Linguistic Foundations of Language Teaching: Phonology

Fondement linguistique de l'enseignement du langage: la phonologie

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Résumé

Trois questions fondamentales à la théorie linguistique sont présentées par rapport à leur relation avec les troubles phonologiques chez les enfants. La recherche expérimentale à l'origine de ces débats linguistiques est discutée afin de mieux comprendre comment les enfants apprennent les distinctions phonétiques, les distinctions phonémiques et comment ils organisent l'information phonologique dans leur lexique mental. Sur la base de cette recherche, des principes linguistiques ont évolué pour donner lieu à des applications cliniques visant à structurer les programmes d'intervention et à prédire le progrès phonologique.

Abstract

Three basic questions of linguistic theory are addressed as they relate to phonological disorders in children. Experimental clinical research that has appealed to these linguistic concerns is discussed in understanding how children learn phonetic distinctions, how they learn phonemic distinctions, and how they organize phonological information in their mental lexicon. From this research, linguistic principles arise for clinical application in structuring intervention programs and in predicting phonological change.

Linguistic Foundations of Language Teaching

As teachers of language, speech-language pathologists have a fundamental responsibility to understand the very nature and structure of human language itself. To teach language, we must know about language. Teaching a child about the ambient language system would be an unguided, if not impossible task if language teachers knew little or nothing about the composition, structure, or function of that which was being taught. For teachers of language, then, it is necessary to be familiar with answers to such basic linguistic questions as: What constitutes a possible language? What is the range of variation in language? How does language restructure and change? Here, the term *language* is used in its most general sense including both phonology and syntax and encompassing fully developed primary systems such as English or French, interlanguage systems of speakers acquiring a second language, developing systems of young children, and even systems of children characterized as having speech and language disorders.[1]

How can the answers to such linguistic questions aid the speech-language pathologist? First, knowledge of those properties that define potential language systems will lead to more accurate evaluations of the differences in the language systems of those with speech and language disorders. Further, an understanding of how these properties function or pattern in languages of the world will provide guidelines for structuring effective intervention programs that afford the learner opportunities to modify these differences in his or her own linguistic system. Finally, information about the nature and extent of change in language systems will serve as a framework for evaluating effectiveness of intervention programs. Thus, teachers of language can use the basic structure of language itself to provide a framework for assessment, to motivate clinical treatment programs, and to account for subsequent language learning and change.

All linguistic theories involve a hierarchical structure of distinct yet interacting units that combine to form what we know to be language. For the phonological aspect of language, in particular, linguists focus on sounds and their analyzability into distinctive features, phonemes and their use in contrasting meaning, and morphemes and their representation in the mental lexicon. Phonological theory is specifically concerned with three basic questions about language:

1 The term *disorder* is used herein in its most neutral sense, referring to that population of clinical interest with phonological and/or syntactic systems that are different from that of the surrounding speech community.

(1) What are the basic structural properties that distinguish among sounds? Or, how do sounds differ from one another in the phonetic inventory?

(2) Of those structural properties that differentiate sounds, which are used to distinguish meaning? Or, what is the function and distribution of sounds in the phonemic inventory?

(3) How are these functional properties that distinguish meaning organized in the representation of morphemes in the mental lexicon? Or, what must a speaker know about the structural and functional properties of the sound system in order to relate form and meaning?

To answer these questions, two linguistic assumptions about the autonomy and continuity of language must be considered. First, certain properties of sound systems, patterns of sound production, and sequences of sound acquisition result purely for linguistic reasons (Anderson, 1981; Chomsky, 1980, 1982; Labov, 1981, 1987). Language is an entity in and of itself; the systematicity observed in language is due to language principles. Language is not an instantiation of motor abilities or a subset of cognition. Language does not follow from any other mental or behavioral source. This view of language is structural in character and is consistent with, for example, with the research of Chomsky (1980, 1982) in theoretical linguistics, Labov (1981, 1987) in historical linguistics and sociolinguistics, Greenberg (1979) in typological universals, Eckman (1981) in second language acquisition, and Dinnsen (1989) in speech disorders. (For competing functional perspectives of language, see Dirven & Fried, 1987; Grossman, San, & Vance, 1975).

This autonomous view of language gives rise to the second assumption that places speech and language disorders in the larger picture of language systems. In accepting that certain independent elements compose language, children clinically classified as having phonological disorders cannot be considered *deviant* or *delayed* language users (Dinnsen, in press; Dinnsen, Chin, Elbert, & Powell, 1990). These children simply have a different language system. It is true that this different language system varies from the idealized version used by a majority of speakers in the surrounding speech community. However, the properties of this system resemble, in all ways and at all points in time, those properties that define languages in general. The principles that capture language also shape disordered systems.

The purpose of this paper is to address the three basic questions of linguistic theory as they relate to phonological disorders in children. One aspect of each question will be examined by discussing experimental clinical research that has appealed to these linguistic concerns in order to understand how children learn phonetic and phonemic distinctions and how they organize phonological information in their mental lexicon. The results of this research delineate a set of essential clinical principles for application in structuring linguistically-based intervention programs and in predicting linguistically-motivated phonological change.

On Learning Phonetic Distinctions

One goal of linguistic theory is to describe the basic structure of language or to determine those properties which necessarily constitute a possible language. For phonology, in particular, the aim is to identify universal patterns of sound systems. Language universals are statements that offer generalizations about the occurrence and frequency of specific sounds and the cooccurrence of certain segments in languages of the world. The natural groupings of sounds associated with universals provide an account of the consistency observed across phonological systems.

