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Tutorial

Minimal, Maximal, or Multiple: Which Contrastive Intervention Approach to Use With Children With Speech Sound Disorders?

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ABSTRACT

Purpose: This tutorial contrasts a familiar and frequently used speech sound disorder (SSD) intervention approach, conventional minimal pair, with newer but less familiar and less frequently used variants that may be more effective: (a) maximal opposition and (b) multiple oppositions.
Method: This tutorial provides a general description of each contrastive approach, focusing on the evidence base and a small number of critical elements that define the approach and make it unique from all other approaches. Hypothetical cases are used to illustrate how the approaches can be tailored to child needs and speech-language pathologist (SLP) expertise. Supplemental materials enhance the reader's skill in using these approaches in their practice with a minimal initial investment.
Results: The reader will be able to identify which children with SSD are appropriate for conventional minimal pair, maximal opposition, or multiple oppositions approaches and will be able to plan intervention (i.e., select target sounds and contrasting words or nonwords, develop intervention activities, write goals, and determine intervention intensity) for each of these approaches.
Conclusions: This tutorial highlights that using the conventional minimal pair approach should be restricted to children with a small number of errors (i.e., older children or children with mild SSD). There is an opportunity for SLPs to use newer, more efficacious approaches with younger children and children with more severe SSDs. The maximal opposition approach is well suited to children with multiple errors across multiple sound classes. The multiple oppositions approach specifically targets global phoneme collapses that impact intelligibility.
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The last 4 decades have generated over 200 studies of intervention of children with speech sound disorders (SSDs), covering over 20 different intervention approaches (Baker & McLeod, 2011; Sugden et al., 2018). Generally, these studies focus on efficacy, namely, documenting that intervention improves outcomes under ideal conditions, which typically are high-intensity, individual sessions in university clinics (Baker & McLeod, 2011; Sugden et al., 2018). Not surprisingly, speech-language pathologists (SLPs) have difficulty implementing these varied interventions, tending to borrow methods from a small array of approaches to create an SLP-specific hybrid approach (Brumbaugh & Smit, 2013; Furlong et al., 2021; Hegarty et al., 2018; Sugden et al., 2018). There are likely numerous barriers to implementing new intervention approaches, including (a) an SLP's lack of familiarity with newer approaches (Brumbaugh & Smit, 2013; Hegarty et al., 2018), (b) the dearth of effectiveness research that would provide a roadmap for delivering the approach in a typical school setting, (c) incomplete descriptions of the approach in publications (Sugden et al., 2018), and (d) the high SLP investment in learning and adopting a new approach because of all of these factors (Furlong et al., 2021). However, newer intervention approaches may promote better

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outcomes for children with SSD. Consequently, it is worthwhile to try to overcome these barriers to best practice.

This tutorial contrasts a familiar and frequently used SSD intervention approach, conventional minimal pair, with newer, but less familiar and less frequently used variants that may be more effective (Gierut, 1990, 1991; Gierut & Neumann, 1992; Topbaş & Ünal, 2010; Williams, 2000b, 2005): (a) maximal opposition and (b) multiple oppositions. This tutorial is written to overcome barriers that prevent SLPs from adopting newer practices. Clear guidelines and intervention materials are provided to lower SLP costs in learning and implementing maximal opposition and multiple oppositions approaches. This tutorial begins with a general description of each approach, focusing on the small number of key elements defining the approach and making it unique from other approaches. Then, a hypothetical case is presented to provide a more detailed description of how to implement and tailor the approaches to child and SLP needs. Next, components of intervention planning (i.e., writing goals, selecting the linguistic content, and determining intervention intensity) are discussed.

Contrastive Intervention Approaches

Conventional minimal pair, maximal opposition, and multiple oppositions intervention approaches all share the same basic format of comparing two or more sounds in words that differ only by the target sounds, namely, minimal pairs. For example, /r/ can be paired with /w/ in word pairs such as ring-wing, rag-wag, and rake-wake. The focus is on pronunciation rather than spelling. Although the word-initial position is frequently used in research studies, the target sounds can occur in any word position. The basic premise of contrastive intervention approaches is that directly comparing two sounds in minimal pairs sparks phonological learning because the direct comparison of sounds in words highlights how differences between sounds are used to signal differences in meaning. That is, for rake-wake, the phoneme /r/ signals the meaning "the tool used to collect leaves," whereas the phoneme /w/ signals the meaning "what we do when we stop sleeping." This approach highlights that /r/ and /w/ are different phonemes that cannot be used interchangeably without losing important meaning. While all three contrastive approaches share this main feature of highlighting how sounds communicate meaning, there are variations across the approaches in the specific theoretical underpinnings. The approaches vary in (a) how the target sounds are selected and (b) the intervention activities used to highlight the contrast between the target sounds. These variations are aligned with the theoretical underpinnings of each approach. The introduction to each approach focuses on the key components and the evidence base.

