SPEECH DISORDERS

RESOURCE GUIDE FOR PRESCHOOL CHILDREN

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SECTION

3

ANALYSIS PROCEDURES

We discuss analysis procedures separately from assessment procedures because they serve different purposes. As we discussed in the previous chapter, *assessment* identifies whether a speech disorder exists relative to a child's chronological-age peers. It determines the need for intervention and might also assess the severity of the disorder. Little information, however, is obtained regarding specific treatment goals or intervention plans. That is the objective of an *analysis* of disordered sound systems. Phonological analyses provide detailed information regarding the nature of the speech disorder, or as Grunwell (1997) claims, to identify "the order in the disorder." From a phonological analysis, clinical decisions can be made regarding appropriate target selection and intervention methods to be used.

Different analysis procedures are available to SLPs. Some are geared more toward describing mild to moderate speech disorders while others are more appropriate in analyzing severe to profound speech disorders. This chapter will provide a framework for phonological analyses, describe different analysis procedures, and conclude with a comparison of three different analyses in the description of one child's sound system.

COMPONENTS IN A PHONOLOGICAL ANALYSIS

WHO?	Speech-language pathologists who analyze children's sound systems
WHAT?	*System, Structure,* and *Stability* are the three components that comprise a phonological analysis of a child's sound system
WHY?	To provide a thorough analysis of disordered sound systems
HOW?	Determine the phonetic inventory, rules and organization, and consistency of a child's sound system

- Grunwell (1997) suggests that the primary objective of a phonological analysis is to *identify, describe,* and *classify* sound differences between a child's sound system and the target sound system.
- To accomplish this objective, Grunwell (1997) states that there are three key components of a phonological analysis: system, structure, and stability.
  - *System* includes the inventory of different sounds produced by the child. The sounds comprised in the system function contrastively to signal differences in meaning. For example, "*p*at" and "*b*at" differ in only one sound, but that difference signals a difference in meaning.
  - *Structure* refers to the rules and organization of the sound system. The structure of a sound system specifies the distribution and combination of sounds within a language. For example, the sound rules of English specify that the velar nasal [ŋ] cannot occur word-initially and that only certain consonant combinations are permissible (for example, [pl, bl, kl, gl] are permissible, but not *[tl, dl]).
  - *Stability* refers to the predictability of the speaker's systemic and structural patterns or organization of his or her sound system. The inventory of sounds (system) and the rules that govern the distribution and combination of sounds (structure) provide the organization and therefore the predictability of a "phonology."
- These three components provide a framework for any phonological analysis of children's speech.

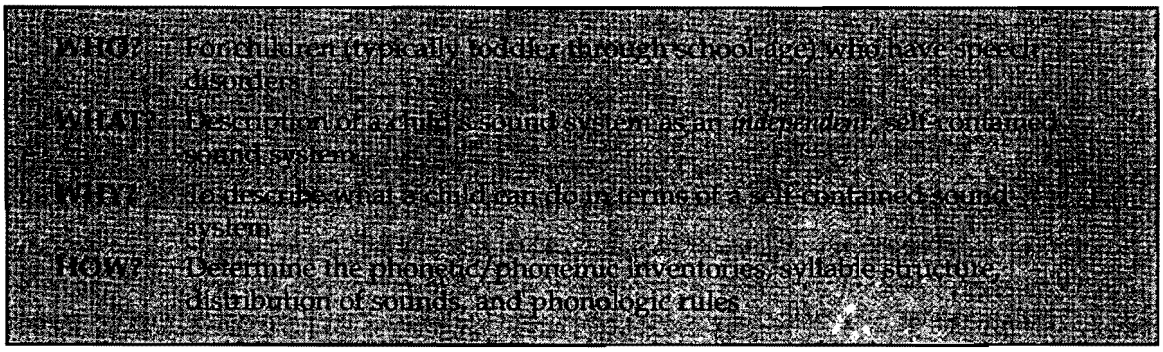
RELATIONAL ANALYSIS

WHO?	For children (typically toddler through school-age) who have speech disorders
WHAT?	Comparative description of a child's sound errors to the adult target
WHY?	To describe and classify a child's error productions relative to the adult target
HOW?	Sound-by-sound analysis or pattern analyses

- Most phonological analyses that SLPs complete on children's speech are relational analyses.
- Relational analyses provide a description of the child's sound errors *in relation* to the adult standard.

- Relational analyses make a one-to-one comparison of the child's production to the adult target and describe the differences with regard to SODA (substitution, omission, distortion, and addition), phonological processes, distinctive features, PVM (place-voice-manner) descriptions, phonological rules, or phoneme collapses.
- Because relational analyses describe only the sounds produced in error, they are also referred to as an *error analysis* of the child's speech.
- Some common relational phonological analyses include phonological process analysis and place-voice-manner analysis.
- Generally, relational analyses are based on shorter, single-word elicited samples and/or conversational speech.
- A relational analysis, such as a phonological process analysis or a PVM analysis, can be completed from the whole-word transcriptions of a standardized sound inventory test. There are also standardized phonological process analyses, as described in Table 2-6.
- Relational analyses might be more appropriate to use with children who have mild to moderate speech disorders because their sound systems are more intact and tend to have fewer idiosyncratic or unusual phonologic rules.

