25 Phonological Analysis, Phonological Processes

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25.1 Introduction

Phonological process analysis has had considerable influence on the analysis of children’s phonological systems and, to a lesser extent, on the methods that have been used to treat disordered phonological systems since the 1980s. This chapter provides a summary of the theoretical basis of this approach and discusses some of the clinical issues that have arisen through the application of phonological processes to the assessment and treatment of disordered phonological systems.

25.2 Theoretical Underpinnings

According to natural phonology theory (Donegan & Stampe, 1979; Stampe, 1979), phonological processes describe phonetically motivated and natural patterns of speech production. Supporting evidence for natural theory comes from examples of evolutionary language change and from descriptions of sound change in children’s developing phonological systems. Stampe (1979) argued that the sound patterns of language are governed by the limitations of the human speech perception and production mechanisms and are thus both innate and natural. During development, phonological processes merge potential phonological oppositions into the member of the opposition that puts the least strain on a human’s speech ability. A phonological process will, for example, merge the potential contrast between /t/ and /k/, resulting in production of [t], the unmarked member of the pair. A child whose language requires a contrast between /t/ and /k/ will learn from experience to suppress this process (velar fronting) and produce the contrast between /t/ and /k/. A phonological process may apply to a class of sounds or sound sequences (Stampe, 1979); for example, the process of stopping results in the production of stops where fricatives occur in the adult language. The reverse would not occur naturally
because fricatives have the more difficult property. A sequence of consonants may reduce to a singleton, e.g., /pl/ may reduce to the simpler member of the cluster /p/, reflecting the physiological constraints of the speech mechanism. Phonological processes can co-occur, giving rise to more unique pronunciations. On the other hand, phonological processes that do not have a clear physiological basis are not natural and are considered deviant processes.

Natural phonology does not view a child’s underlying mental representation as distinct from its surface form. The underlying representation (UR) is assumed to be correct even when production is incorrect. This is a major distinction between natural phonology and generative phonology, the primary alternative view at the time (Chomsky & Halle, 1968; Kenstowicz, 1994). The generative approach, as applied to children with phonological disorders, argues against assuming that children have adult-like URs (Dinnsen, 1984). Rather, the status of the UR must be determined for each child through evaluation. To determine the nature of a child’s URs, morphophonemic alterations are observed. A child who omits the final consonant of the word dog, for example, but produces the /g/ in the diminutive doggie provides evidence of an adult-like UR for dog and a rule for deletion of final consonants. This is not the case, however, for the child who omits /g/ in both contexts because a final consonant cannot be deleted if it is not in the UR. The primary problem with the clinical application of this approach does not relate to its utility in describing phonological change or in predicting change that would result from treatment, but is rather that the approach requires an in-depth knowledge of phonology and an understanding of rule formulation (Edwards, 1997).

In natural phonology, on the other hand, there is no need to distinguish between competence and performance by writing phonological rules that change the UR to a simpler phonetic form because the URs are equivalent to the adult forms (with the exception of predictable phonetic details). Thus, the formalisms required to write phonological rules are avoided in natural phonology. These differences led researchers (Grunwell, 1982, 1985; Ingram, 1976, 1981) to describe patterns observed in the delayed or disordered speech of young children as phonological processes. As a result of their work, the concept of phonological processes was made accessible to speech-language pathologists.

The concept of identifying patterns of change was particularly appealing in cases with multiple speech sounds in error. To describe patterns without having to understand distinctive features or write formal phonological rules was also immensely appealing to clinicians. As a result, phonological process analysis continues to influence clinical practice.

### 25.3 Clinical Application of Phonological Processes

Historically, linguistic theory was not applied clinically; rather clinicians used standardized articulation tests that do not differentiate among error types.
Treatment concentrated on school-age populations with residual errors related to one or a few consonants, e.g., /s/, /z/, /l/. Speech errors were viewed individually and assumed to be peripheral in nature. Phonemes in error were taught one at a time, first in words, then in larger units, following a behaviorist framework (Hodson, 1997). As increased attention was paid to early intervention with preschool children, the unintelligible speech of children with multiple errors began to receive notice.

