds that were related at the feature level of

analysis (Elbert, Shelton, & Arndt, 1967). In order to target distinctive features in therapy, clinicians have taken a number of different approaches based upon traditional therapy. The most traditional approach targets production of a particular phoneme that is affected by the missing feature contrast (Hodson & Paden, 1983). A second approach involves simultaneously practicing the production of two phonemes whose phonetic differences are neutralized by the missing feature distinction (Costello & Onstine, 1976). A third teaches the feature contrast using contrastive phonemes within minimal pair words (Weiner, 1981). A fourth seeks to teach multiple feature contrasts by teaching word pairs with consonant contrasts involving many features (Geirut, 1989).

Phonological Rules

Chomsky and Halle (1968) had not only proposed a set of distinctive features, they also sought to write a rule system that would mediate between underlying representations of morphemes and their surface representations. The intention of these phonological rules was to account for the different pronunciations of a morpheme in different utterances. For example, these rules would account for the vowel shifts that occur in production of the morpheme "Canada" when it is produced in the word "Canadian." A major thrust of this line of thought was to determine the phonological forms of abstract morpheme units and the phonological rules that a speaker of a language must deduce to convert those underlying forms to surface forms. Inasmuch as there are at least two unknown quantities in this pursuit (i.e., the underlying forms and the rules), generative phonologists proposed formalistic standards for choosing optimal descriptions of phonological knowledge (e.g., keeping the number of rules to a minimum).

Compton (1970) was first to apply this concept to the description of children's functional misarticulation. Recently, inconsistency of morpheme production has been used to distinguish different types of phonological rules in children's misarticulation (Elbert, Dinnsen, & Weismer, 1984). If a morpheme was produced correctly sometimes, it was thought that the underlying morpheme was adultlike, but that a phonological rule was applied to change its production characteristics in some contexts. If a morpheme was never correctly produced, a phonotactic constraint was thought to be acting to affect the underlying form of the morpheme. These phonotactic constraints refered to the child's phonetic inventory (i.e., sounds that the child never produces), phonemic inventory (i.e., sounds that the child does not use to contrast morpheme meaning), and sequential constraints (i.e., restrictions upon the use of a phoneme with respect to word position). Thus, the concept of inconsistency of phoneme production that was incorporated in the sensory-motoric viewpoint has evolved into a inconsistency of morpheme production at the phonological level.

Treatment studies conducted within this framework have found that children who inconsistently produce morphemes containing a problem phoneme are better able to learn from therapy experiences targeting production of syllables (Elbert, et al., 1984). However, studies also have shown that teaching focused upon phonotactic constraints and phonologically less marked phonemes may produce more extensive change in the child's speech production (Elbert & Geirut, 1986). Thus, this framework has resulted in reversing the typical order of targeting speech sounds for treatment. Within the motoric framework, sounds that normally are developed earlier were the first targets; within this framework, later developing sounds (i.e., phonologically less marked) are targeted first. Within the motoric framework, sounds that were misarticulated inconsistently were targeted first; within this framework, sounds and word shapes that are never produced correctly are targted first.

Phonological Processes

Stampe (1969) proposed that "natural" rather than formal criteria should be used to determine an optimal phonological description of a language. In part, his natural criteria were based upon children's development of sound production. He suggested that common error patterns constituted phonological processes that exist as mental strategies used to cope with developing vocal tract ability. These strategies were not thought to be learned, as were the phonological rules of the generative phonological viewpoint. Rather, processes were thought to be eliminated as a way of fostering development. Natural phonology's use of child development data, typical patterns of children's misarticulations, and its allusion to motoric constraints made it an appealing theoretical framework for speech-language pathologists.

Ingram (1976) provided the spark that focused attention upon phonological processes for the explanation of children's misarticulation of many phonemes. Compared to distinctive feature notation, phonological processes provided a simpler system for detailing syllabic level patterns of misarticulation as well as feature substitutions and assimilations. Descriptive research has shown that certain patterns, particularly those that delete segments, are indicative of disordered development (Hodson & Paden, 1981; Renfrew, 1966). Furthermore, children whose speech is characterized by such deletions tend to show disordered development of higher levels of language organization as well (Panagos, 1974; Smit & Bernthal, 1983).

The primary theoretical argument regarding the use of phonological processes compared to phonological rules revolves around the child's underlying knowledge of word or

morpheme forms. The wholesale use of phonological process rules assumes that the child knows the adult form of a word prior to deleting segments or syllables, or changing one segment into another.

The assessment of young children's misarticulations incorporated phonological processes in a number of traditional formats. The picture articulation test was restructured to measure the percentage of occurrence of phonological processes rather than the percentage of use of phonemes (Weiner, 1979). Forms were developed to make phonological process analyses using standardized picture articulation tests (Lowe, 1986). Detailed procedures were published to make phonological process analyses of conversational speech samples (Shriberg & Kwiatkowski, 1980). Suggested treatment strategies focused upon treatment of the phonological patterns. One approach involves teaching the child to perceive and produce minimally different pairs of words that would be produced identically because of the child's error pattern (Weiner, 1981). An alternative approach teaches perception and production of phonemes that are affected by the pattern of misarticulation (Hodson & Paden, 1983). This strategy can be used with one phoneme target at a time or multiple phoneme targets (Elbert & Gierut, 1986).