One specific type of language universal is the typological or implicational universal. *Implicational universals* state that the occurrence of a specific sound X in a language implies necessarily the occurrence of another sound Y in that same language, but not vice versa. The implying sound, X, is called the marked segment, and the implied sound, Y, is unmarked. Some examples of implicational laws (cf. Jakobson, 1941/1968) shown to hold across language systems include:

(1) The presence of voiced obstruents implies the presence of voiceless obstruents, but not vice versa.

(2) The presence of fricatives implies the presence of stops, but not vice versa.

(3) The presence of aspirated stops implies the presence of unaspirated stops, but not vice versa.

(4) The presence of mid vowels implies the presence of high vowels, but not vice versa.

Implicational universals have been used in the formulation of phonological rules (Houlihan & Iverson, 1979), in assessments of phonological systems (Eckman, 1977), and in accounts of patterns of acquisition (Ferguson, 1977, 1989; Pinker, 1989). With regard to acquisition, sounds that are typologically more marked are presumably more difficult to learn; hence, they occur later in development, and fewer fully developed primary languages have these sounds in their phonetic inventories. Unmarked sounds, on the other hand, are easier to learn, acquired relatively early, and occur more frequently. Thus, if a language has segments in its inventory that are more difficult to learn, that language also will have sounds that are easier to learn.

These predictions about phonetic acquisition and learning associated with implicational universals are relevant to teaching and clinical intervention. Given the unidirectionality of implicational laws, it should be the case that when more marked (difficult) segments are taught, a child will learn both marked and unmarked sounds (Dinnsen & Elbert, 1984). If, on the other hand, unmarked (easy) segments are taught, a child will only learn unmarked sounds, without a necessary change in marked members. To date, three intervention studies have substantiated these predictions for speech disordered populations. In one study, McReynolds and Jetzke (1986) found that teaching hearing impaired children voiced stops resulted in their learning both voiced and voiceless stops; other hearing impaired children who were taught voiceless stops only learned these voiceless sounds. Here, teaching more marked voiced sounds facilitated acquisition of unmarked voiceless sounds, but not the reverse. In another study, Dinnsen and Elbert (1984) reported that phonologically disordered children who were taught fricatives improved their production of both fricatives and stops, but those who were taught stops only improved in production of stops. Thus, fricatives enhanced the learnability of stops, but not vice versa. Finally, Elbert, Dinnsen, and Powell (1984) observed that treatment of more marked fricative + liquid clusters (e.g., /sl/) resulted not only in changes in these clusters, but also in changes to unmarked stop + liquid clusters (e.g., /bl/). Conversely, children who were taught unmarked stop + liquid clusters did not show gains in marked clusters. Importantly, these three studies support the applicability of implicational universals to speech disordered populations and provide evidence that sequences of acquisition predicted by universals seem to hold. One implication is that clinical intervention programs can be structured consistent with language universals and that learning following such intervention will follow an expected course. (For further experimental validation of these points, see Eckman, 1977, 1985; Eckman, Moravcsik, & Wirth, 1989; Gass, 1979; Hawkins, 1987; Hyltenstam, 1984.)

Most recently, the study of phonologically disordered children has motivated the identification of a new typological universal (Dinnsen et al., 1990). Dinnsen and colleagues examined the phonetic inventories of 40 children with functional speech disorders in an attempt to identify patterns of sound production in this population. Perhaps, as with fully developed language systems, the phonologies of this group would follow consistent or universal patterns such that there would be limits on the characteristics of disordered sound systems and boundaries on the range of variation within such systems. In a first pass, examinations of the number and type of sounds in the children's phonetic inventories did not lead to generalizations about the nature of their language systems. However, when the focus of research moved away from specific sounds to higher order linguistic descriptions characterized by distinctive features, consistencies across the phonetic inventories were captured. Specifically, by using the Chomsky-Halle (1968) feature system, five independent types of phonetic inventories were identified for phonologically disordered children.[2] These are shown in Table 1.

The inventories ranged from the most simple (Level A) to the most complex (Level E) by the necessary addition of progressively more feature characteristics. Specifically, the simplest or most limited phonetic inventory (Level A) included nasals, glides, and stops, with only a labial-alveolar place distinction among the stops. The occurrence of these sounds in the phonetic inventory is characterized by only a few feature distinctions: (1) consonants are differentiated from glides by the feature [consonantal]; (2) for consonants, obstruent stops are differentiated from nasal stops by the feature [sonorant]; and (3) among the obstruent stops, labials are differentiated from alveolars by the feature [coronal].

The next most complex inventory (Level B) included both voiced and voiceless stops. The occurrence of these additional sounds to the inventory is characterized by all of the feature distinctions of Level A inventories plus the unique [voice] distinction. (In some cases, there was also an optional place of articulation contrast, with the addition of [k] and/or [g] to the inventory. This optional contrast is characterized by the feature [anterior]. For a further discussion of place of articulation distinctions, see Dinnsen, 1989; Dinnsen, Chin, & Elbert, 1989).

Advancing in complexity, Level C inventories included the occurrence of fricatives and/or affricates. This type of phonetic inventory is characterized by all of the distinctions of Level A, plus those of Level B, plus the new features [continuant], to describe the occurrence of fricatives, and/or [delayed release], to describe the occurrence of affricates.

Level D inventories incorporated a liquid consonant, either [r] or [l]. The occurrence of these sounds in the inventory

2 The Chomsky-Halle feature system was specifically used because it meets the four criteria of an adequate feature system as outlined by Kenstowicz and Kisseberth (1979: 241-242). The two criteria of most importance to this research are that this particular feature system appropriately describes both the phonetically and phonemically possible sounds of language and, at the same time, it excludes those sounds that are phonetically and phonemically impossible.