Describing errors as phonological processes met a need to describe multiple errors. With the publication of a number of phonological process analysis procedures, process analysis became more widely applied in clinical practice, especially during the 1980s and 1990s (Dean, Howell, Hill, & Waters, 1990; Grunwell, 1985; Hodson, 1980; Ingram, 1981; Shriberg & Kwiatkowski, 1980; Weiner, 1979). Unfortunately, these assessments utilized a number of different criteria for defining phonological processes and resulted in a wide variation in the number and types of processes used to describe children’s speech patterns. Grunwell (1985), for example, described nine common natural processes and 13 less common processes. Shriberg and Kwiatkowski (1980), proposed eight processes. According to these authors, a process must result in the simplification of speech production and be widely attested in natural languages. The eight processes involved phoneme deletions and/or substitutions, but not distortions. Processes also had to occur frequently in the speech of children with delayed language development and had to be transcribed reliably. This resulted in the exclusion of context-sensitive voicing from the basic processes described in Grunwell. Alternatively, Hodson (1983) included 42 observed deficient patterns and grouped them into 10 categories.

Many of the analysis procedures do not distinguish between natural and deviant processes; others include processes that describe any observed patterns without attention to the theoretical underpinnings. In general, all approaches view processes as attempts by children to simplify the adult target. While each analysis procedure differs in the number and types of processes assessed, they all attempt to describe children’s productions as patterns of error.

Common processes used clinically to describe children’s error patterns are listed below, with an example of each. For a more complete discussion of types of phonological processes and examples, see Velleman (1998) or Vidman (2004).

25.3.1 **Word- and syllable-level processes**

These processes affect the shape of a word or a syllable.

**Unstressed syllable deletion**: deletion of a syllable that is present in the adult form, usually the weak syllable before a strong syllable. ‘banana’ [nana]

**Final consonant deletion**: deletion of a word-final consonant. ‘boat’ [bo]

**Cluster reduction**: reduction of the number of consonants in a cluster. ‘play’ [pe]
25.3.2 Assimilation processes

These processes occur when two elements become more alike, usually in terms of consonant place, manner or voicing. Vowel harmony may also occur but is not seen as frequently in children of preschool age or older. Assimilation refers to two adjacent segments becoming more alike, whereas harmony occurs across other segments. Clinically, a distinction is not always made between harmony and assimilation; assimilation is commonly used to describe both types of sound changes.

Consonant harmony: two or more segments become more alike. ‘coat’ [tot]
Reduplication: the co-occurrence of consonant and vowel harmony resulting in repetition of a syllable. ‘water’ [wawa]

25.3.3 Substitution processes

These processes describe the substitution of one segment for another. Typical substitutions are segments with a different place of articulation, a simplification of the manner of articulation or a voicing change.

Velar fronting: production of a coronal stop for a dorsal stop. ‘car’ [tar]
Stopping: production of a fricative (or affricate) as the homorganic stop. ‘see’ [ti]
Gliding: production of a glide for a liquid. ‘rope’ [wop]
Vowelization (vocalization): production of a vowel for a consonant; usually for a postvocalic liquid. ‘call’ [ka.o]
Context-sensitive voicing: voiceless obstruents produced as voiced, usually in the word-onset or intervocalic positions. ‘top’ [dap]. Voiced obstruents produced as their voiceless cognates, usually in word-final codas. ‘bob’ [bap]

25.3.4 Atypical processes

A number of different labels describe sound changes that are not considered natural processes. Two common ones are mentioned here.

Initial consonant deletion: deletion of the word-onset consonant. ‘top’ [ap]
Backing: producing a consonant further back in the oral cavity for a more anterior target. This process usually describes the production of a dorsal stop for a coronal stop. ‘toe’ [ko]

Phonological processes call attention to systematic relationships between the target adult production and the child’s simplified production, and provide a framework for describing patterns of both typical and atypical phonological acquisition (cf. Grunwell, 1985; Stoel-Gammon & Dunn, 1985). In addition to describing segment-level simplifications, phonological processes provide a straightforward way to describe common nonlinear phenomena through
syllable structure and word-level processes. Over the years, the theoretical bases of phonological processes have become virtually ignored in the clinical domain. This has not been without consequences. Some of these issues are discussed below.

### 25.4 Issues in the Clinical Application of Phonological Processes

#### 25.4.1 Lack of agreement on what constitutes a process

Natural phonology theory is based on observations of ‘normal’ phonological acquisition, not the clinical observation of phonological disorders. Patterns observed in disordered systems cannot always be described by natural phonological processes. As a result, most clinicians use phonological processes to label the patterns observed in a child’s speech production without regard to theoretical underpinnings. Subsequently, most clinical procedures now use the term phonological patterns to refer not only to natural phonological processes, but to any patterns observed in children’s productions. Totally discarding the concepts put forth in natural phonology allows clinicians to label more patterns, but it results in a lack of distinction between patterns that occur in typical development and those that are atypical or unusual (Edwards, 1992). Determining the presence of typical patterns vs. unusual ones provides information on intelligibility, severity of disorder, prognosis and appropriate targets for intervention.

