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CHAPTER 6

Independent and Relational Accounts of Phonological Disorders

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Phonological disorders have been described from two very different perspectives: in relation to the target sound system or independent of it. These two approaches have yielded very different claims about the nature of disordered sound systems. Relational accounts (e.g., Edwards & Shriberg, 1983; Ingram, 1989) have been advanced primarily within the framework of Natural Phonology (Donegan & Stampe, 1979), although this perspective has at times also been evident in other theoretical frameworks and in the description of other developing sound systems (e.g., Candour, 1981; Lorentz, 1976; Menn, 1976; Spencer, 1986). The relational perspective has for years dominated clinical research and practice. This approach maintains that there is a systematic relationship or correspondence between the target system and the child's erred productions. This presumed systematic relationship is accounted for by assuming that the child's underlying mental representations of words are correct and that a finite set of innate natural processes convert those underlying representations into the child's erred

substitutes. A phonological disorder thus is characterized as a phonetically simplified derivative of the target system. The problem is seen as unidimensional, requiring a focus on the more superficial aspects of the system, namely the persisting natural processes that when eliminated should result in entirely correct productions. Although this approach may seem attractive, it is admittedly quite abstract in terms of its claims about children's underlying representations. Many of the postulated distinctions attributed to the child are absolutely neutralized by the natural processes and thus are never realized phonetically in the child's speech.

The other approach (sometimes referred to as the Indiana perspective) analyzes disordered systems independently of the target system, just as fully developed sound systems are analyzed in generative theory (Chomsky & Halle, 1968). Claims about what a child knows about his or her sound system thus are based on facts evident only in that child's speech, without regard to any presumed relationship with the sound system of the surrounding speech community. These claims tend to be much less abstract compared with those made in relational accounts. For examples of detailed analyses within this framework, see Chin (1993), Gierut (1985), and Maxwell (1979, 1981). This framework has resulted in a very different characterization of disorders. The principal difference is the finding that children's errors can, in some cases, be attributed to underlying representations that are in some sense "incorrect," at least relative to the target system. The nature of children's underlying representations thus need not be assumed a priori to be correct. Rather, the correctness of underlying representations can be determined on empirical grounds. The possibility that children's errors may be attributed in part to the nature of their underlying representations broadens the scope of the problem, requiring a focus on both rules and representations.

This broadened focus is based on four general arguments which suggest that it is not possible in certain cases to postulate correct underlying representations in the characterization of phonological disorders. One argument relates to the need to differentiate among seemingly identical error patterns for different children. For example, final consonant omissions have been found (Weismer, Dimmsen & Elbert, 1981) to fall into two distinct subtypes depending on the relative correctness of underlying representations. The subtype of final consonant omission associated with correct underlying representations exhibits the following two empirical characteristics: an alternation with word-medial consonants and a vowel length alternation that is sensitive to the voicing of the underlying omitted final consonant. The subtype of final consonant omission associated with incorrect underlying representations exhibits neither a consonantal alternation nor a vowel length alternation. Empirical differences of this sort associated with a single error

pattern cannot be explained if all underlying representations are assumed to be correct. Another argument for distinguishing between correct and incorrect underlying representations derives from observed differences in children's learning patterns (e.g., Dimmsen & Elbert, 1984; Gierut, Elbert & Dimmsen, 1987). That is, the remediation of children's errors is highly dependent on the relative correctness of their underlying representations. Regardless of which errors are targeted for treatment, the greatest improvements are observed in errors associated with correct underlying representations. Also, when treatment is directed at errors associated with correct underlying representations, improvements tend to be limited to that class of errors. However, when treatment is directed at errors associated with incorrect underlying representations, improvements are observed across the child's entire system. A third argument for postulating incorrect underlying representations relates to the existence of nonsystematic correspondences between the target system and the child's system (e.g., Gierut, 1989; Leonard & Brown, 1984). If underlying representations are assumed to be correct in cases of nonsystematic correspondence, competing (and even contradictory) processes with unexplained or optional applicability would have to be postulated. Finally, the existence of certain allophonic phenomena (e.g., Camarata & Gandour, 1984; Gierut, 1986b; Williams & Dimmsen, 1987) requires the postulation of at least some incorrect underlying representations. That is, if children's underlying representations were assumed to be correct in these cases, the nontarget complementary distribution of sounds would have to be viewed as accidental. It thus appears that there are several empirical reasons for distinguishing between correct and incorrect underlying representations as essential properties of these systems. For further discussion of these and related issues, see Gierut (1986a).