Table 1. Implicational Hierarchy of Phonetic Features Ranging from Simple (Level A) to Complex (Level E).

Level	Contrastive Features	Example Inventories			
A	[syllabic]	4:	b	d	
	[consonantal]		m	n	ŋ
	[sonorant]		w	j	ʔ h
	[coronal]				
B	[voice]	26:	pb	td	kg
			m	n	ŋ
			w	j	ʔ h
C	[continuant]	1) 13:	pb	td	kg
	[delayed release]		fv		
			m	n	ŋ
			w	j	ʔ h
		2) 8:	pb	td	kg
			fv	szʃ	
			t͡s	d͡z tʃ dʒ	
			m	n	ŋ
			w	j	ʔ h
D	[nasal]	1) 15:	pb	td	kg
			fv θð	ʃ	
				tʃ dʒ	
			m	n	ŋ
				l	
			w	j	ʔ h
		2) 11:	pb	td	kg
				tʃ dʒ	
			m	n	ŋ
				r	
			w	j	
E	[strident]	1) 39:	pb	td	kg
	[lateral]		fv θð	sz	ʃ
				tʃ dʒ	
			m	n	ŋ
				l	
			w	j	ʔ h
		2) 17:	pb	td	kg
			fv	sz	ʃ
				t͡s	tʃ dʒ
			m	n	ŋ
				lr	
			w	j	ʔ
		3) 34:	pb	td	
				fv θð sz	
				t͡s d͡z	
			m	n	
				l	
			w	j	ʔ

Note: Adapted from Dinnsen et al., (1990). The presence of feature distinctions characteristic of a given level of phonetic complexity implies the presence of all other feature distinctions characteristic of simpler levels of complexity. Examples of phonetic inventories characteristic of each level of complexity are provided.

is characterized by the feature distinctions of Levels A through C with the added feature [nasal]. In all less complex inventories, the only sonorant consonants that occurred were always and only nasals (glides are sonorants, but nonconsonants). The feature distinction [nasal] was critical to Level D inventories because, now, sonorant consonants were both nasal (i.e., nasals) and nonnasal (i.e., liquids). Thus, a feature distinction among sonorant consonants was necessary.

The most complex type of phonetic inventory is Level E. Inventories of this type consist of either a stridency distinction among fricatives, as in the occurrence of both [s] and [θ], and/or a laterality distinction among liquids, as in the occurrence of both [l] and [r]. All less complex feature distinctions of Levels A, B, C, and D are relevant to the characterization of Level E inventories along with the features [strident] and/or [lateral].

Importantly, the phonetic inventories of all 40 phonologically disordered children were consistent with one of these levels of phonetic complexity. That is, each child's phonetic inventory was assigned uniquely to one of the five levels. Moreover, following clinical treatment, the post-treatment inventories of these children were still consistent with the typological hierarchy, regardless of the specific sounds that were taught (Dinnsen et al., 1989). A further observation was that these categories also provided a framework for characterizing the phonetic inventories of both normally developing young children and fully developed primary languages (Dinnsen, 1989). Thus the sound patterns of these populations were consistent with the typology of phonetic inventories for phonologically disordered children.

The implication of these findings is that all language systems, regardless of their nature or origin, are highly constrained in phonetic structure. Sound systems can only be constructed and elaborated in very limited and precise ways. Like other typological universals, then, the sequence of phonetic complexity provides an explanatory account of the presence and use of certain phonological structures in language (Dinnsen, 1989; see also Comrie, 1981; Givón, 1979; Greenberg, 1979; Hawkins, 1983, 1985; and Keenan, 1978, on the explanatory nature of language universals). The sequence is explanatory because it offers hypotheses that make predictions, that are testable and, importantly, that are also theory-neutral. That is, any theory of language has to appeal to and account for the systematicities captured by language universals.

The implicational relationship associated with the typology of phonetic inventories also has applications for clinical intervention. It is clear that there is a hierarchical relationship among the various levels of phonetic complexity such that Level E distinctions imply the occurrence of Level D distinctions which, in turn, imply the occurrence of Level C distinctions and so on. As with other implicational universals, this typology is unidirectional. The presence of more complex distinctions implies the presence of less complex distinctions, but not vice versa. Thus, Level E inventories are considered more marked and presumably most difficult to acquire; whereas, Level A inventories are least marked and easiest to acquire. For clinical intervention, then, teaching more marked or more complex phonetic distinctions should result in the occurrence of both marked and unmarked distinctions; the reverse, however, should not be true. To illustrate, consider a child who exhibits a phonetic inventory characterized by Level C complexity. If this child was taught to elaborate his or her phonetic inventory from Level C to Level E complexity, by necessity, he or she also would learn Level D distinctions without direct instruction (Dinnsen et al., 1989). The typology predicts that the more complex Level E implies less complex Levels D and C. In contrast, if this same child were taught to expand his or her inventory from Level C to Level D, then only Level D distinctions would be learned. The typology predicts that Level D implies Level C, but Level D does not also imply Level E.

Thus, the linguistic principle for clinical treatment that derives from an understanding of typological universals or implicational laws is: Teach the most marked aspects of production. In these cases, unmarked aspects will be gained without direct instruction. For phonetic inventories, in particular, treatment of the Level E distinctions of stridency (i.e., [s] versus [θ]) or laterality (i.e., [l] versus [r]) likely will lead a child to experience the greatest expansion of his or her phonetic repertoire.