#### 25.4.2 Lack of agreement on labels

The same pattern is not described uniformly across process analyses. Fronting, for example, may refer to velar fronting or to any phone produced more anterior to the target, for example, producing [p] for /k/. Some terms used to describe processes result in contradictory or redundant processes within an individual and lead to confusion when analyzing data.

##### 25.4.2.1 Conflicting processes

Fronting and backing, for example, may be reported in the same child. Productions of [kap] for ‘top’ and [ti] for ‘key’ may be described as backing and fronting respectively. When this happens, a key pattern is ignored. A more likely explanation of this example, and a more helpful one with regard to treatment planning, is that both instances are the result of assimilation, with front vowels triggering a more anterior production and back vowels triggering the dorsal stop. Teaching this child to produce more words with /k/ or /t/ without consideration of vowel context would not be efficacious.
25.4.2.2 Redundant processes

Stridency deletion refers to the lack of a stridency contrast. Although this label is not common across all analysis programs, it is often used to refer to any pattern that results in the loss of a strident phoneme regardless of whether or not the two segments in question contrast in stridency. Producing ‘sex’ as [sl], for example, may be described as both stridency deletion and as stopping. The two opposing segments, /s/ and /t/, however, do not contrast in stridency. In English, the only non-redundant stridency contrasts are /s/ and voiceless /θ/ as in ‘sink’ and ‘think’ and the contrast between /z/ and /θ/. Ignoring this distinction prevents the understanding of what a child is doing. To produce ‘sink’ as ‘think’ is not the same process as producing ‘sink’ as ‘tink’. Clearly distinguishing among patterns describes a child’s system more accurately and yields more useful information regarding treatment priorities.

25.4.3 Lack of understanding of what a child can do

Process analyses describe each word in a sample and assign processes to that individual word without looking at the entire sample for commonalities in the actual productions. Velleman (1998, p. 125) described the process analysis of a hypothetical child’s speech that revealed eight processes: fronting, backing, initial consonant devoicing, stopping of fricatives, stopping of liquids, cluster reduction, alveolar consonant harmony and reduplication. One process, alveolar consonant harmony, described the largest number of errors. There were, however, a number of errors that did not conform to this pattern. In addition, contradictory processes occurred, such as fronting and backing. A reanalysis of the data, with attention to the entire sample and using the most general possible description of the child’s productions, revealed that the child’s phonological system contained two singleton consonants, [d] and [n]. Typically, attention is paid to what a child cannot do in relation to the adult, but not to what a child can do. Understanding that a child’s phonetic inventory is limited to two consonants explains the problem and provides the information needed to design an efficacious treatment. A process account does not allow for a description of a system of this type. Recent constraints-based theories show promise for facilitating more elegant descriptions of highly constrained phonological systems.

25.4.4 Cross-linguistic application of process analysis

With the rapidly increasing number of clinical referrals for children whose first language is not English (in anglophone countries), it is important to consider the cross-linguistic application of phonological processes. If phonological processes are innate and universal, they must be attested across languages. A study of Italian children (Boroli & Leonard, 1991) found commonalities across languages in the developmental patterns of both typically developing
and disordered phonological systems. Exceptions were attributed to differences in the sound classes that occur. The trilled Italian /\textipa{/r}/, for example, was commonly replaced with [l], rather than glides, as commonly occurs for the English rhotic consonant. Yavas and Lamprecht (1988) observed cluster reduction and liquid gliding in Portuguese-speaking children, but stopping of fricatives, glottal replacement and obstructive devoicing did not occur. So and Dodd (1994) found common processes used by both Cantonese- and English-speaking children, but observed a low frequency of gliding as well as processes in Cantonese that are not typical in English (e.g., initial consonant deletion, backing of alveolars, and substitution of [h] for aspirated plosives and /s/). Although these investigators found phonological process analysis to be a useful means of describing speech patterns cross-linguistically, there were major differences in the frequency of usage of processes across languages. This suggests that the articulatory account of children’s productions is not a complete explanation of the patterns (Ingram, 1997).