Conventional Minimal Pair

Systematic reviews show that the conventional minimal pair approach has been used in over 40 (Baker & McLeod, 2011) to 50 research studies (Sugden et al., 2018). Some studies focus on documenting the efficacy of the approach for (a) monolingual children with SSD (Almost & Rosenbaum, 1998; Baker & McLeod, 2004; Blache et al., 1981; Dodd et al., 2008; Grunwell et al., 1988; Hoffman et al., 1990; Masterson & Daniels, 1991; Tyler et al., 1987; Weiner, 1981); (b) children with SSD and other accompanying impairments or etiologies, such as hearing impairment (Abraham, 1993) or cleft palate (Grunwell & Dive, 1988); and (c) children with SSD who speak multiple languages (Holm & Dodd, 2001; Ray, 2002). In contrast, other studies use the conventional minimal pair approach to address general questions about intervention for children with SSD, including issues of (a) sound selection (Miccio et al., 1999; Powell, 1991; Powell & Elbert, 1984; Powell et al., 1991); (b) area of intervention focus, such as whether perceptual activities, motor training or instruction, or phonological awareness activities are needed (Saben & Ingham, 1991; Shiller et al., 2010; Smith et al., 1998); (c) generalization related to speech sounds but also generalization to other areas, like language (Elbert et al., 1990, 1991; Hoffman et al., 1990; Miccio & Ingrisano, 2000; Tyler & Sandoval, 1994); and (d) service delivery, such as whether parents or teachers can deliver the intervention (Dodd & Barker, 1990; Leahy & Dodd, 1987; Ruscello et al., 1993).

Because there are many studies of conventional minimal pair, there are varied descriptions of the intervention steps. That is, each research team seems to implement the approach in slightly different ways. However, the heart of the conventional minimal pair approach is in creating homonymy to induce phonological learning. Here, *homonymy* means that a child produces two words the same (e.g., wing-wing) when an adult would produce the words differently (i.e., ring-wing), leading to confusion (e.g., Are we talking about rings or wings?). The underpinnings of this approach are that highlighting the communication breakdown that occurs when a child does not distinguish sounds in the same way as an adult will induce the child to mark the difference between the words to avoid communication failure. Two core aspects of the approach ensure the opportunity for homonymy: (a) pairing the target and its substitute/deletion in minimal pairs and (b) interactive intervention activities that set up opportunities for communication breakdown.

In terms of sound selection, the selected minimal pairs contrast a target sound that the child needs to learn with the child's typical production of the target, namely, a substitute or a deletion. For example, /θ/ would be contrasted with [t] in initial position (e.g., thick-tick, thought-taught) for a child who produces [t] for /θ/ in initial

position. Likewise, /θ/ would be contrasted with nothing in the final position (e.g., booth-boo, both-bow) for a child who deletes /θ/ in the final position. Typically, an error pattern or process is selected, such as improving production of fricatives or eliminating the phonological process of stopping of fricatives. Studies vary on whether they select one or several targets affected by the process (e.g., selecting /θ/ vs. selecting /θ/ and /z/). Thus, other aspects of sound selection, beyond pairing a target with a substitute/deletion, are not specified and are left to the SLP's discretion.

In terms of intervention activities, the SLP and child engage in interactive games where communication breakdowns are likely to occur. For example, for a child practicing /θ/–/t/ minimal pairs, the SLP would place multiple pictures of thick and tick on the table and tell the child that the object of the game is to get the SLP to pick up all the pictures of thick (Weiner, 1981). The child will then attempt to say thick. If the child successfully produces the /θ/, the SLP picks up a picture of thick. If the child produces the [t] substitute, the SLP will pick up a tick picture. The picture chosen is one form of feedback that the child's production was correct or incorrect. The SLP provides additional feedback if the child continues to produce the target incorrectly. Typically, the additional feedback is explicit instruction about the need to use the correct sound: "You keep saying tick. If you want me to pick up thick, you must say the /θ/ sound at the beginning, not the [t] sound" (Weiner, 1981). Note that the SLP is producing the sound, not the letter name, in this feedback.

There are opportunities to tailor the approach to the needs of a specific child. For example, some versions of the approach add feedback to produce the sound accurately (e.g., Elbert et al., 1990, 1991). For example, the SLP could provide explicit instruction about using the correct sound and then provide a correct model by saying: "Watch me. Thick (with an emphasized /θ/ model). Your turn." The instruction also could include articulatory cues or instructions to further assist the child in achieving a correct production (e.g., "You're putting your tongue up and making a short sound. You need to stick your tongue out and make a long sound. Watch me. Thick. Your turn"). In addition, some versions of the intervention first establish a child's skill in producing the target sound before moving to communicative games and paired activities (Miccio et al., 1999; Miccio & Ingrisano, 2000). Finally, some versions of the intervention select stimulable sounds so that the child can already correctly produce the sound (e.g., Abraham, 1993; Dodd & Barker, 1990; Leahy & Dodd, 1987).