INDEPENDENT ANALYSIS

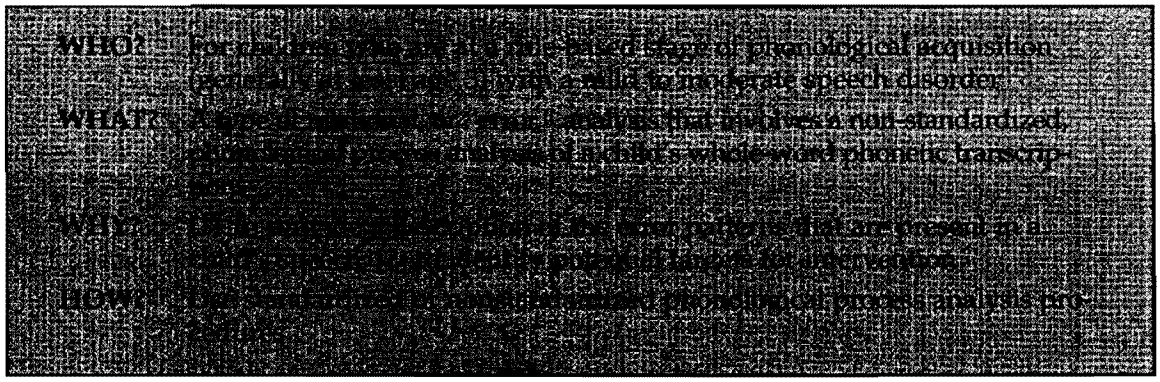


- An independent analysis is a more recently developed type of analysis that examines a child's sound system *independently* of the adult sound system.
- The child's speech is described as a unique, independent, self-contained sound system that considers the child's sound system as the "primary language."
- An independent analysis describes what sounds the child produces regardless of accuracy relative to the adult target.
- An independent analysis includes a description of the child's (1) phonetic inventory, (2) syllable structure, and (3) distribution of sounds in his or her language.
- An independent analysis describes what the child *does* as opposed to what he or she *does not* do relative to the adult target (in other words, relational analysis).
- Usually, an independent analysis is completed in conjunction with a relational analysis.
- Some phonological analyses that incorporate an independent analysis include the Assessment of Productive Phonological Knowledge (PPK; Gierut, 1988; Williams, 1991); Systemic Phonological Analysis of Child Speech (SPACS; Williams, 2001); and non-linear phonological analyses, such as autosegmental (Goldsmith, 1976; 1990),

lexical (Goldsmith, 1990), metrical (Goldsmith, 1990), feature geometry (McCarthy, 1988; Sagey, 1986), and optimality theory (Paradis, 1988; Barlow and Gierut, 1999).

- Phonological analyses that incorporate both an independent and relational analysis are generally based on longer samples of elicited words (100–250 words) and are typically used with children who exhibit moderate to severe speech disorders.
- The combination of an independent and relational analysis provides a more complete and thorough description of a child's speech.
- A fuller understanding of a child's speech is possible if we first understand the structure and organization of his or her own system (independent analysis).
- Information about the child's own sound system then provides a basis for relating the child's system to the adult system (relational analysis) in order to determine how the two sound systems (in other words, child:adult) are aligned.

PHONOLOGICAL PROCESS ANALYSIS: A RELATIONAL ANALYSIS



- Although there are a number of commercial phonological process tests available, research has demonstrated that an informal phonological process analysis that is independent of a closed set of processes was better in identifying children's error patterns than the published tests (see Research Support).
- Edwards (1994) suggested some guidelines for using a non-standardized phonological process analysis that included:
  - Using a representative speech sample of 50–100 words
  - Completing whole-word phonetic transcriptions
- The *Goldman-Fristoe Test of Articulation 2 (GFTA-2)* (Goldman and Fristoe, 1999) is commonly used as the basis for a non-standardized phonological process analysis.
- The non-standardized phonological process analysis described here will incorporate general procedures that are common to all such commercial tests without utilizing the procedures of any one particular test.
- A list of common phonological processes was compiled from phonological processes common to many commercial tests. This list is included in Table 3–1. As indicated in this table, phonological processes can be divided into four categories:
  1. *Deletion processes* in which a sound segment or syllable is deleted from the adult target
  2. *Substitution processes* in which one sound segment is replaced by another

3. *Assimilation processes* in which one sound segment influences the production of another sound to make it more similar to it in terms of place, voice, or manner
4. *Idiosyncratic processes* include sound changes that are unusual or atypical, such as [hɪp] for "ship."

TABLE 3–1 List of Common Phonological Processes

Structural Processes (Deletion Processes)	
Process	***Example***
Final Consonant Deletion (FCD): Deletion of a consonant at the end of a word.	hot [hɑ]
Initial Consonant Deletion (ICD): Deletion of a consonant at the beginning of a word.	hot [ɑt]
Cluster Reduction (CR): Deletion of one or more consonants in a consonant cluster.	stop [tɑp]; squirrel [kɜʊ]
Weak Syllable Deletion (WSD): Deletion of an unstressed syllable.	telephone [tɛfon]
Consonant Deletion (CD): Deletion of an intervocalic consonant.	Santa [sæə]
Simplification Processes (Substitution Processes)	
Stopping (ST): Substitution of a stop for an affricate or fricative.	cheese [tiz]; soap [top]
Fronting (FR): Substitution of an alveolar for a palatal or velar.	ship [sɪp]; gum [dʌm]
Backing (BA): Substitution of a velar or palatal for an alveolar.	top [kɑp]
Gliding (GL): Substitution of a glide for a liquid.	read [wid]
Vocalization (VO): Substitution of a vowel for a liquid.	scissors [sɪzʊz]; shovel [ʃʌvo]
Denasalization (DN): Substitution of an oral consonant for a nasal.	mop [dɑp]
Deaffrication (DA): Substitution of a fricative for an affricate.	peach [peʃ]
Apicalization (AP): Substitution of an apical consonant for a labial.	bee [di]
Labialization (LAB): Substitution of a labial consonant for a lingual.	thumb [fʌm]

(continues)