Other factors, such as functional load or frequency of occurrence, are also important (Pye, Ingram, & List, 1987; Vihman & Velleman, 2000). Pye and colleagues argue that sounds will be acquired early if they occur in a greater number of important words in the child’s early expressive vocabulary. The fricative /\textipa{/v}/, for example, occurs in the early vocabulary of Italian children, whereas it is a later-occurring fricative in English (see Ingram, 1997, for an extensive discussion of cross-linguistic evidence). Findings of cross-linguistic studies suggest that more information is needed to make appropriate clinical decisions than is provided by process analysis alone.

### 25.5 Phonological Processes and Treatment Decision Making

As phonological processes made inroads into clinical assessment procedures, the prevalent treatments were sound-by-sound approaches that taught one sound at a time, usually in a developmental order. Alternatively, minimal-pair approaches paired a child’s target sound with its substitution. In both cases, behavioral modification strategies were used to teach the target sound.

According to natural phonology, learning to pronounce requires suppression of the innate phonological system (Stampe, 1979). Evidence for this claim is provided by the observation that children make across-the-board changes once they produce a segment that they did not use previously. This view is popular among many practitioners as it asserts that a child knows the sound; consequently, he or she simply needs to learn from experience to suppress the innate processes in question.

Treatment research has not always supported this conclusion (Miccio, 1995). McReynolds and Elbert (1981) found that in the case of cluster reduction, generalization was limited to the targeted cluster type. Children who were taught /s/-clusters did not learn /r/-clusters and vice versa. Elbert and
McReynolds (1985) found that when children with final consonant deletion were taught stop-ending words, they learned words ending in stops, but generalization did not extend to words ending in fricatives. A study by Saben and Costello Ingham (1991) provides an example of more issues that arose from the application of phonological processes to treatment. Based on a phonological process analysis, they administered a minimal-pairs treatment to two children with no direct teaching of the target sound. Participants were asked to produce a target sound paired with its substitution. For both children, modeling and phonetic placement cues had to be added before change occurred and generalization did not extend to other phonemes affected by the target processes. These investigators defined a correct response as one in which the target process was suppressed. In other words, production of any fricative was considered a correct response to the goal of suppressing stopping of fricatives (Ingram, 1976; Monahan, 1986; Weiner, 1981). These decisions were made on the assumption that the children would become aware of the need for the contrast and produce it. In this study, the children were unable to produce the target sound and were confused by the reinforcement of any fricative, i.e., [t] for /s/. It is not known how children who have some productive knowledge of the target sound would have responded to the same treatment, but reinforcement of any sound that results in a process change, rather than a correctly produced target, has not proven to be an effective strategy.

Since these early studies that investigated the application of phonological processes to treatment, experiments have shown that complexity is likely the most robust predictor of phonological change as a result of treatment, i.e. treatment of more complex targets such as typologically marked properties, non-stimulable sounds, sounds excluded from the phonetic inventory and sounds in words from low-density neighborhoods (cf. Gierut, 1998, 2001). These and other complexity factors may not always be apparent from phonological process analysis.

Regardless of the theoretical basis of an analysis used to describe a phonological system, treatments may not differ greatly. This is not usually the fault of the theory, but rather lies in the clinical application of bits and pieces without an understanding of the larger picture. As described above, current phonological process approaches do not usually distinguish between processes used by typically developing children and those that may be described as deviant or atypical. Furthermore, diverse labeling procedures lead to the lack of a clear understanding of a child’s system. As a result, crucial information for designing efficacious treatments may be ignored.

25.6 Contributions of Phonological Process Analysis to Phonological Disorders

Effective clinical assessment requires knowledge of typical phonological development. The attention paid to describing the many processes that occur
across children and across languages has advanced our understanding of
typical acquisition. Although the physiological underpinnings of phonological
processes are often ignored, natural phonology has led to positive changes
in how clinicians look at children's phonological systems by calling attention
to patterns. Clinicians learned how sounds fall into natural classes and that
phonological problems may relate to entire sound classes or levels above the
segment. Despite the criticisms of process analysis or its clinical implementation,
it has led to the recognition of multiple levels of the phonological hierarchy
and the subsequent application of principles from a number of phonological
theories to clinical issues (Ball & Kent, 1997).
Nonlinear theories now influence both assessment and treatment (see
Bernhardt & Stemberger, chapter 26 in this volume, and Dinnsen & Gierut,
chapter 27). Some of these approaches are nonlinear extensions of generative
linguistics, but they are also heavily influenced by natural phonology and its
ability to describe patterns above the level of the segment. As more attention is
turned to current theories, it is important to remember that some of the recent
developments are linked to previous work in natural phonology and phonolog-
ical processes.

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