On Learning Phonemic Distinctions

A second goal of linguistic theory is to describe the functional units of language. For the study of phonological systems, the aim is to identify the contrastive elements or phonological oppositions of a language. Phonological oppositions refer to that feature or set of features that uniquely distinguishes one phoneme from another in a language (Sommerstein, 1977). For example, the feature [voice] distinguishes the phonemes /p/ and /b/, whereas the feature [coronal] distinguishes the phonemes /p/ and /t/ (cf. Chomsky & Halle, 1968). Phonological oppositions are central to linguistic theory in that they support the analyzability of sounds into component parts. Phonological oppositions also are essential to any rule-governed description of natural languages.

Importantly, phonological oppositions are not to be confused with minimal pairs. Minimal pairs are simply sets of words that differ by only one sound (Crystal, 1985), as in the examples *bat-pat* or *mink-think*. Although each of these sets of words conforms to the definition of a minimal pair, the sets are different in terms of distinctive oppositions. The former pair, *bat-pat*, is distinguished by a single opposition: [voice]. This pair shares many common features, unique by only one. In comparison, the latter pair, *mink-think*, is distinguished by multiple oppositions: [sonorant], [coronal], [voice], [continuant], [nasal]. This pair shares relatively few features in common. Thus, minimal pairs may be minimally opposed, differentiated by few unique features, or maximally opposed, differentiated by multiple unique features.

This notion of minimal and maximal oppositions associated with minimal pairs has raised important linguistic questions about the nature of phonological acquisition and learning. In particular, two competing hypotheses have been advanced. The first hypothesis suggests that minimal oppositions will be relatively easy for a child to acquire (Archangeli, 1988; Trubetzkoy, 1958/1969). Presumably, few unique features would have to be learned, and these would be highly recognizable and identifiable in given sound or word pairs. A second hypothesis suggests that minimal oppositions will be relatively more difficult to acquire (Mester & Itô, 1989). Although a child would only have to learn a few new distinctions, these would be repeatedly distributed throughout the language (i.e., *proportional* following Trubetzkoy, 1958/1969). This alternate hypothesis goes on to propose that maximal oppositions, on the other hand, would present a child with many more unique distinctions to discover, but these would be easy to recognize and identify from all other sound pairs in the language.

An example serves to illustrate these two hypotheses. Consider the minimal opposition /p/-/b/, sharing a single distinctive feature, [voice]. The first hypothesis would predict that it would be relatively easy for a child to differentiate between these sounds because there is only one unique feature to be learned. The second hypothesis would agree that this opposition would be easy to learn; however, once learned, the child would encounter difficulty because there are other sound pairs in the language that also share this [voice] distinction (e.g., /t/-/d/, /f/-/v/, /s/-/z/, and so on). Apparently, the child would have trouble differentiating among these different sound pairs, all with contrastive voicing. The second hypothesis further predicts that maximal oppositions avoid precisely this problem. When presented with a maximal opposition such as /tʃ/-/m/, the child would have many unique features to discover, including [sonorant], [nasal], [voice], [anterior], [coronal], [delayed release], and [strident]. However, once learned, no other sound pair in English would share exactly these same contrastive elements. This sound pair then would be uniquely distinguished from all others in the language. Thus, the two hypotheses offer opposing perspectives on phonemic learning. For minimal oppositions,

Table 2. Changes in Treated and Untreated Sounds under Conditions of Minimal versus Maximal Opposition Treatments.

	Changes in Treated Sounds (% of accuracy achieved on the final probe)		Changes in Untreated Sounds (Number of new sounds added to the inventory)	
	Maximal Opposition Treatment	Minimal Opposition Treatment	Maximal Opposition Treatment	Minimal Opposition Treatment
Child 1	43	14	2	1
Child 2	57	33	3	0
Child 3	86	86	1	0

learning parts of the whole sound system is predictably easy; whereas, for maximal oppositions, learning the parts may be more difficult, but how these parts integrate into the whole is presumably easy.

From a clinical perspective, these hypotheses have implications for phonological intervention. The hypotheses are especially important because both minimal and maximal oppositions have been used to structure treatment programs. One commonly used clinical paradigm involves presenting a child with two minimally opposed sounds for contrast: the desired target versus its corresponding error production from the child's grammar (i.e., conventional minimal pair treatment; Ferrier & Davis, 1973; Weiner, 1981). By pairing the adult and child sound systems in this way, the treatment is intended to illustrate to the child that any collapses of distinctions will result in confusions in communication. The child's attention is directly focused on potential instances of homonymy in his or her own system, and these typically involve a few (minimal) feature differences. A second intervention paradigm, introduced more recently, involves comparing two maximally opposed sounds: the desired target versus a sound that is always produced and used correctly in the child's existing sound system (i.e., maximal opposition treatment; Gierut, 1989). The intent here is to demonstrate that the contrasting sounds hold equal status in the phonological system; that is, they both are phonemes. The child must discover and choose the relevant features of contrast and then must identify the appropriate contexts in which to use these newly learned distinctions. By default, homonymy is reduced, since new phonemes are added to the sound system. Both treatment methods ultimately have the same goals of increasing phonemic distinctions and decreasing phonemic collapse, but the processes a child apparently goes through to reach these goals may be different.

As a first attempt to understand these processes and as a test of the alternate accounts of phonemic learning, children's phonological learning following minimal versus maximal opposition treatments has been evaluated (Gierut, 1990). Three four-year-old children participated in a single-subject experimental study involving a complex alternating treatments design (Barlow & Hayes, 1979; Brady & Smouse, 1978; Kazdin & Hartmann, 1978). This design allows for comparisons of the relative effectiveness of treatments within-subject. The design exposes a child to two or more forms of treatment in rapid succession. Presumably, a child differentiates between the treatments and thereby responds differentially on independent probes associated with each of the different methods (see Ellis Weismer & Murray-Branch, 1989; and Thompson & McReynolds, 1986, for applications of this design to communication disorders).