TABLE 3–1 *(continued)*

Simplification Processes (Substitution Processes)	
Process	***Example***
Glottal Replacement (GR): Substitution of a glottal stop for a consonant in the middle or end of a word.	coat [koʔ]
Idiosyncratic (ID): Unusual or atypical substitution.	car [sɑr]
Assimilation Processes and Whole Word Processes	
Velar Assimilation (VA): Substitution of a velar for a nonvelar when the word contains another velar.	cat [kæk]
Labial Assimilation (LA): Substitution of a labial for a nonlabial when the word contains another labial.	pot [pɑp]
Nasal Assimilation (NA): Substitution of a nasal for an oral consonant when the word contains another nasal.	mop [mɑm]
Prevocalic Voicing (PV): Substitution of a voiced sound for a voiceless, when followed by a vowel in the same syllable.	chimney [dɪmni]
Devoicing (DV): Substitution of a voiceless consonant for a voiced.	dog [dɑk]; zip [sɪp]
Reduplication (RD): Duplication of a stressed syllable within a word.	bottle [bɑbɑ]
Epenthesis (EP): Insertion of a sound in a word.	athlete [æθəlit]
Metathesis (ME): Reversal of two adjacent segments within a word.	ask [æks]
Coalescence (CO): Combination of two adjacent sounds resulting in two sounds being substituted with one.	sweep [fip]

- Important points to know before beginning a phonological process analysis include:
  1. *In general,* each phonological process changes one aspect of consonant production (place, voice, or manner).
  2. *Process ordering* is required when one sound error involves several different phonological processes. In this case, the application of multiple phonological processes in a sequential manner is required in order to account for all the

changes that are present relative to the adult target. Thus, the sequential application of processes is referred to as *process ordering*.

- An example of process ordering is shown as follows for a child's production of [dæt] for the target word "fat":

/fæt/	adult target
[pæt]	stopping
[tæt]	apicalization
[dæt]	prevocalic voicing

- Edwards (1992) described the occurrence of multiple processes affecting a single sound as *process density*. The further a child's production is removed from the adult target, the more phonological processes there are affecting that production. Edwards devised a metric to reflect the average number of processes that is used per word, called *process density index* (PDI). This rough measure of phonological severity is calculated by adding the total number of phonological processes that occurred for all words in a sample and dividing by the total number of words. The higher the PDI, the more severe the speech disorder. Caution should be exercised when using PDI as a severity measure, however, because all processes are given equal weight or value. For example, a common substitution process of stopping, such as t/s, is given the same value as an idiosyncratic substitution, such as w/s. Obviously, idiosyncratic errors will negatively impact intelligibility and thus increase the severity of the speech disorder—more so than the common substitution error.
- An exception to process ordering is the presence of unusual or idiosyncratic error productions, such as [l] for several different target sounds /w, s, ʃ/. In this instance, it is better to label all such unusual substitutions as idiosyncratic rather than try to apply numerous phonological processes to account for this unusual error pattern.

3. More than one phonological process can be used to label an error. For example, a child's production of [ʃɪp] for "sip" could be labeled as backing or palatalization. Either process would be correct; however, the process of palatalization provides a more precise description of what the child is doing rather than the broader and more vague process of backing.

- The following procedures are involved in completing a non-standardized phonological process analysis:

1. In order to examine the child's productions *in relation* to the adult target, the first step is to broadly transcribe the adult target for each test item. Note: The *GFTA-2* provides this first step on the response form.
2. Systematically list all phonological processes that occur in the child's production in a sequential fashion. Continue until all processes have been listed that account for the differences between the child and adult productions. An example might help illustrate this step:

Adult target	/fiŋgɚ/	"finger"
	piŋgɚ	stopping
	tiŋgɚ	apicalization
	diŋgɚ	prevocalic voicing
	diŋgʊ	vowelization

Notice in this example that target f → d involved the application of three different phonological processes (stopping, apicalization, and voicing), which changed the manner, place, and voicing of the target. Thus, each process only changed one aspect of consonant production. In this example, the PDI would be 4; in other words, four different phonological processes operated on this one word. This situation indicates that the child's production was further removed from the target than would be indicated if the child had produced "finger" as [piŋgʊ], which would be a PDI of 2.

3. Organize and summarize the phonological processes identified in the analysis.
   a. A summary sheet (Williams, 2001) organizes the processes according to deletion, substitution, assimilation, and idiosyncratic processes. The Summary Sheet for the Non-Standardized Phonological Process Analysis is included in Appendix E.
   b. The number of occurrences of each process is summarized on the summary sheet.
   c. The relative ages at which the most common processes are suppressed according to Grunwell (1987) are included on the summary sheet.
4. Edwards (1994) suggested that additional information be provided to more specifically describe how the processes were applied in a sample of a particular child. Specifically, additional information would be provided about the following:
   a. Process limitation or application with regard to a class or classes of sounds
   b. Process limitation with regard to the position(s) in which the process is applied
   c. Frequency of process occurrence
   d. Consistency of the process application (in other words, which processes were the most consistent)
   e. Presence of process interaction

      Example: In the production of [diŋgʊ] for "finger," there was a process interaction of stopping, apicalization, and prevocalic voicing in the sound change of f → d.
   f. Persisting normal processes
5. The final step in the phonological process analysis is selection of treatment targets.

   There are different perspectives about choosing the most appropriate phonological processes for intervention. One perspective is to select the most frequently occurring processes because these would have the greatest impact on intelligibility. Another option is to use a developmental perspective and select processes that have persisted beyond the age at which they should have been suppressed. A third option is a combination of the first two options and involves the selection of developmentally appropriate processes that are also frequently occurring.

