Phonological Analysis and Treatment Targets Version 2.0

User Manual

Overview

Phonological Analysis and Treatment Targets (PATT) is a protocol with step-by-step procedures for independent phonological analysis of English and/or Spanish speech samples. The results of these analyses are then used to guide treatment target selection for maximal impact across the sound system according to principles of linguistic complexity and treatment efficacy evidence for children with speech sound disorders.

Updates in Version 2.0

- Name changed from Phonological Assessment and Treatment Target Selection to Phonological Analysis and Treatment Targets to clarify that the procedures outlined can play a role in the assessment process, but they, alone do not constitute a comprehensive speech assessment.
- The PATT User Manual was developed to provide thorough and step-by-step instructions for completing the PATT protocol, with tutorial videos, and includes evidence that informed PATT protocol development.
- Target selection guidelines have been updated in accordance with the updated research published since the development of the first version. Consequently, the effect of linguistic complexity, especially syllable-level complexity via consonant clusters in English and Spanish is given additional emphasis.
- Instructions in the protocol have been streamlined to simplify the target selection process.
- Tools to assist with speech sampling and more detailed instructions and support have been added to the PATT User Manual.

How to Cite this Resource

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Analysis

The procedures outlined in PATT are centered upon independent speech sound inventory analyses which provide a holistic description of a child's developing speech sound (i.e., phonological) system. These independent analyses follow procedures similar to those used by linguists, in keeping with the linguistic frameworks and procedures implicated in much of the evidence base that informs complexity-based intervention target selection. Independent inventory analyses are also descriptive in nature, and do not require comparison to model productions. This contrasts with accuracy calculations that can be misleading when applied unilaterally across diverse individual phonological systems (e.g., across users of different dialects and language varieties, or multilingual learners).

Treatment/Intervention Target Selection

PATT procedures for target selection constitute a complexity-based approach to intervention for children with developmental speech sound disorders, as described in Gierut (2007) and Storkel (2020) and reviewed in Tambyraja and Dunkle (2014). The original version of these procedures was adapted from Gierut (2004) and Morrisette et al. (2006).

A good intervention target represents new area(s) of speech sound knowledge for the child. Further, by teaching a previously unknown target, the child's phonological system is more likely to expand. This form of broad generalization can result in improvement to untreated sounds and sequences, especially if the converging implicational language relationships and typical developmental trajectories indicate that the target is more complex relative to other sound structures (see Evidence in Support of these Guidelines at the end of this manual).

Procedures

Data Required

PATT procedures require the following data to assess a child's phonological system:

1. Transcriptions of a thorough speech sample, used to generate inventories
2. results of a stimulability assessment, if available

To reliably generate phonetic, phonemic, and cluster inventories for analysis, a speech sample must include sufficient opportunities to produce the singleton phonemes and consonant clusters of the language(s) assessed **at least two times** in each permissible word position. Screening probes or short conversation samples typically do not provide sufficient production opportunities for reliable inventories; however, these can be used in conjunction with supplemental probes. PATT was developed using speech samples from the following probes, available under Resources at the end of the User Manual:

- Singletons and Clusters Probe from the *In-Depth Phonological Assessment* (Taps Richard, 2012)
- *Shorter Protocol for the Evaluation of English Phonotactics* (Little PEEP; Barlow, 2012)
- *Evaluación de la Fonología Española* (EFE; Barlow & Combiths, 2020)

Part 1. Assessment and Analysis

Once one or more representative speech samples are collected and transcribed using the International Phonetic Alphabet (IPA), the speech-language therapist (SLT) or speech-language pathologist (SLP) may proceed through PATT **Part 1 Steps 1**–**3** to generate inventories.

After completing each of three independent inventory analyses, SLPs are directed to identify phones, phonemes, and consonant clusters that are present (IN) and absent (OUT) from an individual's phonetic, phonemic, and cluster inventories, respectively. These are used to describe the individual's phonological knowledge and identify gaps that may be addressed with intervention. Model inventories based on the specified language of the PATT form are provided to facilitate this process; however, care must be taken in this step to interpret gaps in phonological knowledge as they relate to the target adult form of the assessed individual's language variety or multilingual background.

Step 1. Phonetic Inventory.

IN Phones

A phonetic inventory is based exclusively on the child's productions, in **any** location, even when produced in a context that is not considered accurate. Using the child's transcribed speech sample, any transcribed speech segment that **occurs at least two times** in the sample is included in the phonetic inventory.