In this particular study, each child excluded a minimum of six sounds from his phonetic and phonemic inventories (i.e., 0% baselines for these targets). Of these, two unique sound pairs were identified for treatment for each child. One pair included a target sound minimally opposed to its corresponding error from the child's grammar (e.g., substitute); the other pair included a target sound maximally opposed to a sound produced correctly in the child's grammar. First a child was exposed to one treatment (and hence its associated sound pair) followed by a 10-min nonspeech-related activity; then the child was exposed to the second treatment (and its associated sound pair). Order of treatment was varied randomly across sessions, and treatment proceeded in two phases: (1) imitation of a given sound pair with 75% accuracy over two consecutive sessions secondary to one of the treatment methods, and (2) spontaneous production of a given sound pair with 90% accuracy over three consecutive sessions secondary to one of the treatment methods. Sound pairs were taught in the context of a nonsense word story-telling procedure (cf. Leonard, Schwartz, Folger, & Wilcox, 1978). Two independent probes associated with each treatment method were administered periodically to evaluate the acquisition of sounds not included in the child's pretreatment inventory.

Results of treatment were examined in two ways: changes in treated sounds and changes in untreated sounds. Changes in treated sounds were measured in several ways;

however, for purposes of this discussion, only probe performances relative to percentage of accuracy achieved on the final probe in each of the two treatment conditions are considered (cf. Winner & Elbert, 1988). Changes in untreated sounds were measured by considering the number of new sounds added to a child's inventory post-treatment using a minimum 10% mean difference score (cf. Elbert et al., 1984).

As displayed in Table 2, greater improvements in treated sounds were observed under conditions of maximal opposition treatment for Children 1 and 2. Similar changes were observed for untreated sounds, such that more new sounds were added to the inventory following treatment of maximal oppositions. Child 3 presented a slightly different pattern of learning. For this child, more untreated sounds were added to the post-treatment inventory following maximal contrast treatment, consistent with the learning patterns of Children 1 and 2. However, for treated sounds, Child 3 showed essentially equivalent learning of minimal and maximal contrasts. These findings support a conservative statement that maximal opposition treatment is at least as good, if not better, than minimal opposition treatment in changing both treated and untreated sounds.

The individual differences of Child 3 raised several questions. In particular, what factors could have accounted for the differences observed in Child 3's learning of treated sounds? What was it about the nature of the treated oppositions or, more generally, about the nature of language itself that contributed to these individual differences? A close examination of treated sounds revealed that not only the number of phonological distinctions — minimal versus maximal — but also the type of distinctions — major class versus nonmajor class — played a role in phonemic learning. Major class distinctions refer to three higher order features — [sonorant], [syllabic], and [consonantal] — that uniquely interact to distinguish the natural groupings of sounds in language (Chomsky & Halle, 1968). Together, these three features sort out nasals and liquids from obstruents, glides, and vowels, as displayed in the following:

	[consonantal]	[sonorant]	[syllabic]
Obstruents (i.e., stops, fricatives, affricates)	+	-	-
Liquids and nasals	+	+	-
Glides	-	+	-
Vowels	-	+	+

All other features that differentiate among particular sounds or sound classes are considered nonmajor class distinctions.

It is precisely this major/nonmajor class division that appeared to affect Child 3's learning. For this child, a nonmajor class distinction was taught during maximal opposition treatment, that is, a stop versus a fricative. Children 1 and 2, on the other hand, were taught major class differences in this same maximal treatment condition, that is, an obstruent versus a sonorant. It appears that, for maximal oppositions, major class differences had a differential impact on phonological learning, while nonmajor class differences did not. This finding is important because it provides behavioral evidence that higher order features are both structurally and functionally more important than lower order features, as would be predicted by linguistic theory (Clements & Keyser, 1983).

Together, the results of this study indicated a differential course of learning minimal versus maximal oppositions and major versus nonmajor class distinctions. Maximal oppositions enhanced acquisition of treated and untreated sounds to a greater degree than minimal oppositions. Furthermore, targeting major class distinctions resulted in greater phonological change than did nonmajor class differences. With regard to the acquisition of phonemic distinctions, the findings support the hypothesis that discovery of multiple features, distinct from all other contrasts of a language, will be easier for a child to learn than a few features distributed repeatedly throughout the language (Gierut, 1990).

Thus, the linguistic principle for clinical intervention that results from an understanding of the contrastive aspects of language is: *Teach sound pairs that involve maximal oppositions and major class distinctions.* If children are taught sounds that differ by many features, more widespread improvements in the phonological system are likely to be observed. Moreover, if these multiple features also involve a higher order contrast, for instance, the difference between stops and liquids, nasals and glides, or liquids and affricates, phonological learning will be enhanced. When combined, the two components of maximal opposition and major class distinction are expected to result in greater changes in the sound system during treatment.

On the Organization of Phonological Information in the Mental Lexicon

A third goal of linguistic theory is to discover what knowledge a person must have in order to speak a particular language and, further, what form this linguistic knowledge must take. The linguist is concerned with constructing grammars of language. A grammar is a speaker's unconscious knowledge of language that guides or governs his or her conscious use of language. A grammar is language competence that allows for accurate language performance. A grammar consists of principles of word and sentence formation that permit the construction of novel utterances.