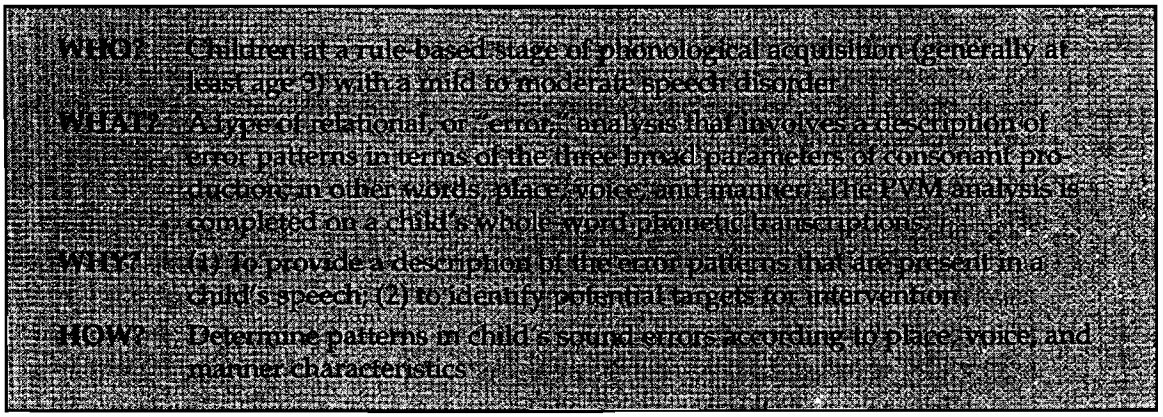
- Advantages of a phonological process analysis:
  1. A description of the error patterns is provided.
  2. By identifying error patterns, more efficient intervention can be developed.
  3. The use of phonological process terms is common among SLPs and is easily understood by parents and teachers.

- Disadvantages of a phonological process analysis:
  1. The amount of time required to complete the analysis, particularly as compared to a similar analysis (PVM analysis) that takes less time
  2. The selection of treatment targets from the summary sheet is not always so obvious or easy. Frequently, the clinician must refer back to the analysis to determine the specific application of a phonological process.
  3. Only errors are described, and no information is provided about what the child can do. Thus, the phonological process analysis is also called an error analysis.

Research Support

Dunn (1982) compared a non-standardized phonological process analysis to several commercial phonological process analyses in the description of one child's error patterns. She found that the APP (Hodson, 1980) captured more of the child's error patterns than the other commercial analyses. None described as many of the child's error patterns, however, as the non-standardized phonological process analysis.

PLACE-VOICE-MANNER ANALYSIS: A RELATIONAL ANALYSIS



- The PVM analysis describes a child's patterns of error productions on the basis of three broad categories of consonant production—place, voice, and manner of articulation.
- The PVM analysis was first described by Weber (1970) and later by Turton (1973), but it has also been used in the commercial tests of the *Fisher-Logemann Test of Articulation* (Fisher and Logemann, 1971) and the *Compton-Hutton Phonological Assessment* (Compton and Hutton, 1978).
- A PVM analysis can be completed on whole-word transcriptions from a sound inventory test, such as the *Goldman-Fristoe Test of Articulation-2*.
- The Place-Voice-Manner form is used to complete the analysis (see Appendix F). This form was developed by Thomas Powell at Indiana University in 1982. This form organizes the consonants according to manner (nasals, fricatives, affricates, liquids, and glides) along the top row of the form. Within each manner class, the consonants are listed according to place of production from the most anterior to the most posterior. Finally, voicing is indicated by shading of the voiced consonants.

- Below each consonant, there are three rows that correspond to the three syllable positions of prevocalic, intervocalic, and postvocalic. These syllable positions are listed on the left margin of the form beside each row. The clinician can choose to use word position rather than syllable position. In that case, the rows would represent word-initial, word-medial, and word-final positions. There are shaded boxes on the form to represent syllable positions (or word positions) in which a particular consonant cannot occur in English. Specifically, /ŋ/ cannot occur prevocalically (or word-initially), and glides [w, j, h] cannot occur post-vocalically (or word-finally).
- The bottom of the form contains boxes where target clusters can be included in the analysis. The clusters are divided into nasal clusters, [l] clusters, [r] clusters, [w] clusters, and [s] clusters. Examples of specific clusters are listed at the bottom of each cluster box.
- There are two final boxes on the bottom-right section of the PVM analysis form. One box provides space for the child's phonetic inventory, and the other box provides a space to summarize the predominant error patterns according to place, voice, and manner.
- Important points to know before completing a PVM analysis:
  1. Although the PVM analysis is an assessment of consonant production, vocalic [l], vocalic [r] – [ɜ˞, ɚ˞] and the family of diphthong [r]'s can be recorded in the columns for [l] and [r].
  2. Color coding is used in completing this analysis, which increases the visualization and identification of error patterns. Tally marks in blue or black ink can be used for correct productions, and a red pen can be used to write in the child's error productions. After the analysis is completed, a visible pattern of the child's errors can be easily identified.
- The following procedures are used for completing the PVM analysis:
  1. Proceed word by word from the whole-word transcriptions of the child's single-word sample. Within each word, proceed consonant by consonant until all of the child's consonantal responses have been recorded on the PVM form.
  2. Mark each consonant with the appropriate color pen (black = correct; red = incorrect) in the appropriate box for syllable or word position of the target consonant.
  3. Use tally marks to indicate multiple occurrences of a consonant, either correct or incorrect.
  4. List each error that might occur for a particular sound in a given position.
  5. Errors of deletion are indicated by the null sign, "Ø."
  6. Mark clusters in the appropriate boxes, continuing to use black pen for correct productions (such as, br – /) and the red pen to specify errors (such as, b/br – /).
  7. List the sounds produced by the child in the Phonetic Inventory box. You might choose to construct the child's phonetic inventory on the basis of independent or relational analyses. For the independent analysis, all sounds produced by the child are listed in the phonetic inventory regardless of their accuracy. For the relational analysis, only those sounds produced correctly are listed in the phonetic inventory.

- Stoel-Gammon (1987) and others suggest that a sound must occur at least two times in order to be included in the phonetic inventory. Sounds that occur fewer than two times can be listed in the inventory as marginal sounds. This situation can be indicated by placing the marginal sounds in parentheses.

8. In the last box, write the predominant error patterns that were noted according to errors of place, voice, and manner.

   For example:

Place	replaced velars with alveolars
Manner	replaced fricatives with stops
Voice	replaced voiced with voiceless
Other	replaced clusters with singletons

9. The final step in the PVM analysis is the selection of treatment targets. Similar to the phonological process analysis, a developmental or intelligibility perspective can be used, or a combination of both, for target selection.