In summary, the goal of the conventional minimal pair approach is to teach a class of sounds (e.g., fricatives) or eliminate a phonological process (e.g., stopping of fricatives) by teaching one to several sounds representative of the sound class/phonological process. This goal is accomplished by pairing the target(s) with its substitute(s) in minimal pairs and engaging in interactive games that will create communication breakdowns if the child does not adhere to the adult production of the target words. Because of its focus on a single target sound class or phonological process, conventional minimal pair is best suited to older children or children with mild SSD, characterized by a small number of error patterns. A child with numerous error patterns (i.e., a child with a moderate-to-severe SSD) would benefit more from an approach that targets global change to rapidly improve intelligibility.

Maximal Opposition

The efficacy of the maximal opposition approach has been demonstrated or is emerging in American English (Gierut, 1989, 1990, 1991, 1992; Gierut & Neumann, 1992), Brazilian Portuguese (Bagetti et al., 2012; Ceron et al., 2010; Donicht et al., 2011; Keske-Soares et al., 2008; Mota et al., 2007; Pagliarin et al., 2009, 2011), and Turkish (Topbaş & Ünal, 2010). The approach has been used with children with mild-to-severe SSD from age 3 to 8 years. Gierut's series of studies in American English (Gierut, 1989, 1990, 1991, 1992; Gierut & Neumann, 1992) systematically manipulated the two sounds being contrasted in a minimal pair to identify the best sound selection method to maximize phonological learning. This work established that alternatives to conventional minimal pair were associated with better intervention outcomes, and this advantage was replicated in Turkish (Gierut, 1990, 1991; Gierut & Neumann, 1992; Topbaş & Ünal, 2010). The work in Brazilian Portuguese addressed similar issues of sound contrast options with similar findings and also compared maximal opposition to other types of approaches (e.g., cycles), demonstrating no difference among the approaches (Bagetti et al., 2012; Ceron et al., 2010; Donicht et al., 2011; Keske-Soares et al., 2008; Mota et al., 2007; Pagliarin et al., 2009, 2011).

The heart of the maximal opposition approach is the guidance on sound selection. Gierut manipulated three features of sound selection (Gierut, 1989, 1990, 1991, 1992; Gierut & Neumann, 1992): (a) number of features differences (maximal vs. minimal); (b) type of feature differences (major vs. nonmajor); and (c) number of inaccurate sounds (i.e., two vs. one). This work relied on distinctive features, which are not frequently used by SLPs today. This tutorial provides a sound selection worksheet (reviewed later) that codes sound pairs along the relevant dimensions so that readers do not have to learn distinctive features. By way of brief background, distinctive features are a more detailed coding of place, voice, and manner and thus provide a means of tallying the number of feature differences

at a finer level than the broader place, voice, and manner categories. Distinctive features allow identification of sound pairs with a large number of feature differences (e.g., f–g differing by seven features) versus a small number of feature differences (e.g., f–θ differing by two features). The distinctive features also indicate whether a feature differentiated large classes of sounds, termed *major class differences*, or smaller groups of sounds, termed *nonmajor class differences*. For intervention of SSD, the major class distinction between sonorants (i.e., nasals, stops, and glides) and obstruents (i.e., stops, fricatives and nasals) is the most useful because it captures a range of sounds that children tend to produce inaccurately. Thus, an SLP could pair sounds across the two classes to create a major class difference (e.g., obstruent f – sonorant l) or pair sounds within a class to create a nonmajor class difference (e.g., obstruent f – obstruent θ).

Finally, two inaccurate sounds could be selected for intervention, or an inaccurate sound and an accurate sound could be selected for intervention. Note that conventional minimal pair intervention typically results in the selection of an inaccurate sound and an accurate sound (i.e., its substitute), and typically, the target and substitute are somewhat similar to one another, tending to differ by a minimal number of nonmajor class features (e.g., obstruent f – obstruent p). However, Gierut's research showed that greater phonological change emerged when intervention focused on two inaccurate sounds (sometimes referred to as the empty set) that differed by a major class and a maximal number of features. Thus, for a child who produced all fricatives and liquids inaccurately, intervention of /f/ paired with /l/ (two unknown sounds differing by a major class and a maximal number of other features) is predicted to lead to greater change than intervention of /f/ paired with its likely substitute /p/ (one unknown sound differing by a minimal number of nonmajor class features).