For phonology, a grammar describes a speaker's unique productive phonological knowledge. *Phonological knowl-*

edge refers to the idiosyncratic and unpredictable aspects of language that are learned and stored in the mental lexicon, along with the predictable rules that associate sound to meaning (Chomsky & Halle, 1968). On the one hand, phonological knowledge is unpredictable because there are no a priori reasons why particular segments and segment sequences are associated with specific morphemes. There is no reason, for example, that the morpheme *dog* should consist of three segments, that the first segment should be a voiced alveolar stop, or that the word shape should conform to a consonant-vowel-consonant sequence. Phonological knowledge is also idiosyncratic because different languages use different sound combinations to signal the same meaning. Continuing the example, the realization of the morpheme [dɔg] *dog* is peculiar to English; other languages use other sounds and sound combinations such as [ʃ j ɛ̃] *chien* (French), [perro] *perro* (Spanish), [kane] *cane* (Italian), [hʊnt] *hund* (German), and [kou] *góu* (Mandarin). Because certain aspects of production are idiosyncratic and unpredictable, every speaker of a language must learn and store these unique morphemes in his or her own mental lexicon for later retrieval and use. Thus, English speakers must learn all of the phonological (as well as semantic and syntactic) information associated with the morpheme *dog*, and this information constitutes a part of the grammar.

Phonological knowledge also encompasses the predictable rules that associate sound to meaning. For instance, in English, the plural morpheme meaning *more than one* may be pronounced or realized phonetically in three different ways: (1) as [s] when following a voiceless sound, for example, *cups, cakes*; (2) as [z] when following a voiced sound, for example, *bags, tubs*; and (3) as [ɪz] when following sibilants and affricates /s/, /z/, /ʃ/, /tʃ/or /dʒ/, for example, *churches, buses.* Despite these differences in pronunciation, one and only one meaning is communicated. Moreover, these three different pronunciations of the plural morpheme are highly predictable. The contexts required for the use of each pronunciation can be specified precisely. Thus, a speaker of English need only store one meaning in the lexicon with the various surface forms of this meaning generated by rule. Here, both the plural morpheme and the phonological rule are entries in the grammar.

Importantly, the phonological knowledge a person has in his or her lexicon can be translated into three different levels of organization. These are the underlying level, associated with those idiosyncratic properties of a grammar; the mediating rules, associated with deriving predictable properties of a grammar; and the phonetic level, associated with pronunciations. An obvious question associated with phonological knowledge and speech disorders is: What is the nature of a phonologically disordered child's grammar, and how does this grammar relate to the adult or target grammar? Several descriptive studies of speech disordered children's grammars have been reported (Dinnsen, Elbert, & Weismer, 1980; Gierut, 1985; Gierut, Elbert, & Dinnsen, 1987). In these studies, both the overall components and specific aspects of disordered sound systems were examined. Five independent qualitative categories of phonological knowledge were identified: (1) sounds that are ambient-like or essentially correct in all respects; (2) sounds that are produced in error as a result of the misapplication of phonological rules (i.e., either the use of rules that are not target-appropriate, such as postvocalic glottalization or deletion, or the nonuse of rules that are target-appropriate, such as intervocalic flapping); (3) sounds that occurred in some positions but not others as accounted for by a positional constraint; (4) emerging sounds that are very low in frequency of occurrence and often in free variation with other sounds; and (5) sounds that are excluded from both the phonetic and phonemic inventories.

Two important observations emerged from these grammars of phonologically disordered children. First, a given child may have differential knowledge of the target phonology; that is, a child may exhibit more knowledge of some aspects of the target sound system than others. For example, some target sounds may be ambient-like in all contexts, while others may be conditioned by phonological rules, and still others may be excluded entirely from the inventory by phonotactic constraints. Secondly, different children displaying superficially similar patterns of production may have different knowledge of the target phonology. To illustrate, Weismer, Dinnsen, and Elbert (1981) described three children who omitted final consonants. Two of the children marked the occurrence of final consonants in morphophonemically-related pairs such as [dɔ] ~ [dɔgi] *dog - doggie* or [pæ] ~ [pæti] *pat - patty.* The occurrence of final consonants in these pairs indicated that these children had phonological knowledge of these sounds and their use. The third child, however, consistently produced morphophonemically-related pairs without final consonants as in [dɔ] ~ [dɔ i] *dog-doggie.* Unlike the other children, this child did not have knowledge of final consonants, excluding these sounds from this word position. While all three children appeared to have identical patterns of production regarding final consonants, their grammars, in fact, were quite different.

Are such differences in phonological knowledge within and across children reflected in learning during phonological intervention? Will a child's knowledge of certain aspects of the grammar influence how these components will be learned? Predictably, a child's performance on errored but phonologically known aspects of the grammar will be as good or better than his or her performance on errored but phonologically unknown aspects (Dinnsen & Elbert, 1984).

Figure 1. Accuracy of probe performance for three children who received treatment beginning with errored but phonologically known aspects of their grammars. Open circles reflect phonologically known sounds or most knowledge; closed squares, phonologically unknown sounds or least knowledge. (Adapted from Gierut et al., 1987).