- Advantages of the PVM analysis:
  1. Relatively simple and quick to complete
     a. PVM analysis provides similar results as a phonological process analysis and requires less time.
     b. The PVM analysis and summary sheet were together on one page, whereas the process analysis required several pages to complete and was separate from the summary sheet.
  2. The visual representation of patterns is the most functional advantage of the PVM analysis.
     a. Patterns are easily identified by the color coding of the errors and the organization of the PVM form.
     b. The selection of targets for intervention is enhanced by the visual display of the completed analysis.
  3. Because color coding is used to tally correct and incorrect consonant productions, the PVM form enables the clinician to see not only the errors in the child's speech, but also what the child is capable of doing correctly.
  4. The PVM form provides a useful tool for communicating analysis results to parents and other professionals.
  5. The PVM form is also useful in comparing pre- and post-intervention phonological analyses.
- Disadvantages of the PVM analysis:
  1. Does not identify assimilation errors
  2. Does not provide a description of deletion errors within the three broad parameters of place, voice, and manner, although these errors would be noted by the red null in the specified consonant rows or in the cluster boxes and could be specified as "Other" in the box for summary of predominant error patterns

INDEPENDENT + RELATIONAL ANALYSES

WHO? Children at a rule-based stage of phonological acquisition (generally at age 3 1/2) with a moderate to severe speech disorder

WHAT? Independent + relational phonological analyses of children's speech

WHY? To provide a detailed description of a child's unique sound system as it relates to the adult sound system

HOW? Determine the unique characteristics of a child's sound system and then compare that sound system to the adult sound system.

The combination of an independent and relational analysis provides a more complete description of the organization and rules of a child's sound system. Recall that an independent analysis examines a child's sound system as a unique, "exotic," self-contained sound system. A relational analysis then maps the child's unique sound system onto the ambient, or target, sound system.

Independent + relational analyses provide a *system-to-system* comparison of adult-to-child sound systems. This information is contrasted to the relational, or error, analyses described previously that involve *sound-to-sound* comparisons between the adult and child productions.

- Completing an independent analysis first provides the clinician with a basis for understanding the child's sound system and discovering the "order in the disorder."
- Different analyses utilize independent + relational analyses in the assessment of a child's sound system. One common analysis approach that has been frequently reported in the literature is the assessment of productive phonological knowledge (PPK), as described by Gierut (1986) and Gierut, Elbert, and Dinnsen (1987).
  1. This approach assesses productive phonological knowledge by using the tenets of standard generative phonology to infer the nature of a child's underlying representations, or competence, from the child's productions (in other words, performance) on an extensive list of words plus a conversational sample.
  2. We will describe this approach in greater detail in a following section.
- Another approach that incorporates independent + relational analyses is the Systemic Phonological Analysis of Child Speech (SPACS) described by Williams (2001).
  1. This approach incorporates aspects of Grunwell's (1987) work of mapping the child's system to the adult system.
  2. No inferences are made about a child's knowledge of the ambient sound system.
  3. This approach focuses on the description of the structure and organization of the child's sound system as it relates to the adult sound system.
  4. The mapping of the child-to-adult sound system is described in terms of phoneme collapses that are viewed as compensatory strategies developed by the child to communicate in the ambient language with his or her "own language" or limited sound system.
  5. We will describe this approach in greater detail in the following section.

SYSTEMIC PHONOLOGICAL ANALYSIS OF CHILD SPEECH (SPACS)

WHO? For children who are at a rule-based stage of phonological acquisition (generally at least age 3) with a moderate to severe speech disorder

WHAT? Systemic Phonological Analysis of Child Speech (Williams, 2001)

WHY? (1) To provide a description of the organization and rules that are present in a child's sound system; (2) to identify potential targets for intervention

HOW? Compare the child:adult sound systems in terms of phoneme collapses

General Information

- Child's entire sound system is examined as a unique, independent system and viewed as child's "own language"
- SPACS views child as an active and creative learner of the adult sound system
- SPACS maps the child's sound system to the adult's sound system by diagramming phoneme collapses.
- The collapse of several adult phonemic contrasts results in a one-to-many correspondence between the child:adult systems.

Procedures in completing a systemic phonological analysis include the following:

1. Obtaining an extensive sample of the child's productions by using an instrument such as the Systemic Phonological Protocol (SPP; Williams, 1992; and reprinted in Appendix C)
   a. This protocol elicits each target consonant a minimum of five times in each word position in which it can occur. It also provides opportunities to elicit minimal pairs and morphophonemic alternations in word-initial and word-final positions.
   b. Completing whole-word phonetic transcriptions of the child's responses
2. Organize the sample by consonant and by position.
3. Use the form for a Systemic Phonological Analysis of Child Speech (Appendix G) to complete the following steps.
4. Construct the child's phonetic inventory independently of the accuracy of his or her productions.
   a. Use Stoel-Gammon's (1987) criterion of two occurrences of a sound to be included in the inventory.
   b. Separate inventories can be constructed for word-initial and word-final phonetic inventories to provide additional information, or a composite inventory across all positions can be constructed.
5. List the distribution of sounds in the child's language.
   a. This information is Part II on the SPACS form.
   b. Indicate the presence, absence, or marginal occurrence for each consonant in each position by using the following notation:

(1) The presence of a sound in a given position is indicated by an "X."

(2) The absence of a sound in a given position is indicated by an open box, "□."