1. Skim word-by-word through the sample.
2. The first time you encounter a speech sound in the sample, underline that sound in the model phonetic inventory on the PATT form. If the sound is not listed on the PATT form, write the segment into the inventory and underline it.
3. The second time you encounter a speech sound in the sample, circle that sound. Only sounds that are circled are considered IN the phonetic inventory.

Tutorial: A video tutorial for generating a phonetic inventory is available here: https://youtu.be/gq5s-08jrcc

Additional Instructions:

- Once a sound has been identified twice and circled on the PATT form, you do not need to note additional occurrences.
- Sounds identified only once in the sample (underlined but not circled) are not included in the phonetic inventory.
- The sounds printed in the model phonetic inventory on the PATT form provide commonly used IPA characters to represent each consonant of the target language for the PATT form being used (e.g., Mainstream American English, Standard Latin American Spanish). This is not a comprehensive set of all the sounds a child might produce in their speech sample. Write into the form any sound not listed that occurs in the sample. Depending on the level of detail in the transcribed sample, sounds not listed in the model are likely to occur. These may be:
    - allophones or expected variations of the provided segments in the language variety used by the child,
    - sounds influenced by one or more other languages spoken by a multilingual child.
    - non-ambient or idiosyncratic sounds not expected in the child's language variety. All sounds produced twice should be included in the inventory.
- Include any distinct segment that occurs twice in the inventory. Segments with a diacritic (e.g., [p^h], [$w^ɹ$], [$t̪$]) are distinct from segments without them (e.g., [p], [w], [t]). This means [p^h] and [p] are counted separately, and either one can be in the inventory if it occurs twice.
- Include **ALL** segments produced twice in the sample, even if they are non-ambient (i.e., not part of the target language). For example, [β] is not typically produced if a child produced the segment [β] (voiced bilabial fricative) two times in the sample, this is written into the inventory, underlined, then circled.

OUT Target Phones

Any phones (i.e., speech segments) that are expected in the child's target language but were not included in the child's IN phonetic inventory are listed in the OUT Target Phones box to the right of the IN phonetic inventory on the PATT form. The phones OUT of the child's phonetic inventory provide information about gaps in the child's phonological knowledge and areas of potential growth to guide treatment target selection.

Note that the sounds printed in the model phonetic inventory on a PATT form only provide commonly used IPA characters to represent the consonants of one target language variety/dialect. These targets may not be an accurate reference of target consonants for every speaker of the specified language. **Only those phones that are obligatory in the language variety/dialect being acquired by the child should be referenced for determining OUT phones missing from the child's phonetic inventory.**

Step 2. Phonemic Inventory (PATT – English Only*)

IN Phonemes

Phonemes are speech sounds used to distinguish different words. Minimal pairs are semantically distinct word pairs with minimal phonological contrast that demonstrate a speech sound's phonemic function. For instance, /pɪt/ "pit" and /bɪt/ "bit" are a minimal pair in English that establishes a contrast between the phonemes /p/ and /b/. A phonemic inventory uses evidence from minimal pairs in a transcribed speech sample to identify phonemes used by the child. Using the child's transcribed speech sample, two occurrences of a sound functioning as a phoneme (i.e., two minimal pairs) are recommended to include a sound in the phonemic inventory.

1. Highlight or identify all monosyllabic words (words with only one syllable) in the speech sample. These short words are the most likely to form minimal pairs.
2. Group the monosyllabic words according to the vowel in the word.
    a. For instance, the productions [pɪg] and [bɪg] would be listed together under words with the [ɪ] vowel.
3. Identify which sounds function as phonemes in the child's inventory by finding minimal pairs within each set of words grouped by their shared vowel. Only look for minimal pairs for phones that are **IN** the phonetic inventory. If a sound is not in the phonetic inventory, it could not have occurred twice and thus cannot form two minimal pairs.
    a. For instance, the productions [pɪg] and [bɪg] form a minimal pair, and one occurrence of /p/ and /b/ as phonemes is recorded on the PATT form. Likewise, if a child produced [kʌp] and [kʌb], a second occurrence of /k/ and /g/ as phonemes is recorded.

Tutorial: A video tutorial for identifying minimal pairs and generating a phonemic inventory is available here: https://youtu.be/81wA3VFOBPk

Additional Instructions:

- The phonemes printed in the model phonemic inventory on the PATT form provide commonly used IPA characters to represent each phoneme of Mainstream American English. This is not a comprehensive set of all the phonemes a child might use in an English speech sample. Write into the form any phonemes not listed that are evidenced with minimal pairs in the sample.
- When you find a minimal pair for a consonant, you can also immediately add that minimal pair as an example for the other contrasting consonant in the pair. For example, [fʊt] "foot" and [pʊt] "put" can be listed as a pair for /f/ and for /p/.
- Check to make sure that the minimal pairs you find are not two productions of the same word. Minimal pairs must be semantically distinct productions.