The maximal opposition approach typically does not create homonymy. Because the target sounds differ maximally, the child's incorrect pronunciation rarely creates overlapping forms. For example, in intervention of /f/–/l/ pairs, like "face" and "lace," the child's likely inaccurate production, such as "pace" for "face" and "wace" for "lace," maintains a distinction between the two forms, albeit an incorrect one. Thus, the heart of maximal opposition is not homonymy but rather contrasting two sounds that illustrate the wide range of features available in the language's phonology. This contrast is highlighted through intervention activities, which are another crucial aspect of the approach. In particular, children practice the paired words in their pairs, saying one word (e.g., "face") and then the other (e.g., "lace") in whatever order is convenient before moving on to the next pair. In addition, the SLP typically holds the two paired picture cards (e.g., "face"–"lace") or the electronic display (e.g., tablet) near their mouth so that the child can focus on the pair during production practice. Although perceptual training or judgment activities are not required in the approach, the SLP consistently provides perceptual models (e.g., saying something like "face and lace: those two go together").

Beyond production practice, children regularly engage in two conceptual phonological activities: matching and sorting. In matching activities, the child or the SLP selects one word (e.g., "lace"), and then the child has to identify its mate (e.g., "face") from the remaining options. The child then practices the two paired words sequentially, as previously described. Matching activities tend to be done throughout intervention. In sorting activities, the child groups the words based on their sounds in common (e.g., putting all the /f/–initial words in one pile and all the /l/–initial words in a second pile). Sorting activities are usually not done in the early sessions but are incorporated later. When both activities are being used in intervention, they are often done in a sequence. For example, the child may first produce all the words as pairs through a matching activity. After each production, the child may sort the words into their word-initial piles. Once matching and sorting have been completed, the words in each pile are practiced. These activities are intended to help the child learn the similarity between the matching sounds (i.e., sorting activities) and the differences between the contrasting sounds (i.e., matching activities), enhancing the child's conceptual learning of the phonological system.

The goal of the maximal opposition approach is to teach the child two new sounds that represent different aspects of the phonological system and highlight the diversity of the phonological system through explicit phonological activities (i.e., sorting, matching). In this way, the child is expected to learn the two sounds taught (e.g., /f/–/l/) and gain broader insights about the phonological system, leading to system-wide change that extends beyond the two specific sounds taught. That is, intervention of a pair like /f/–/l/ would be predicted to induce learning of /f/–/l/ and increase accuracy in other fricatives and other liquids. Moreover, the child may apply newly learned features to other sounds, increasing the accuracy of unrelated sounds. In this way, maximal opposition is appropriate for young children or children with moderate-to-severe SSD, characterized by multiple errors across multiple sound classes.

Multiple Oppositions

The multiple oppositions approach has been studied in children age 3–6 years with moderate-to-severe SSD in American English (Allen, 2013; Lee, 2018; Williams, 2000a, 2000b, 2005, 2012), Australian English (Sugden et al., 2020), and Brazilian Portuguese (Ceron & Keske-Soares, 2013; Pagliarin et al., 2009, 2011). Williams

initially developed and documented the efficacy of the approach in American English (Williams, 2000a, 2000b, 2005), and then subsequent work examined issues of intervention intensity (Allen, 2013; Williams, 2012) and intervention format (Lee, 2018; Sugden et al., 2020). In general, greater gains are seen with more intense interventions, but various formats (e.g., telepractice, parent-implemented intervention) are efficacious (Allen, 2013; Lee, 2018; Sugden et al., 2020). The research in Brazilian Portuguese replicated the efficacy findings in a new language (Ceron & Keske-Soares, 2013; Pagliarin et al., 2009, 2011).

The heart of multiple oppositions is selecting a global phoneme collapse as the intervention target and the guidance on how to select the specific intervention targets within the collapse. A global phoneme collapse occurs when one sound is substituted for many target sounds. For example, the sound /h/ may be substituted for seven target sounds: /f θ s z ʃ ʧ ʤ/ (Williams, 2000b). This mapping of one substitute to many targets greatly impacts intelligibility by creating rampant homonymy in the child's productions. For instance, in the prior example collapse (i.e., [h] substitute for /f θ s z ʃ ʧ ʤ/), the words "hill–fill–sill–chill–Jill" (i.e., five target words) would all be produced identically as "hill," which could cause confusion in conversation. Williams initially attempted to address a global phoneme collapse using conventional minimal pair but documented poor results (Williams, 2000b). However, when multiple targets from the collapse were paired with the substitute in minimal quadruplets (rather than pairs), stronger phonological learning was observed (Williams, 2000b). Thus, in multiple oppositions, the SLP selects a global phoneme collapse as the intervention target. Then, within the collapse, the SLP selects one to four target sounds to pair with the substitute sound in minimal pairs (if only one target selected) to minimal quintuplets (if four targets selected).