PURPOSE

Given that the proper characterization of phonological disorders may depend on the postulation of incorrect underlying representations in certain circumstances, it is important to specify what those circumstances are and determine what the extent or magnitude of this problem is for disorders. That is, do all phonologically disordered children evidence at least some incorrect underlying representations? Also, for any given child, what proportion of that child's underlying representations is correct? This chapter will attempt to answer these and other related questions by briefly reviewing the empirical criteria for determining the nature of underlying representations and then by advancing a procedure for quantifying the resultant claims. These procedures then will be applied in the analysis of 40 phonologically disordered children

to determine the prevalence of incorrect underlying representations in phonological disorders.

SUBJECTS

The subjects for this study represent the initial 40 children drawn from a large scale investigation of the sound systems and learning patterns of young children with functional (nonorganic) speech disorders. The children ranged in age from 3 years 4 months to 6 years 8 months. To be included in the study, each child exhibited six sounds in error across three manner classes on the *Goldman-Fristoe Test of Articulation* (GFTA) (Goldman & Fristoe, 1986). Of the 40 children, 21 scored below the 1st percentile on the GFTA, and no child scored above the 34th percentile. All children evidenced normal hearing. Various aspects of these children's phonologies have been described elsewhere (Chin & Dinnsen, 1991, 1992; Dinnsen, 1992; Dinnsen & Chin, 1993; Dinnsen, Chin, & Elbert, 1992; Dinnsen, Chin, Elbert, & Powell, 1990; Elbert, Dinnsen, Swartzlander, & Chin, 1990).

DETERMINATION OF UNDERLYING REPRESENTATIONS

All contemporary theories of phonology allow for at least two levels of representation, namely a phonetic and an underlying level of representation. The character of the phonetic level is relatively clear, but details of the underlying level can only be hypothesized. The underlying level is a theoretical abstraction that is intended to represent a speaker's mental representation of the morphemes and words of the language. The underlying level incorporates all and only the idiosyncratic, learned properties of pronunciation. Thus, only contrastive (unpredictable) information is represented at the underlying level. The noncontrastive (predictable) properties of pronunciation then are specified by phonological rules, thus relating the two levels. The task of describing any phonological system, then, is to determine which properties of pronunciation are contrastive and must then be specified at the underlying level and which properties are noncontrastive and thus are specified by rule. The general procedures for making these determinations in fully developed languages have been detailed in many generative phonology textbooks (e.g., Kenstowicz & Kiseseberu, 1979). The extension of the same procedures to the description of phonological disorders has also been detailed in Dinnsen (1984).

Within this framework, a child is credited with knowledge of a target distinction only if the child's productions offer evidence of the distinction.

Two general conditions in a child's speech will fail to provide any positive evidence for a target distinction and thus result in the claim that that aspect of the child's underlying representations is incorrect. First, if a target sound fails to occur in any context, then that sound is not represented anywhere in the child's phonology. The nonoccurrence of that sound is taken to be a nonaccidental property of pronunciation and is thus predicted to be excluded by an inventory constraint. These inventory constraints may be very general to account for the nonoccurrence of whole classes of sounds, or they may be more limited in scope to account for the nonoccurrence of one or two sounds. For example, the rule in (1) below would account for the exclusion of all fricatives and affricates from a child's system.

- (1) [+consanantal] → [-continuant, -delayed release]

This rule expresses the generalization that all consonants are (non-affricated) stops and was characteristic of two children in this study (see Dinnsen et al., 1990 for details). The rule in (2) is less general, accounting for the nonoccurrence of [ʃ] and [ʒ] and the fact that all fricatives are anterior.

- (2) [-sonorant, +continuant] → [+anterior]

This rule was characteristic of 23 children in this study.

The second condition that will fail to support a claim of correct underlying representations relates to the occurrence of a target sound or class of sounds in only certain contexts. That is, the target sound occurs in the child's phonetic inventory and is produced correctly in some contexts but fails to occur in certain other contexts. The fact that the target sound is produced correctly in some contexts certainly can be taken as support for the claim that the child has underlying knowledge of the target sound, at least in those contexts where it does occur. However, the systematic nonoccurrence of a target sound in the other contexts would appear to be nonaccidental, and thus would be accounted for by a positional (or phonotactic) constraint that holds at all levels of representation, including the underlying level. This means that a given target sound may be represented correctly in some word positions but incorrectly in other word positions. Such constraints were evident in 37 of the 40 children in this study (Dinnsen et al., 1990). In sum, incorrect underlying representations will be posited in cases where a child's errors can be accounted for by either inventory constraints or positional constraints.