Researchers working within the phonological process framework have used receptive and expressive activities to treat process errors, measuring generalization to untreated phonemes or syllabic shapes that should also be affected by the process error (Weiner, 1981). Such studies virtually all show incomplete generalization predicted from the process error pattern targeted. For example, treating the production of reduced consonant clusters generalizes more to consonant clusters containing the particular phonemes used in training than to other clusters (McReynolds & Elbert, 1981).

An Integrated Future?

Over the past 25 years research and clinical practice regarding children's speech production errors have evolved from using peripheral to cognitive mechanisms. Linguistic descriptive devices have been used to describe what the child has learned, or failed to learn. But the rule-like nature of the linguistic devices raises serious questions about how that learning occurred. A description suggesting that preschool children create and test hypotheses (Macken & Ferguson, 1983) about the underlying structure of English phonological morpheme shapes and rules is contradicted by the nature of children's language development. During the preschool years, children develop language as a conversational tool within social interchanges. They do not learn to develop the ability to metalinguistically discuss language until the school years (Nelson, 1985). Thus, a more automatic learning process is apparently necessary. Clinical practice often has utilized behavior modification techniques as a means of structuring teaching without asking the child to use metalinguistic processing. Perhaps these various viewpoints will be brought together in the future as investigators and clinicians apply the newly emerging variety of cognitive models.

One promising appraoch appeared in the Parallel Distributed Processing model of cognition (Rumelhart, McClelland, & PDP Research Group, 1986). Rather than suggesting that language is a system of rules that generate objects such as sentences, phrases, or morphemes, this model suggests that language structure exists as cognitive patterns that result from sensory input and motoric output interactions (Hoffman & Norris, 1989; Hoffman, Schuckers, & Daniloff, 1989). The use of sensory patterns as a base allows for a melding of the sensory-motoric and cognitive-linguistic research approaches. Learning occurs because each time an event is experienced, its sensory characteristics are interconnected, forming a pattern. The more often an object or action is experienced, the more strongly related the sensory patterns become, forming concepts. Novel actions and objects are first part of routines in which they occur. As an object or action is experienced in many different routines, a concept representing the object or action is parsed out of the routines. The concepts then are triggered by stimulus inputs and by internal processing as related concepts are activated. As new sensory patterns are encountered they trigger old patterns while laying down the beginnings of a new pattern that interacts with the old.

Phonological development is seen as an integral part of social-communicative development in which large units are parsed into smaller conceptual units (Nelson, 1985). For example, in the course of a mother-child eating routine, the mother may say, "mommy loves you ... open your mouth for mommy ... do you want mommy to take a bite?" The auditory-visual feature complex representative of the spoken event [mami] is simultaneously activated in the child's cognitive system with the sensations of the whole event of eating. Development of connections between the auditory-visual [mami] and the child's speech motor system result in the child's production of the word in her presence within this event. Eventually, [mami] parses out of this particular event as it is sensed and output in many different daily routines, such as shopping, bathing, and riding in the car. The earliest word forms include speech gestures for which patterns already exist, that is, the sounds that were babbled (Locke, 1983; Oller, Weiman, Doyle, & Ross, 1975). The first word productions will be processed as whole units that will later be parsed into phoneme units (Ferguson & Farwell, 1975). Learning of phonemes and syllable shapes is driven by the need to be communicative. While shopping, the child may need to distinguish between the words [mami] and [mʌni]. The child's first attempt at the new word will likely result in activation of

the pattern for [mami]. When this production causes a miscommunication, the child will receive inputs that adjust the connections for the new word form and the phonemic contrast between /m/ and /n/ (e.g., "No dear, you can't give the lady your mommy, give her your money.").

Inasmuch as this type of model characterizes phonological knowledge as integrally related to all levels of cognition and language, it would seem natural that treatment of children's speech disorders will meld into treatment for language disorders. In this regard, we may find a return to the treatment of what Van Riper (1963) called the speech delayed child. Support for this notion is found in the descriptive research showing that young, phonologically-disordered children show higher level language organization problems, and that these children adjust their speech production in order to be understood better during actual communication (Campbell & Shriberg, 1983; Weiner & Ostrowski, 1978). Initial treatment studies (Hoffman, Norris, & Monjure, 1990; Matheny & Panagos, 1978) suggest that a focus on higher levels of language production increases children's articulatory abilities as well. As language therapy has begun to move away from behavior modification strategies targeted at discrete aspects of language knowledge toward the use of more natural conversation (Norris & Hoffman, 1990), treatment of children's speech sound production errors may well follow suit (Hoffman, Schuckers, & Daniloff, 1989).

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