Two principles guide the selection of the targets within the collapse: maximal classification and maximal distinction (Williams, 2000a, 2005, 2012). *Maximal classification* focuses on selecting targets that represent the breadth of the collapse. That is, targets representing different structures (e.g., singletons vs. clusters) and different places, manners, and voicing impacted by the collapse are selected to cover the full extent of the error pattern. In the error of /h/ being produced for targets /f θ s z ʃ ʧ ʤ/, one would want to consider selecting fricatives versus affricates to represent the manners involved in the collapse as well as voiced versus voiceless sounds since the collapse impacts both. This particular collapse impacts numerous places. The SLP might want to think of place at a global level, such as anterior versus posterior places (e.g., /f θ s z / vs. / ʃ ʧ ʤ/), rather than every individual place. *Maximal distinction* focuses on the number of feature differences between the substitute and each potential target. This principle is similar to maximal opposition. With these two criteria in mind, for the collapse of /f θ s z ʃ ʧ ʤ/ to [h], an SLP might select /ʧ/, a posterior voiceless affricate maximally differing from /h/, and /z/, an anterior voiced fricative maximally differing from /h/, yielding minimal triplets of /h ʧ z/ (e.g., hip–chip–zip) as the focus of intervention.

At this point, it should be apparent that the multiple oppositions approach combines features of both the conventional minimal pair and maximal opposition. On the one hand, multiple oppositions is similar to conventional minimal pair in pairing a substitute with one (or more) target sounds to highlight homonymy. On the other hand, the multiple oppositions approach is similar to maximal opposition in creating a maximal contrast between the target and substitute. Finally, the multiple oppositions approach is unique from both approaches in focusing on identifying and targeting global phoneme collapses.

The intervention activities are a critical component and, once again, reflect a combination of maximal opposition and conventional minimal pair approaches. In particular, the intervention activities for multiple oppositions begin with drill-play activities similar to maximal opposition but then move into more naturalistic activities that are similar to conventional minimal pair. Early activities focus on building the child's skill to accurately produce the target sounds in words through imitative and spontaneous practice trials. In addition, during early activities, words are practiced in their sets, focusing on saying the substitute–target pairs within a set. For example, hip–chip–zip would be practiced together by producing hip–chip and then hip–zip before moving on to the next set. As the child gains production accuracy at the word level, practice becomes more varied and less drill based. Later activities focus on building the child's understanding of how the sounds are used to communicate meaning, similar to conventional minimal pair. Specifically, the SLP and child engage in interactive games with the SLP doing what the child says and reacting appropriately to the communicative context. For example, if the child says "Hand me hip" and there is no picture of hip, the SLP would say, "I don't see hip." The child might point to "chip" and then the SLP would provide further feedback (e.g., "I thought you said hip with a throat sound, but you meant chip with a popped sound"). Further intervention details are well described elsewhere (Allen, 2013; Sugden et al., 2020; Williams, 2021 ; Williams et al., 2020) with accompanying supplemental materials (Sugden et al., 2020) or videos (Williams, 2021; Williams et al., 2020).

To summarize, the multiple oppositions approach prioritizes improving a child's intelligibility by selecting a global phoneme collapse as the intervention target. The goal is to eliminate the global phoneme collapse by

treating a small, representative set of sounds involved in the collapse that differ maximally from the substitute. The target sounds are taught through various phonological activities (similar to maximal opposition) and communicative activities that highlight homonymy (similar to conventional minimal pair). The multiple oppositions approach is appropriate for any child who exhibits a global phoneme collapse, which will tend to be young children or children with moderate-to-severe SSD. In addition, it is useful to note that final consonant deletion is a type of global phoneme collapse. That is, in final consonant deletion, many consonant targets are collapsed into nothing (i.e., a deletion). Contrasting the lack of a sound (e.g., bee) versus the presence of multiple targets (e.g., beak, beef, beach) in a multiple opposition approach may be well-suited to this error pattern.

Application: Hypothetical Case Example

Use of the contrastive treatment approaches should begin with the SLP obtaining a broad sample of the child's speech. An SLP could begin with a broad articulation test that samples all sounds in limited contexts (i.e., a standardized test of phonology/articulation) to screen for error patterns. Alternatively, the SLP could take a conversational language sample, with efforts directed toward eliciting less frequently occurring sounds (e.g., include a playset with a thumb or thimble to elicit θ). The SLP would identify sounds in error from this broad sample, and then, it is critical to administer a deep test of those sounds, namely, a probe that samples the target sound in multiple words and word positions, to get a better understanding of the accuracy of the sound (i.e., Is the sound consistently incorrect?) and the details of the error pattern (i.e., What is the error pattern, and is it consistent?). The supplemental materials of Storkel (2018a) include a free deep probe and scoresheet for the mid- and late-8 singletons as well as clusters. The use of these materials is illustrated in the cases.