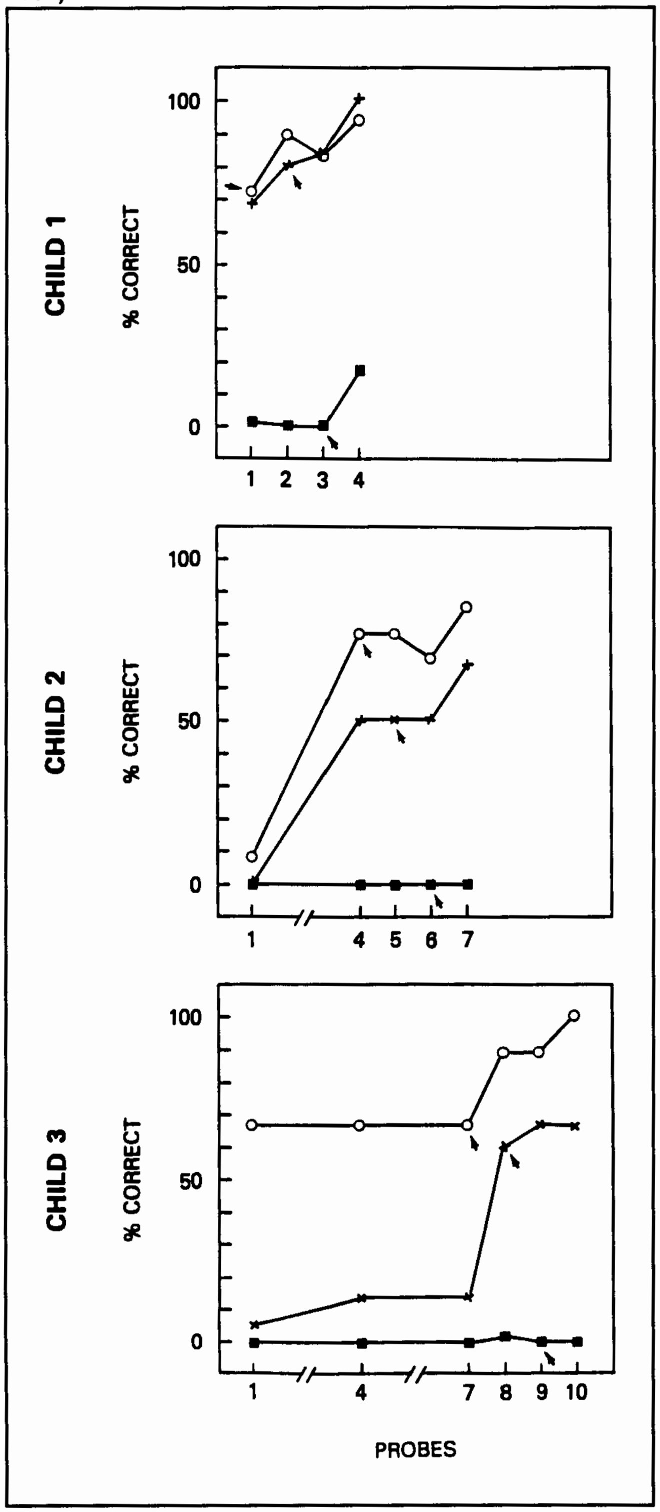
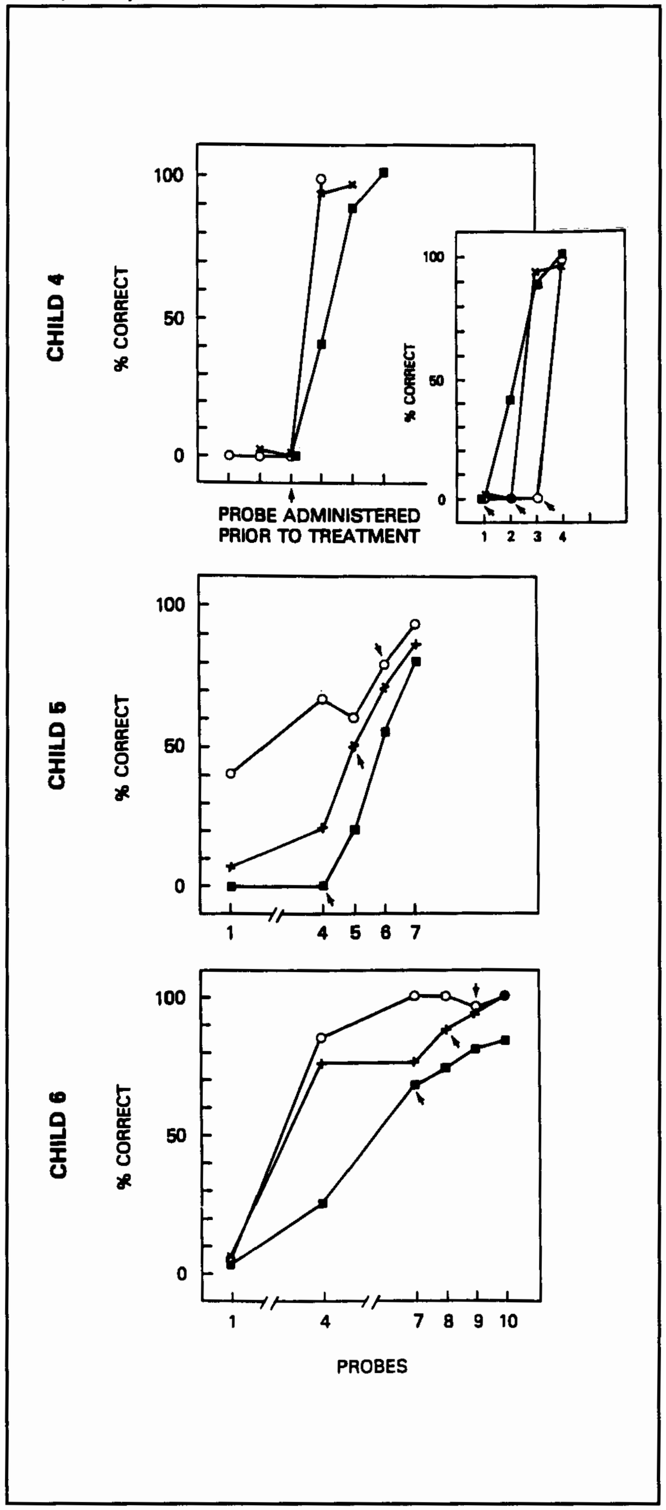


Figure 2. Accuracy of probe performance for three children who received treatment beginning with errored but phonologically unknown aspects of their grammars. Open circles reflect phonologically known sounds or most knowledge; closed squares, phonologically unknown sounds or least knowledge. (Adapted from Gierut et al., 1987).