On the other hand, the postulation of correct underlying representations is especially well supported under two other general circumstances: (a) in phonological contexts where a target sound is produced correctly

(although see Dinnsen & Chin, 1993, for certain well-defined exceptions), and (b) in contexts where an error alternates with a correct production in morphophonemically related forms. The former circumstance is relatively uncontroversial because the child is not producing any errors, and the two systems are congruent, at least with regard to those sounds in those contexts. The forms in (3) below illustrate a child's (S3; age 3;6) correct productions of target /k/ in all phonological contexts (word-initial, -medial, and -final), even though other target segments may not be produced correctly. For example, [s] did not occur in the child's system and appeared to have [θ] as its substitute. Similarly, [t] did not occur and appeared to have [w] as its substitute. In the case of S3, it is apparent that target /k/ was represented correctly at the underlying level in all three word positions. Notice that the medial and final /k/ occur in morphophonemically related forms, which are potentially subject to rule-induced errors; such, however, was not the case.

- (3) a. Target initial /k/: kʰiːdɔ̃ "kids," kʰiːθŋ "coughing"
 b. Target medial /k/: θaki "sockie," waki "rocky"
 c. Target final /k/: θak "sock," wak "rock"

As regards /k/, then, the child's system and the target system are in congruence at both the underlying and the phonetic levels of representation.

The other cases in which correct underlying representations are especially well supported involve the operation of a phonological rule. This can be exemplified by considering the following forms from child S22 (age 4;6) from this study:

- (4) a. [bʌs]/[bʌʃɪn] "brush/brushing"
 [wɪtʃ]/[wɪtʃɪ] "witch/witchie"
 [kʰeɪdʒɪ]/[kʰeɪdʒɪ] "cage/cagey"
 b. [bʌs]/[bʌsɪ] "bus/bussy"

The forms in (4a) show an alternation between a (correct) palatoalveolar in intervocalic position and an (incorrect) alveolar in final position. These forms are considered to have a correct underlying representation (at least as regards the postvocalic segment in question), and the incorrect production in final position is accounted for by a rule requiring that all [+coronal] segments also be [+anterior] in final position. Evidence for the correctness of this analysis is given in (4b), where it is seen that it is not the case that alveolars become palatoalveolars in intervocalic position. Also, a comparison of the (4a) forms with (4b) shows that alveolar and palatoalveolar segments do indeed contrast intervocalically. Thus, although

the forms in (4a) show an error production in final position, the occurrence of correct productions in intervocalic position in morphophonemically related forms speaks for the correctness of the underlying representation.

In sum, many empirical considerations of the sort just discussed can be brought to bear in postulating children's underlying representations. In certain instances, correct underlying representations can be supported; in other circumstances they cannot.

DATA FOR ANALYSIS

To support the claims of an independent analysis empirically, an extensive speech sample that tests a full range of target sounds in a variety of contexts and provides multiple opportunities for each sound in each given context is needed. It is also especially important to examine how the sounds of any given morpheme are realized when the contexts for that morpheme are varied. The latter concern relates to the identification of morphophonemic alternations and provides the clearest evidence about the underlying representation of those morphemes. These general points have been integrated into the design of a probe and elicitation procedure first developed by Ciernut (1985) and subsequently adapted for this and related studies (as noted above in the description of subjects). This probe consists of 306 picturable words that are likely to be known to children in this age range. All English consonants (except /y/ and glides are tested in word-initial, word-medial and word-final positions, except as limited by the phonotactic restrictions of English (e.g., the velar nasal is not probed in word-initial position). Wherever possible, words that allowed for possible morphophonemic alternations were selected. The full set of pictures depicting these words was presented to each child for spontaneous naming. Each child's responses were tape-recorded and phonetically transcribed by trained listeners with high levels of reliability.