A sound selection spreadsheet is provided as Supplemental Material S1 to help SLPs use these three contrastive approaches. Instructions are provided in the "Read Me" tab of this sound selection spreadsheet. Supplemental Material S2 provides video instructions for entering data in this sound selection spreadsheet. Finally, the sound selection spreadsheet is illustrated for several hypothetical cases in Supplemental Materials S3–S7, with one of these cases, Ethan, being discussed in this tutorial.

The hypothetical cases were constructed using children who participated in research. Parents/guardians agreed to have their child's de-identified data used for research and teaching purposes. Data were combined from multiple cases, and additional unknown information was added so that the case was rich. A name was selected for each case.

Ethan (5;11 [years;months])

Ethan is a 5-year 11-month-old boy. Supplemental Material S3 shows his completed sound selection worksheet. Supplemental Material S4 provides a video demonstration of how to complete his sound selection worksheet. His standard score on the Arizona Articulation and Phonology Scale–Fourth Edition (Fudala & Stegall, 2017) was below 50 for both scales (Articulation and Phonology), corresponding to a percentile rank of < 0.1 for both scales. The Arizona classified Ethan as having a severe articulation/phonological impairment. Table 1 shows that Ethan had difficulty producing velars (k g ŋ), several fricatives (θ ð ʃ), affricates (ʧ ʤ), liquids (l r), and all clusters except /tw/. Given that Ethan has a severe SSD, characterized by multiple errors across different sound classes (velars, fricatives, affricates, liquids) and structures (singletons, clusters) and that his errors are primarily substitutions and deletions (rather than distortions), the maximal or multiple oppositions approaches are likely appropriate options. A conventional minimal pair approach is likely

Table 1. Accuracy and error patterns for Ethan.

Target sound	Overall accuracy	Type of error	Substitute
k	20%	Substitution, primarily in word-final position	t
g	0%	Substitution	d
θ	0%	Substitution	t word-initial; t f s word-final
ð	0%	Substitution	d
ʃ	0%	Substitution	s
ʧ	30%	Substitution, primarily in word-final position	ts, s word-final
ʤ	0%	Substitution	d word-initial; z word-final
ŋ	0%	Substitution	n
l	0%	Deletion	N/A
r	0%	Substitution word-initial; deletion word-final	w
w-clusters	33%	Substitution for kw, cluster reduction for sw	tw for kw
l-clusters	0%	Cluster reduction	
r-clusters	0%	Cluster reduction	
s-clusters	0%	Cluster reduction	
3-element cluster (CCC)	0%	Cluster reduction	

Note. N/A = not applicable.

not appropriate because it would target only one of his many error patterns. Consequently, conventional minimal pair would not create the change in intelligibility that Ethan really needs. The next steps are to evaluate whether (a) Ethan shows a global phoneme collapse that would suggest the need to use the multiple oppositions approach; (b) any of his low-accuracy obstruents (g θ ð ʃ ʤ) can be paired with his low-accuracy sonorants (ŋ l r) for the maximal opposition approach.

Multiple oppositions. Ethan does show two global phoneme collapses (see Supplemental Material S3). Ethan produces [t] for 10 targets in the initial position: /t θ kl kr tr θr sk st skr str/. Ethan produces [d] for seven targets in the initial position: /d g ð ʤ gl dr gr/. The multiple oppositions approach would be a good approach for Ethan so that one of these two global phoneme collapses could be targeted to improve his intelligibility. The SLP could consider input from the family, the Individualized Education Program (IEP) team, and their expertise to decide which of the two collapses to prioritize for intervention initially. If the second collapse does not improve when the other is targeted, it could always become the focus of intervention later. For this illustration, we will assume the SLP selects [t] for /t θ kl kr tr θr sk st skr str/ as the target because more targets are involved in the collapse.

The next step within multiple oppositions is to apply maximal classification (i.e., select targets representative of the collapse) and maximal distinction (i.e., select targets that differ maximally from the substitute) to select the intervention targets for the [t] for /t θ kl kr tr θr sk st skr str/ collapse. In terms of maximal classification, note that the collapse affects one singleton target (θ), three stop + liquid clusters (kl, kr, tr), one fricative + liquid cluster (θr), two s + stop clusters (sk, st), and two three-element clusters (skr, str). Here, the SLP needs to make some decisions about what sound classes or error types to prioritize. The SLP could decide to focus on the two-element clusters rather than the singleton or the three-element clusters, reasoning that the two-element clusters are appropriate because of the child's advanced age and severity of his disorder. In addition, Ethan reduces most two-element clusters to singletons, and this pattern is not age appropriate. As summarized by McLeod et al. (2001), cluster reduction is relatively rare by age 3;6 and beyond. While three-element clusters also would be appropriate for Ethan's age and severity, the SLP may not choose these because Ethan only produces the s + stop elements of those clusters accurately as singletons. Prior research suggests that children with that particular profile do not learn and generalize three-element clusters well (Gierut & Champion, 2001).