OUT Target Phonemes

Any phonemes that are expected in the child's target variety of English but were not included in the child's IN phonemic inventory are then listed in the OUT Target Phonemes box to the right of the IN phonemic inventory on the PATT form. The phonemes OUT of the child's phonemic inventory provide

information about gaps in the child's phonological knowledge and areas of potential growth to guide treatment target selection.

Note that the phonemes printed in the model phonemic inventory on the PATT form only provide commonly used IPA characters to represent the consonant phonemes of Mainstream American English. These targets may not be an accurate reference of target phonemes for every English-speaking child. Only those phonemes that are obligatory in the variety of English being acquired by the child should be referenced for determining OUT phonemes missing from the child's phonemic inventory.

*Generating a phonemic inventory is a required step for the PATT – English due to its use in selecting appropriate three-element English cluster targets. Three-element onset clusters are not a feature of Spanish, and generating a phonemic inventory is not required for the PATT – Spanish.

Step 3. Word Initial Cluster Inventory

IN Clusters

A cluster inventory can provide information about a child's knowledge of syllable structure. A word-initial consonant cluster inventory is based exclusively on a child's productions. It is similar to a phonetic inventory in that it does not require evidence from minimal pairs. It differs from a phonetic inventory in that it only includes two or three adjacent consonants produced at the beginning of a word, such as [fl-] in [flæp] or [skw-] in [skwɑt]. The cluster inventory on the PATT form is organized by sonority distance because sonority distance is more informative than place, voice, and manner for target selection. Using the child's transcribed speech sample, any adjacent consonants at the beginning of a word are counted as an occurrence of a word initial consonant cluster. Consonant clusters that occur at least two times in the sample are included in the cluster inventory.

1. Skim word-by-word through the sample.
2. The first time you encounter a word-initial consonant cluster in the sample, underline the cluster in the model cluster inventory on the PATT form. If the cluster is not listed on the PATT form, write the cluster into the inventory, and underline it.
3. The second time you encounter a word-initial consonant cluster in the sample, circle the cluster. Only clusters that are circled are considered IN the cluster inventory.

Additional Instructions:

- Once a cluster has been identified twice and circled on the PATT form, you do not need to note additional occurrences.
- Clusters identified only once in the sample (underlined but not circled) are not included in the cluster inventory.
- The clusters printed in the model cluster inventory on the PATT form provide commonly used IPA characters to represent each word-initial consonant cluster of the specified target language variety. This is not a comprehensive set of all the clusters a child might produce in their speech sample. Write into the form any clusters not listed that occur in the sample. Depending on the level of detail in the transcribed sample, clusters not listed in the model are likely to occur.
- Include **ALL** word-initial clusters produced twice in the sample, even if they are not listed on the PATT form or are not expected clusters in the child's language variety/dialect. For instance, a child's productions of [bw-] in [bwʌʃ] "brush" and [bwum] "broom" demonstrate knowledge of a consonant cluster structure, even though [bw-] does not occur in the target variety of English or the target form of the produced words.

Tutorial: A video tutorial explaining sonority distance and how to generate a word-initial cluster inventory is available here: https://youtu.be/5QCiy3I7sNs

OUT Target Clusters

Any word-initial clusters that are expected in the child's target language variety but were not included in the child's IN cluster inventory are then listed in the OUT Target Clusters box to the right of the IN cluster inventory on the PATT form. The clusters OUT of the child's cluster inventory provide information about gaps in the child's phonological knowledge and areas of potential growth to guide treatment target selection.

Note that the clusters printed in the model cluster inventory on the PATT form only provide commonly used IPA characters to represent the word-initial consonant clusters of the specified target language variety. These targets may not be an accurate reference of target clusters for every child who speaks that language. Only those clusters that are obligatory in the language variety/dialect being acquired by the child should be referenced for determining OUT clusters missing from the child's cluster inventory.

Step 4. Stimulability

Once phones that are present (**IN phones**) and missing (**OUT phones**) from an individual's phonetic inventory are identified, the SLP is instructed to complete a stimulability task in Step 4 to determine which OUT phones the child produces with more support. Stimulability tasks involve eliciting productions of phones that were not produced spontaneously by the child (i.e., not in their phonetic inventory) given cueing and support. Sounds are elicited in isolation, in a variety of syllable positions (i.e., initial, intervocalic, final), and with differing adjacent vowels to facilitate production. Many stimulability tasks have been described and made available for use. If stimulability information cannot be obtained, Step 4 should be skipped. In this case, gaps in phonological knowledge are identified based on absence from inventories alone.