ANALYSIS

The phonological system of each child was analyzed within this framework based on the speech sample described above with special emphasis on determining the nature of underlying representations. For illustration purposes, these criteria are applied in the description of a particular child, S4, age 3;7. This child produced the glides [w ɪ h] and the velar nasal [ŋ] correctly in all probed word positions; therefore, he was credited with correct underlying representations in all word positions. The alveolar nasal

[n] occurred correctly in initial and final position, but did not occur in intervocalic position. However, the word-final occurrences alternated with null intervocalically in morphophonemically related forms. Therefore [n] was represented correctly at the underlying level in all word positions. The segments [m b d] occurred correctly in word-initial position, but were either missing or had substitution sounds in both postvocalic positions (intervocalic and word-final positions). Therefore, these sounds were correct underlyingly only in initial position. Finally, all other target English segments were never produced at all and were thus determined to be incorrectly represented underlyingly.

QUANTIFICATION OF CLAIMS ABOUT UNDERLYING REPRESENTATIONS

Based on the description of the above child's phonological system and the general considerations noted earlier, it appears that certain target sounds can be represented incorrectly in all contexts, certain other target sounds can be represented correctly only in certain contexts, and yet other target sounds can be represented correctly in all contexts. The possibility thus exists for considerable variation both within and across children along this dimension with no established measure for quantifying the difference (or distance) between the child's system and the target system. To address this concern, a measure has been developed which attempts to quantify the percentage of correct underlying representations (PCUR).

The calculation of the PCUR is as follows. Each target English phoneme is assigned a value of 1 for each context in which it can occur as sampled in the probe described above. The number of phonemes (by context) is divided by the total number of possible target phonemes (by context) and multiplied by 100, yielding the PCUR. For the specific probe described above, 23 target English sounds were sampled in from one to three word positions. Using the procedure just described, the maximum number of points that could accrue to any one child for representing all sounds correctly in all contexts at the underlying level was 63, which would correspond to a PCUR of 100%.

RESULTS AND DISCUSSION

For illustration purposes, this quantification procedure is applied to the description of child S4, described above, to yield a measure of the correctness of his underlying representations. In this case, the target

appropriate production of the three glides and the velar nasal credited 7 points toward the PCUR; the glides were probed in two contexts, word-initial and intervocalic, and the velar nasal in final position. Because [n] alternated with null intervocalically due to a phonological rule and otherwise occurred correctly in initial and final position, the alveolar nasal was considered to be correctly represented underlyingly in all positions: 3 points thus accrued toward the PCUR. The situation with [m b d] is different, however. In this case, these segments were represented correctly in initial position but incorrectly in intervocalic and final position. The representations in initial position therefore added 1 point each for the three sounds to the determination of the PCUR, and no points were given for postvocalic underlying representations. In all, then, 13 points accrued toward the PCUR, which was then determined to be $13/63 \times 100 = 21\%$. The remaining sounds by context (50 points) were not considered to be correctly represented at the underlying level and thus did not contribute to the PCUR.

A PCUR was calculated in a like manner for each child in this study based on the independent analysis. The results are reported in Table 6-1 on page 142.

It can be seen from Table 6-1 that children exhibited considerable variation in the correctness of their underlying representations. The range in PCUR was from a high of 92% to a low of 18%. The mean PCUR score for the group was 58%, and importantly, all subjects in this study evidenced at least some incorrect underlying representations. This is in sharp contrast to what would be expected from relational accounts which simply assume a priori that underlying representations are correct. The fact is that the incidence of incorrect underlying representations in these phonologies is quite high, and the magnitude of the problem in at least some cases is considerable.

The measure PCUR differs in important respects from another current measure, namely "Percentage of Consonants Correct" (PCC) (Shriberg & Kwiatkowski, 1982). PCC provides a superficial measure of a child's errors based on a conversational speech sample, although it is equally possible to compute PCC on other types of speech samples such as those used in this study. The important difference is that PCC weights all errors equally, PCUR, on the other hand, weights errors differently depending on the source of the error. That is, errors associated with correct underlying representations do not in some sense count as errors. Errors associated with incorrect underlying representations do, however, count as errors. The value in making this distinction is evident in the results of treatment studies (e.g., Dinnsen & Elbert, 1984; Cieru, Elbert & Dinnsen, 1987), which have found characteristically different learning patterns in accord with the nature of the underlying representations. Specifically, errors associated with correct underlying

Table 6-1. Ages and Percentage of Correct Underlying Representations (PCUR) of 40 Functionally Misarticulating Children