With this focus on two-element clusters, the SLP might select /kl/ from the stop + liquid clusters, reasoning that k + liquid is more distinct from /t/ than t + liquid (i.e., fulfills maximal distinction). The SLP might also rely on their expertise and note that the child is beginning to produce /k/ in initial position and the /l/ is visible. Thus, the SLP might have some confidence that they will be able to coach Ethan to produce /kl/. The SLP might then select /θr/ so that both /l/ and /r/ clusters are targeted in intervention (i.e., fulfills maximal classification). The SLP may be confident that they can elicit /θ/ from Ethan because their expertise suggests that the articulatory instructions for /θ/ tend to be simple and easy for children to grasp. In addition, the SLP's expertise may suggest that teaching a fricative + liquid cluster facilitates teaching the child to blend the first sound into the second, which sometimes is more challenging in stop + liquid clusters, where children may insert a schwa between the two sounds (e.g., [kᵊlu] for clue). Although /r/ can be challenging to teach, the clinician may plan to incorporate back vowels in the target words to facilitate the child pulling the tongue back from the /θ/ into the correct position for /r/. Finally, the SLP might select /st/ to represent the s + stop clusters affected by the collapse, using their expertise to reason that this cluster should be "easy" for the child because he already produces /s/ and /t/ as singletons. Thus, the SLP has met the criteria for maximal classification and maximal distinction and has selected sounds that they think they will be able to coach Ethan to produce. Note that there are a variety of other targets that could be selected to meet maximal classification and maximal distinction and those alternative options would prioritize other family goals or different insights from the SLP (e.g., /θr/ occurs infrequently in English, so it might be better to prioritize a more frequent target). In this way, the multiple oppositions approach provides guidance on sound selection but allows ample room for tailoring sound selection to other child- or SLP-specific factors.

Maximal opposition. Although the multiple oppositions approach should be prioritized for Ethan because he shows evidence of two global phoneme collapses, maximal opposition is an alternative approach that could be used if the SLP had concerns about implementing the multiple oppositions approach with Ethan. Ethan's teacher reported that Ethan is easily frustrated and reticent to talk in class. It is unclear whether speech sound intervention would frustrate Ethan or not. The SLP used their expertise to select targets that they felt confident they would be able to teach Ethan. If the SLP can provide enough support to Ethan, he may have success and not become frustrated. To evaluate this for Ethan, the SLP may find it helpful to engage in stimulability testing or a single session of diagnostic therapy with Ethan to evaluate what level of support and success he needs to avoid frustration. The SLP would identify several potential target sounds that they are considering as intervention options for Ethan (e.g., the clusters already identified for multiple oppositions). They would try to teach Ethan to produce these sounds using modeling, articulatory instructions,

faciliatory contexts, and the like. The SLP would note which of these factors supports improved production of the target as well as Ethan's general attitude (e.g., is he getting frustrated). The SLP would then use this information to decide whether the multiple oppositions approach targeting clusters was reasonable for Ethan or whether they should pursue an alternative option.

As previously noted, for maximal opposition for Ethan, we would want to pair one of his low-accuracy obstruents (g θ ð ʃ ʤ) with one of his low-accuracy sonorants (ŋ l r) for two unknown sounds differing by a major class. The sound selection worksheet (see Supplemental Material S1) is programmed to highlight pairs that differ by a maximal number of features. A feature matrix reference sheet within the sound selection spreadsheet shows the feature differences for various sound combinations. Focusing on initial position, pairs that would be two unknown sounds differing by a major class and a maximal number of features are g–l, g–r, θ–r, ʃ–l, and ʤ–l (see Supplemental Material S3).

The SLP could now tailor the approach to the client's needs and apply their expertise to make a final selection from among these five evidence-based choices (i.e., g–l, g–r, θ–r, ʃ–l, and ʤ–l). On the one hand, the SLP might want to prioritize the early acquired /g/, focusing on the g–l/g–r options. The SLP might select g–l because of their confidence in teaching /l/ over /r/. Alternatively, the SLP might select g–r to provide greater focus on the back velar and palatal places, hypothesizing that this focus on back sounds might enhance learning. On the other hand, an SLP might focus on the θ–r pair, noting that Ethan is beginning to produce velar /k/ and palatal /ʧ/. The SLP may hypothesize that Ethan might continue to improve and expand on his production accuracy for velars and palatals, potentially improving /k g ʃ ʧ ʤ/ without direct intervention. However, Ethan does not show any accurate production of interdental fricatives /θ ð/ or the liquids /l r/. Ethan may need direct intervention to support learning of these aspects of phonology. In this way, θ–r might be a good choice for the maximal opposition approach with Ethan. As with the multiple oppositions approach, the maximal opposition approach provides clear guidance on sound selection but typically yields a variety of evidence-based pairs that can be whittled down based on the needs of the child and/or the SLP's expertise, ensuring that the approach is a good fit to the child and the school setting.