(3) The marginal occurrence of a sound in a given position is indicated by a fraction that specifies how many times the sound was produced out of the total number of times the sound occurred in the sample. For example, "5/7" indicates that the child correctly produced the target sound in that position 5 times out of 7 opportunities.

c. Concomitantly with (b), specify what the child did in the event of marginal or absent productions of target sounds in target positions. Write above the box or fraction the sound produced by the child, or write "Ø" if the child deleted the sound in a given position. This system will provide the basis for your mapping.

d. Identify patterns in the child's production of target clusters. To identify patterns in the child's production of target clusters, it will be important to classify clusters according to one of the following categories:

Stop clusters	***Fricative Clusters***	***Broad Classification***
stop + liquid stop + glide	fricative + liquid fricative + glide fricative + nasal	C + sonorant
	fricative + stop	C + obstruent

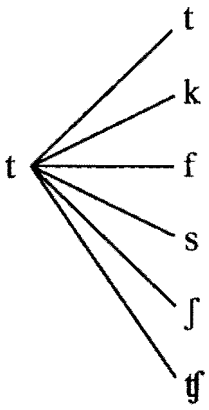
(1) Children develop different strategies to compensate for target cluster production just as they do to accommodate a limited phonetic inventory and distribution of English consonants.

(2) They might develop rules that correspond to specific target clusters, such as "stop + liquid" and "fricative + liquid" clusters. They also might, however, develop rules that are broader than these categories and that encompass all "consonant + sonorant" clusters, which would include all the above clusters except "fricative + stop" clusters. There are variations between these two extremes that reflect the level of differentiation in the child's acquisition of target clusters. Some children might have a rule that differentiates the first consonant of the cluster on the basis of place and manner. For example, "labial stops + consonants" are produced as [f] is an example of a rule that specifies the first consonant but not the second consonant of the cluster.

e. Map the child's system onto the adult's system by diagramming phoneme collapses.

(1) In typical speech, there is a one-to-one correspondence between a target sound and the speaker's production.

(2) In disordered speech, however, there is frequently a collapse of several adult phonemic contrasts to a single sound. This situation results in a one-to-many correspondence. An example is a child's production of [t] for several adult sounds, such as [t, k, f, s, ʃ, tʃ]. In this example, the child has collapsed six different adult sounds into one sound, [t]. This phoneme collapse can be diagrammed as follows:



(3) To identify the phoneme collapses in a child's sound system, return to the distribution of sounds that was completed as part of (c). Part III of the SPACS form includes a section for diagramming phoneme collapses. The collapses are diagrammed by word position.

(4) In the distribution section (Part II) of the form, look for a sound that was used frequently for other target sounds in word-initial, word-medial, and word-final positions.

(5) Write the sound produced by the child in Part III under the specified position, and then diagram all the target sounds that were produced by the child with that one sound.

- Remember to list these sounds in an organized fashion; in other words, list all consonants in one manner category and by place within the manner category.
- Target clusters would be included in the collapses if the child produced the cluster with the same sound as you are diagramming the target singleton collapses.
- Continue diagramming the major phoneme collapses identified in each word position.

f. Identify organization principles that are present in the child's structure of his or her phonological system

(1) Generally, there is a correspondence between the phonetic properties of the child's production and the adult target. In the phoneme collapse diagrammed previously, the child produced a voiceless obstruent [t] for several target voiceless obstruents; that is, [t, k, f, s, ʃ, tʃ].

(2) Identification of organizational principles will lead to the identification of compensatory strategies developed by the child that correspond to the phonetic properties of the ambient sound system.

(3) Look for organized, predictable, logical, and symmetrical patterns.

g. Select targets for intervention.

(1) Williams (2000) described the guidelines for the selection of treatment targets that will have the potential for maximum reorganization and therefore have the greatest impact on intelligibility. These guidelines are discussed in detail in Chapter 4, "Guidelines for Selection of Treatment Targets: Systemic Approach."

Clinical Insight

A helpful hint in completing SPACS is organization of the analysis in terms of place and manner of consonant production.

- Organizing the child's phonetic inventory, distribution of sounds, and mapping of child:adult systems will help the clinician identify gaps in the child's inventory and patterns in their organization.
  - Organize sounds first according to manner of consonant production, such as stops, fricatives, and so on.
  - Then, organize sounds within each manner classification according to place of production, starting from the most anterior to the most posterior place of production (such as, labial, alveolar/velar for the stops).

Advantages of SPACS include the following:

- Examines correct as well as incorrect aspects of child's speech
- Provides a holistic assessment of child's sound system
- Is child-based rather than adult-based
- Describes idiosyncratic errors not captured by common phonological processes
- Phonological rules (phoneme collapses) are seen as compensatory strategies that are organized according to particular aspects of the adult sound system in terms of place, voice, and manner.
- Organizational scheme reflects unique strategies to compensate for restricted sound system

Disadvantages of a SPACS include the following:

- Although mapping of phoneme collapses is possible on smaller samples, a thorough understanding of the child's sound system requires a minimum of 100 words.
- It is time intensive to organize the sample and complete the distribution and mapping procedures. With experience, however, the analysis can generally be completed in about 30–45 minutes.

ASSESSMENT OF PRODUCTIVE PHONOLOGICAL KNOWLEDGE (PPK)

WHO? For children who are at a rule-based stage of phonological acquisition (generally at least age 3) with a moderate to severe speech disorder.

WHAT? Assessment of Productive Phonological Knowledge (Gierut, (1986); Gierut, Elbert, and Dinnsen (1987)

WHY? (1) To describe the nature of children's underlying representations relative to the ambient sound system in order to quantify what is known about the target language and what is unknown; (2) to identify potential targets for intervention.

HOW? Compare the child:adult sound systems in terms of productive phonological knowledge.

In the mid 1980s, the assessment of productive phonological knowledge (PPK) was introduced to describe disordered sound systems. The methodology and procedures of standard generative phonology were borrowed from the field of linguistics to assess the sound systems of children with phonological disorders. As with other approaches, targets for intervention are selected on the basis of the phonological analysis. The assessment framework of PPK, however, does not select targets solely on the basis of an identified error pattern. Instead, targets are selected on the basis of the child's PPK.

Productive phonological knowledge has been defined by Elbert and Gierut (1986) as a speaker's *competence* and *performance* of the ambient sound system. Performance includes the phonetic and phonemic inventories and the distribution of the sounds in the sound system. These aspects of a sound system are contained in the surface level of representation. Evaluation of competence includes the way morphemes are stored in the speaker's mental lexicon, or underlying representation, as well as the phonological rules that operate on the underlying representations to yield the surface representation. Competence, therefore, includes the other two levels of organization: underlying representations and phonological rules.