Part 2. Intervention Target Selection

Once inventories and stimulability of **OUT phones** have been determined, SLPs have the information required to determine singleton (C) or consonant cluster (CC or /s/CC) intervention targets that leverage complexity for maximal generalization to other untreated phonemes or clusters, as outlined in the PATT protocol. These step-by-step procedures use the analysis conducted in **Part 1** to identify gaps in a child's phonological knowledge. From these gaps, relatively complex targets are recommended to facilitate broad phonological growth. See Evidence in Support of these Guidelines at the end of the User Manual for additional guidance.

When appropriate, consonant cluster targets are recommended to maximize generalization from intervention (Gierut, 1999; Gierut & Champion, 2001; Taps Richard et al., 2017). **Step 1** will determine if 3-element /s/CC clusters are appropriate targets. If not, **Step 2** will determine if 2-element CC clusters are appropriate. If not, **Step 3** will determine appropriate singleton (C) targets.

In addition to consideration of individual phonological knowledge and linguistic complexity, SLPs should also consider the practicality and impact of available targets. This could include a child's preferences, overlap with targets shared by other children in a group setting, the frequency of occurrence of a singleton or cluster in the target language(s), or the availability of words appropriate for intervention that contain the target sound(s). For instance, infrequently occurring sounds in English, like /ʒ/, may occur in few words and be more difficult to target in intervention for English.

For reference, the following are English and Spanish consonants by frequency of occurrence within those languages (most-to-least):

- English: /t n ɹ l s d z m ð k w b h v f p ŋ j g θ ʃ ʤ ʧ ʒ /
- Spanish: /s l n t ð-d r t m p β-b ɣ-g f z j r x ʧ ɳ /

Part 3. Monitoring

Once target(s) have been selected, monitoring during intervention is recommended to assess:

1. targeted learning of the treated phoneme(s) or cluster(s)
2. broad phonological generalization to untargeted phonemes or clusters

Frequent monitoring of the productions of the intervention target(s) are recommended (e.g., weekly or biweekly) to confirm that learning is progressing and to document progress. Especially when teaching a relatively complex target, a monitoring system that captures stages of change in the target is recommended, such as a visual-analog scale. This is preferrable to a binary accurate/inaccurate rating scale.

Monitoring of the broader sound system with a thorough speech sample and analysis procedures, such as the inventory analyses in **Part 1**, is recommended periodically (e.g., every 3 months) *or* when an acceptable level of accuracy is achieved with the intervention target(s) as to warrant selection of new target(s).

Intervention

To date, there is little consensus as to optimal goal attack strategies, activities, teaching approaches, materials, or modalities used in intervention for children with speech sound disorders (as reviewed in: Baker & McLeod, 2011; Baker et al., 2018; Crowe et al., 2021; Law et al., 2004; Sugden et al., 2016; Sugden et al., 2018; Tyler, 2008; Wren et al., 2018). Of note, the available evidence does indicate a relationship between intervention frequency greater than once per week and improved outcomes (Kaipa & Peterson, 2016).

PATT does not specify intervention approaches or suggest speech sound teaching strategies beyond target selection. SLPs are advised to teach children recommended phoneme or consonant cluster targets to facilitate broad generalization; however, teaching activities could be employed according to one or more of the approaches shown to be effective for improving intelligibility in children with speech sound disorder, such as those described in Baker et al. (2018).

Suggested Resources

The resources indicated below as well as additional resources and more information about PATT and the open-source AutoPATT plugin for *Phon* are available here: https://cld.lab.uiowa.edu/patt

Speech Elicitation Probes

- Singletons and Clusters Probe from the *In-Depth Phonological Assessment* (Taps Richard, 2012)
- *Shorter Protocol for the Evaluation of English Phonotactics* (Little PEEP; Barlow, 2012)

Stimulability Task

- *In-Depth Stimulability Task*, modified from the Glaspey and Stoel-Gammon (2005) Scaffolding Scale of Stimulability.

Progress Monitoring Tools

- Visual Analog Scales for Singleton Accuracy (Taps Richard, 2018)
- Visual Analog Scale for 2-Element Cluster Accuracy (Taps Richard, 2018)
- Visual Analog Scale for 3-Element Cluster Accuracy (Taps Richard, 2018)
- Visual Analog Scale Scoring Guide for Clusters (Taps Richard, 2018)

Evidence in Support of these Guidelines

Treatment on structure that is absent from the sound system is consistent with a goal of achieving *underlying change in linguistic knowledge*, as opposed to a *surface change in behavior* (Gierut, 2005; Johnston, 1988).