Child	Age (years:months)	PCUR
S1	3;4	61
S2	3;6	64
S3	3;6	54
S4	3;7	21
S5	3;8	84
S6	3;8	70
S7	3;8	47
S8	3;9	65
S9	3;9	89
S10	3;9	65
S11	3;10	41
S12	3;11	76
S13	4;1	40
S14	4;1	65
S15	4;2	65
S16	4;2	33
S17	4;3	78
S18	4;3	18
S19	4;3	92
S20	4;4	59
S21	4;5	79
S22	4;6	63
S23	4;8	73
S24	4;8	43
S25	4;10	62
S26	4;11	21
S27	4;11	48
S28	4;11	25
S29	4;11	51
S30	5;0	73
S31	5;1	70
S32	5;2	70
S33	5;4	51
S34	5;5	73
S35	5;7	84
S36	5;9	27
S37	5;10	41
S38	5;11	57
S39	6;3	83
S40	6;8	53

representations are overcome more easily (i.e., achieve higher levels of accuracy) than errors associated with incorrect underlying representations. Additionally, when treatment targets are selected from the set of errors associated with correct underlying representations, improvements tend to be limited to that class. That is, treatment focused on these errors does not generally yield improvements in errors associated with incorrect underlying representations. On the other hand, when treatment targets are selected from errors associated with incorrect underlying representations, improvements tend to be more widespread, occurring across both error types. Thus, clinical treatment that recognizes that not all errors are equal and moreover focuses on errors associated with incorrect underlying representations can be expected to yield improvement across the entire system.

The difference between the two measures is further highlighted by considering the possibility that two children could have identical PCC scores but significantly different PCURs. This situation could arise if one child produced most errors by phonological rules that operated on correct underlying representations, and the other child produced most of the errors due to inventory and positional constraints associated with incorrect underlying representations. Precisely this situation was reported by Connell, Elbert, and Dinnsen (1991) in a study of two subgroups of children from this study. The two subgroups exhibited PCC scores that were not significantly different. Their PCURs did, however, differ significantly. One subgroup of 10 children was identified as "syntax-delayed," and the other subgroup of 13 children was identified as "syntax-normal." The average PCUR for the syntax-delayed group was 48% and for the syntax-normal group 63%. This suggests that the measure PCUR may have certain advantages over other measures as a diagnostic and/or as a measure of severity.

PCUR appears to provide a gross measure of the difference between a child's system and the target system, at least at the underlying level of representation. There are, however, certain limitations that must be noted in the interpretation of these measurements. This method for quantifying claims about underlying representations may, in certain cases, overestimate a child's knowledge of the target system. The case that is problematic in this regard is where a child represents a target sound correctly in a particular context but not necessarily in all morphemes. In other words, even if a target sound is represented correctly in most (but not all) morphemes, the child will be given credit for correct underlying representations of that target sound in that context for all morphemes. Similarly, a degree of underestimation is also possible in the case where a child represents a target sound correctly in only a few morphemes. In this case, the child would not be credited anywhere with knowledge of the target sound. It remains to be determined whether these potential over- and underestimations are critical in any sense.

CONCLUSION

When analyzed independently of the target system, children's phonological systems can be seen to differ from the target sound system in ways not evident from relational accounts proposed thus far. Although the PCUR is a relational claim, it becomes relational only after the child's system has been established independently of the target system. Within this framework of independence, the problem for the child may not be limited to rules but may also involve, to some extent, the nature of the child's underlying representations. Errors may come about because of nontarget phonological rules and/or because of nontarget underlying representations. This is important clinically because it suggests that not all errors are equal and may respond differently to different forms of treatment. The quantification of claims about underlying representations suggests that the incidence of incorrect underlying representations is high in general and that, for at least some children, incorrect underlying representations outnumber correct underlying representations.

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CHAPTER 7

The Prosodic Tier and Phonological Disorders

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Children with severe phonological disorders commonly have restricted word/syllable structure (see Chiat, 1989; Gunnwell, 1985; Ingram, 1976). Characterization of this aspect of "disordered" systems has evolved as phonological theories have evolved. The purpose of this chapter is to demonstrate application of current nonlinear phonological theories to the description of the syllable/word structure of disordered phonological systems. The chapter begins with a brief overview of the evolution of description of the syllable/word structure of disordered speech, then outlines major aspects of current theories with respect to syllable/word structure, and, finally, provides data demonstrating the utility of the nonlinear frameworks for description and derivation of intervention methodologies.

THE HISTORICAL PERSPECTIVE

Description of the syllable/word structure aspect of children's disordered phonological systems has evolved as linguistic theories have changed. In early characterizations of disordered systems, note was made of the presence of omissions versus substitutions versus distortions. In this