To evaluate the relationship between phonological knowledge and learning, six phonologically disordered children participated in a single-subject experimental study (Gierut et al., 1987). Children had a minimum of six sounds in error from at least two different sound classes relative to the target phonology. Grammars were developed for each child, with phonological knowledge characterized according to the five distinct knowledge categories described previously. Then, children were randomly assigned to one of two treatment groups. For one group of three children, treatment began with sounds in error of which a child had most knowledge (i.e., errored but known sounds as altered by phonological rules). For the second group of three, treatment began with sounds in error of which a child had least knowledge (i.e., errored but unknown sounds as excluded by inventory constraints). Children each received treatment on three errored sounds, progressing in sequence from most to least knowledge or from least to most knowledge.

The results of this study are shown in Figures 1 and 2. For all children, higher percentages of accuracy were noted for aspects of their grammars associated with most knowledge or phonologically known sounds. Performance on aspects of the grammar for which they had most knowledge (open circles) was always as good or better than aspects of the grammar for which they had least knowledge (closed squares). This finding was observed regardless of starting point of treatment, most or least knowledge. This finding also supports the original hypothesis that a child's grammar plays a role in learning during treatment.

An unexpected finding was that starting point of treatment also contributed to phonological learning. When treatment began with errored aspects of the grammar for which children had most knowledge (Figure 1), improvements were limited to this component of the grammar. Changes did not take place in treated sounds of which these same children had least knowledge. On the other hand, when treatment began with sounds of which children had least knowledge, system-wide improvements occurred (Figure 2). Extensive changes were noted across-the-board in phonologically known and unknown aspects of the grammars. Treatment beginning with errored sounds of which children had least knowledge facilitated improvements in errors associated with most knowledge. This finding suggested that treatment of different aspects of a grammar will enhance phonological learning in different ways.

How was it that the payoffs were greater for those children who began treatment with least knowledge even though they were presented with the more difficult task? A comparable demonstration involving the acquisition of mathematical skills may help to interpret these unusual findings (Yao, 1989). Consider a child who does not know how to perform the operations of addition, subtraction, multiplication, or division. If this child is first taught division, he or she not only may learn to divide, but also, by implication and of necessity to this operation, to add, subtract, and multiply. On the other hand, if this child is first taught addition, he or she may learn this specific operation, but nothing about learning addition necessarily will lead the child to learn subtraction, multiplication, or division. Performance of the more difficult superordinate skill requires mastery of other coordinate and subordinate skills in the learning hierarchy (Gagné, 1968, 1977). An understanding of a child's grammar thus provides an appropriate framework for establishing such a learning hierarchy.

Thus, the linguistic principle for intervention that derives from a study of children's grammars is: Teach aspects of the grammar for which a child has least knowledge. Specifically, treatment of sounds excluded from the inventory by phonotactic constraints will result in improvements in these and other errored aspects of production. While a child's performance will likely be better on errored but phonologically known sounds, teaching errored and unknown aspects of the grammar will lead to the greatest overall change in the phonological system.

Linguistic Principles for Intervention

The previous discussion of the goals of linguistic theory resulted in three clinically relevant principles for intervention. To summarize, from the examination of language universals, clinical treatment should emphasize typologically more marked aspects of production. Although language laws suggest that these will also be the most difficult elements to learn, the end result of treatment will be acquisition of related marked and unmarked sounds and properties. From the focus on phonological oppositions, clinical treatment should pair sounds that contrast along multiple feature dimensions and that involve major class distinctions. Although a child will have to discover many relevant and higher order phonemic distinctions, the end result of treatment will be greater improvement in production of treated and untreated sounds. Finally, from the discussion of relative phonological knowledge, clinical treatment first should center on sounds that are phonologically unknown to a child. Although production of phonologically unknown sounds will be less accurate than errored but known sounds, the end result of treatment will be system-wide changes in a child's phonological knowledge.

These three principles can be appealed to either independently or collectively in intervention. If the aim of treatment specifically emphasizes one level of the phonological hierarchy — phones, phonemes, or morphemes — then a single principle may guide the treatment program. However, across all three hierarchical levels, these principles support a unified teaching approach. The combined research suggests that, no matter what aspect of the sound system is targeted, the greatest language change will occur when new phonological information, radically different from a child's existing knowledge of language, is presented. In other words, teach phonologically unknown aspects of sound systems and, within this category, teach marked, teach maximally opposed, and teach major class distinctions.

This dovetailing of principles brings us full circle. In order to implement the collective teaching principle, speech-language pathologists must have the linguistic background and training to determine what knowledge a child already has about the target language. Then, information about language that would be considered novel must be isolated, and linguistic metrics must be used to establish whether this new information is sufficiently different from that of the child's existing grammar. Clearly, a general knowledge of language and linguistics underlies the very application of this approach. Perhaps, most importantly, the collective teaching principle is founded on and derives from theories central to the clinical mission of teaching language. It was not necessary to appeal to or to develop intervention techniques and programs external to the source; rather, those properties and principles unique to language itself can serve as the basis for language intervention. This intimate tie between linguistic theory and application is precisely the link that will continue to lead us to successful clinical intervention programs and to a closer understanding of human language and learning.

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