Treatment of 3-element clusters will lead to improvements on 2-element /s/ clusters, 2-element obstruent + sonorant clusters, liquids, and affricates, as well as other singleton consonants absent from the pretreatment inventory (Combiths et al., 2019; Elbert & McReynolds, 1979; Gallagher & Shriner, 1975; Gierut, 1998, 1999; Gierut & Champion, 2001; Gierut & O'Connor, 2002; Lleó & Prinz, 1997; Maas et al., 2002; Williams, 1986, 1988).

Treatment of 2-element obstruent + sonorant clusters that have a small sonority distance will lead to improvement on 2-element clusters with a large sonority distance, plus liquids, and affricates, as well as other singleton consonants absent from the pretreatment inventory (Anderson, 2002; Barlow, 2005; Broselow & Finer, 1991; Combiths et al., 2022; Combiths et al., 2023; Eckman, 1991; Eckman & Iverson, 1993; Elbert et al., 1984; Elbert & McReynolds, 1979; Gallagher & Shriner, 1975; Gierut, 1998, 1999; Gierut & O'Connor, 2002; Lleó & Prinz, 1997; Powell & Elbert, 1984; Williams, 1986, 1988)

Treatment of /s/ clusters, particularly /s/ + stop clusters, leads to only limited generalization to other clusters in the sound system, due to their different patterning in the sound system and relatively early acquisition by children (Barlow, 2001b; Gierut, 1999; Smit, 1993; Smit et al., 1990).

Consonant + /j/ clusters pattern differently from other clusters and are acquired relatively early in acquisition of English (Barlow, 1997a, 1997b, 2001a).

Treatment on sounds that are excluded from the inventory and subject to obligatory errors leads to greater system-wide change and is consistent with a goal of achieving *underlying change in linguistic knowledge*, as opposed to a *surface change in behavior* (Brière, 1966; Gierut, 1990, 1991, 1992, 2005; Gierut et al., 1987; Gierut & Neumann, 1992; Hammerly, 1982; Hardy, 1993; Johnston, 1988; Williams, 1991).

Stimulable sounds are likely to emerge on their own without direct treatment; thus, treatment should focus on those aspects of the sound system that are least likely to emerge without direct treatment (Dinnsen & Elbert, 1984; Elbert & McReynolds, 1978; Miccio et al., 1999; Powell, 1993; Powell et al., 1991; Sommers et al., 1967).

Greater system-wide change occurs following treatment on later-acquired as opposed to early-acquired sounds (Dyer et al., 1987; Gierut et al., 1996; Powell, 1991; Powell et al., 1998).

Implicational relationships in language indicate that certain hierarchical relationships tend to be maintained in a language system. Presence of a higher-order structure implies presence of certain lower-order structures (Greenberg, 1978; Ladefoged & Maddieson, 1996; Lindblom & Maddieson, 1988; Maddieson, 1984).

Implicational Language Relationships

Structures on the left have been shown to be more marked (more complex) relative to the implied structure on the right (c.f. Watts & Rose, 2020). Teaching these marked structures has been associated with changes to corresponding implied structures.

3-Element /s/CC Clusters → 2-Element /s/ and Non-/s/ Clusters (Gierut & Champion, 2001; Maas et al., 2002)
Clusters with a Small Sonority Distance → Clusters with a Large Sonority Distance *(Gierut, 1999)*
Clusters → Singletons *(Gallagher & Shriner, 1975)*

Clusters → Affricates *(Gierut, 2008; Gierut & O'Connor, 2002)*
Stridency Contrast (e.g., [θ s] or [ð z]) → Liquid *(Dinnsen et al., 1992; Dinnsen et al., 1990)*
Liquids → Nasals *(Dinnsen et al., 1990; Gierut et al., 1994; Tyler & Figurski, 1994)*
Affricates → Fricatives *(Gierut et al., 1994; Ingram et al., 1980; Schmidt & Meyers, 1995)*
Fricatives → Stops *(Cataño et al., 2009; Dinnsen & Elbert, 1984; Elbert et al., 1984)*
Voiced Obstruents → Voiceless Obstruents *(Cataño et al., 2009; Dinnsen & Elbert, 1984)*
Velars → Coronals *(Stoel-Gammon, 1996)*
Consonants → Vowels *(Robb et al., 1999)*

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