Because underlying representations and phonological rules are abstract constructs that cannot be measured directly, they must be inferred on the basis of the child's productions. Empirical evidence is needed to infer the way in which a morpheme is stored in the underlying representations. Assessment of a child's PPK is based on production data only and does not include information about the child's speech perception abilities.

Specific types of data must be collected to determine the nature of the child's stored morphemes, or PPK. According to Elbert and Gierut (1986), three types of data must be collected: (1) elicit each target sound in each word position a minimum of five times in each position; (2) elicit potential minimal pairs; and (3) elicit potential morphophonemic alternations (in other words, variations in the way a speaker produces a phoneme when it occurs in a different context).

There are several protocols that have been developed to elicit the single word sample needed to assess PPK. One is a screening protocol developed by Maxwell and Rockman (1984) to examine a child's phonological knowledge of final consonants. A more extensive protocol is the Phonological Knowledge Protocol (PKP) developed by Gierut (1985), which contains 198 items. The Systemic Phonological Protocol (SPP; Williams, 1992) described previously is an adaptation of the PKP and includes 245 items that samples clusters as well as singletons, elicits potential morphophonemic alternations word-initially and postvocalically, and includes meaningful words.

Three components are considered when determining a child's PPK. These components include: (1) the distribution of sounds in the child's speech; (2) the presence of phonological rules; and (3) the nature of the child's underlying representations as correct (that is, adult-like) or incorrect (that is, non-adult-like).

Once the child's PPK has been assessed, it is ranked on a continuum, or hierarchy, of knowledge. According to Elbert and Gierut (1986), there are six types of phonological knowledge that can be ranked on the continuum of knowledge. These are described as follows:

Type 1: child's underlying representations are identical to the adult's underlying representations for all morphemes in all positions, and no phonological rules apply

Type 2: child's underlying representations are identical to the adult's, but phonological rules apply to change the production of the morpheme at the surface representation

Type 3: isolated incorrect production of particular fossilized forms that have been resistant to change; for example, the child produces [maezəgin] for "magazine"

Type 4: child has correct underlying representation for a target sound in some, but not all, positions in which the sound might occur; referred to as phonotactic positional constraints

Type 5: hypothesized logical possibility that has actually never yet been observed. It is a cross between Type 3 (fossilized forms) and Type 4 (positional constraints) in which a child only correctly produces a target sound post-vocalically in some "unfossilized" morphemes (Type 3) but never word-initially (Type 4).

Type 6: sounds that are represented by non-adult-like underlying representations in all positions and for all morphemes. This situation is characterized by phonotactic inventory constraints.

A summary of the knowledge types adapted from Elbert and Gierut (1985) is presented in Table 3–2.

TABLE 3–2

Knowledge Type	*Underlying Representation*	*Target Position(s)*	*Target Morphemes*	*Rule*
1	Correct	All	All	None
2	Correct	All	All	Phonological or phonetic rules
3	Correct	All	Some	Fossilized forms
4	Correct	Some	All	Phonotactic Positional Constraint
5	Correct	Some	Some	Hypothesized combination of 3 and 4
6	Incorrect	All	All	Phonotactic Inventory Constraint

Using these six types of knowledge, the child's PPK is then ranked on a continuum, or hierarchy, of knowledge. The continuum of knowledge ranges from "most knowledge" at the top to "least knowledge" at the bottom.

Dinnsen, Gierut, and Chin (1987) developed a quantitative measure that determines the proportion of a child's system that is represented by each type of knowledge ranked on the continuum. According to this procedure, one point is assigned to each target sound for each word position in which it occurs in English. Thus, a sound that occurs in three word positions (initial, medial, and final) would receive 3 points, whereas a sound that only occurs in two word positions (for example, [h]) would receive 2 points. The points are assigned to the sounds at each knowledge type along the continuum and then divided by the total number of points for all English consonants, which is 65.

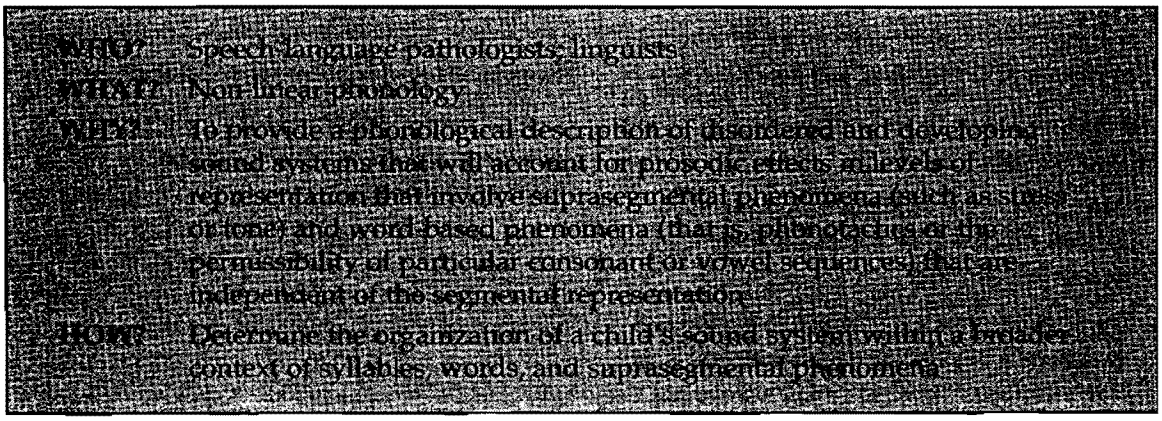
Recently, Forrest, and Morrisette (1999) and Williams (2000b) have utilized this procedure to calculate the percentage of correct underlying representations (PCUR) as a measure of a child's knowledge of the ambient sound system. Knowledge types 1, 2, 3 represent adult-like, or correct, underlying representations and knowledge types 4, 5, 6 represent non-adult-like, or incorrect, underlying representations. Thus, PCUR reflects the proportion of a child's sound system characterized by knowledge types 1, 2, and 3.

Based on the assessment of a child's PPK, sounds can be selected for intervention. Several studies have demonstrated that there is a relationship between PPK and generalization learning (Dinnsen and Elbert, 1984; Elbert, Dinnsen, and Powell, 1984; Gierut, Elbert, and Dinnsen, 1986; Williams, 1991). Specifically, a child's performance will be better on phonologically "known" aspects of his or her sound system than on phonologically "unknown" aspects. Further, Gierut et al. (1986) found that training order also influenced performance. They found that children who were trained in the order of least-to-most knowledge demonstrated more system-wide changes than children who were trained in the order of most-to-least knowledge. Given the relationship between PPK and generalization learning, Gierut et al. suggested that treatment targets should be selected from those aspects of the child's system that represent the least phonological knowledge.

There are some final considerations in the assessment of a child's PPK. First, the definition and characterization of PPK are believed by some researchers to be too narrow. Tyler, Edwards, and Saxman (1990) advocate the use of perceptual and acoustic information in addition to production data in assessing PPK. Williams (1991) claimed that the definition and assessment of PPK as a dichotomous categorization of "correct" or "incorrect" cannot account for the possibility of partial knowledge that a child might have for a particular sound or class of sounds.

Secondly, it might prove more beneficial in selecting training targets to consider the child's overall phonological system rather than one aspect, such as inventory constraints or least knowledge. Consideration of the child's overall system might provide more accurate and insightful information on the nature of the child's phonological learning. The severity of the disorder might have a greater influence on phonological learning than the individual category or knowledge or the training order that is selected for treatment.

NON-LINEAR PHONOLOGY



- In the 1980s, non-linear phonology was developed as an alternative to linear, or segmental, phonology in order to account for the inability of linear phonology to explain the influence of larger units above the level of the segment.
- Linear phonology's view of the sound segment as the ultimate unit for phonological rules could not account for prosodic influences, phonotactic constraints in languages, or express significant phonological generalizations that involve the larger unit of the syllable.
- Non-linear phonology's view of the syllable as a legitimate unit in phonological description is able to explain the relationships among various sizes of units that were previously restricted by linearly sequenced strings of sound segments.

- The development of non-linear phonology, therefore, represents a significant departure from the earlier linear models in that it can explain interactions that occur across various sizes of units (feature, syllable, and word) and types of units (stress, tone) in phonological representations that cannot be described by operations across a single linear sequence of phonological units.
- There are several different models of non-linear phonology, including autosegmental phonology (Goldsmith, 1976, 1990); metrical phonology (Goldsmith, 1990); lexical phonology (Goldsmith, 1990); feature geometry (McCarthy, 1988; Sagey, 1986); and optimality theory (Paradis, 1988).
- The commonality of all of these non-linear models is their emphasis on phonological *representations* rather than phonological *rules*.
- These theories are not restricted to general phonology, but they also have been recently considered with regard to their applications to phonological development and phonological disorders in children.
- In sum, non-linear phonology moves beyond descriptive accounts of children's surface patterns to an understanding of their *internal organization* and representation of their sound systems that motivates the surface patterns. If we understand the internal organization, we can better design effective interventions. It is believed that intervention is more effective by addressing and manipulating hierarchially organized *features* or *constraints*.
- Table 3–3 summarizes the comparison of linear and non-linear approaches to phonological analysis.

TABLE 3–3. Comparison of Linear and Non-Linear Approaches to Phonological Analysis

Linear	***Non-Linear***
Segments and features are inseparable.	Segments and features are independent.
All features of a segment are equal and unstructured. • No justification for one segment to be deleted, added, or modified over another segment • No justification for a phonological rule to affect any one group of features over another • Only whole segments can be deleted or added.	Features are organized into structured bundles with minimally specified representations.
Emphasis is on formulating phonological rules.	Emphasis is on formulating phonological representations.
Unit of phonological description is the sound segment	Unit of phonological description is the syllable

CASE STUDY: COMPARISON OF THREE PHONOLOGICAL ANALYSES

WHO? Speech-language pathologists who assess speech disorders in young children

WHAT? A comparison of three phonological analyses of one child

WHY? To demonstrate different assessment outcomes and compare selection of treatment targets based on each analysis

HOW? Look at the relative benefits and drawbacks when different methods are compared

To illustrate three different phonological analyses discussed in this section, a data sample from one child, Fred, will be used. Fred is a 4-year-old boy who exhibited a severe phonological disorder. Whole-word transcriptions are provided in Table 3–4 from his single-word responses to the *Goldman-Fristoe Test of Articulation* (Goldman and Fristoe, 1986). The results from three analyses, PPA, PVM, and SPACS, will be compared with regard to their descriptions of Fred's sound system, the identification of error patterns, and the selection of treatment targets.

TABLE 3–4 Fred's Single-Word Responses on the GFTA.

Target Word	*Fred's Production*	*Target Word*	*Fred's Production*
house	aʊ	pencils	pɪʔkə
telephone	gɛəbo	this	ɪʔ
cup	gʌ	carrot	gʊə
gun	gʌ	orange	ɔɪwi
knife	aɪ	bathtub	bægʌ
window	wɪgo	bath	bæ
wagon	wæ	thumb	pʌm
wheel	wʊ	finger	pigʊ
chicken	gɪʔə	ring	wi
zipper	jɪpʊ	jumping	gʌʔɪ
scissors	gɪʊ	pajamas	gəwæ
duck	gʌ	plane	be
yellow	jɛo	blue	bu
vacuum	bægu	brush	bʌ
matches	mæə	drum	gʌ
lamp	æ	flag	bʷæ

(continues)