Additional Cases

Additional cases are provided in supplemental materials to illustrate further the decision-making process for contrastive approaches. In Supplemental Material S5, multiple oppositions of [d]–/g ð sl/ is recommended for Sophia (age 4;4, girl, severe SSD) to address one of her three global phoneme collapses, specifically [d] for targets /g ð dr gr gl sl st/. In Supplemental Material S6, maximal opposition of /r s/ is recommended for Isabella (age 4;11, girl, severe SSD) to address her fricative (f v θ ð s z ʃ) and liquid errors (l r) using the most frequently occurring target sounds. In Supplemental Material S7, none of the contrastive approaches are appropriate for Ava (age 5;7, girl, severe SSD), who would likely benefit from a intervention that targets clusters. Having illustrated how to determine which contrastive approach, if any, are appropriate for a given child and how to select target sounds within each approach, I next turn to implementing the selected approach with a focus on (a) writing IEP goals, (b) selecting the linguistic context, (c) determining intervention intensity.

Long-Term IEP Goals

IEP goal writing for children with SSD can be challenging. Although specific sounds are targeted in intervention, it is generally expected within each of the three contrastive approaches that children will show broader learning than simply improving the accuracy of the small set of sounds being treated. As described earlier, each approach predicts that children will suppress a targeted process (as in conventional minimal pair), apply learned features to other target sounds (as in maximal opposition), or break a global phoneme collapse (as in multiple oppositions). However, the exact broader improvements are not known with certainty.

In addition, contrastive interventions tend to be completed relatively quickly. Sugden et al.'s (2018) review of intervention intensity shows that intervention research on conventional minimal pairs typically relied on six to 67 sessions; maximal opposition used 12–36 sessions; and multiple oppositions utilized 15–44 sessions (Sugden et al., 2018). Williams's (2012) review of multiple oppositions studies showed that the average number of sessions was 17–20 sessions for a given phoneme collapse. Given this range of intervention sessions, it is likely that many children will not require a full IEP year of intervention to address the specific target selected initially. However, it is quite possible that children would not be eligible for IEP dismissal after intervention on the first selected target. Additional intervention may be needed, but it is not easy to anticipate what approach or targets will need to be the focus of the next round of intervention. Consequently, it is recommended that the long-term goal of the IEP focus on the broader needs in the child's system, rather than on individual targets.

For example, a long-term goal for Ethan could focus on performance on the deep probe of singletons and/or clusters. To illustrate a singleton goal, I will focus on singleton intervention of maximal opposition of θ–r. A singleton goal might be as follows: Ethan will increase his

production accuracy of /k g θ ð ʃ ʧ ʤ ŋ l r/ from 5% baseline accuracy to 90% accuracy as measured by a single word probe (without models or cueing) administered each quarter. Recall that one prediction from the SLP when selecting the θ–r maximal opposition pair was that Ethan might learn /k g ʃ ʧ ʤ ŋ/ without direct intervention and intervention of θ–r might promote change in the remaining sounds /θ ð l r/. Thus, the SLP might reasonably predict that Ethan will achieve this goal upon completing his θ–r maximal opposition intervention. However, if that does not happen, the SLP indicates that they would continue to select intervention targets and approaches that would yield improvements in the production accuracy for this set of sounds. A similar goal could be written for clusters, or the singleton and cluster goal could be combined into one goal (i.e., list all singletons and clusters in one goal and compute accuracy for the full set of sounds). Although this goal was illustrated for the maximal opposition approach, the same long-term goal could be used for other approaches. The long-term goal highlights the sounds of interest for the duration of the IEP and possibly beyond (depending on progress).

The SLP also may want to write a long-term goal that focuses on conversation because it is possible for children to produce sounds accurately on a probe but show inaccuracies in conversation that impact their classroom success. The contrastive approaches generally focus on word-level production. Thus, a long-term goal related to conversation allows the SLP to monitor whether children generalize word-level production to conversation. If this is not occurring, then conversational accuracy could be targeted in intervention. One possible conversational long-term goal for Ethan is as follows: Ethan will increase his percent consonants correct (PCC) from [BASELINE PCC] to [TARGET PCC] in a conversational task administered each quarter (Shriberg et al., 1997). An alternative possibility is as follows: Ethan will increase his intelligibility in everyday situations from [BASELINE ICS RATING] to [TARGET ICS RATING] as measured by the average target score on the Intelligibility in Context Scale (ICS) using parent ratings (McLeod et al., 2012, 2015). Because Ethan's baseline is unknown for both PCC and ICS, there is missing information in each goal. For the target, one could consider realistic progress given the baseline or choose age-appropriate targets for Ethan: PCC greater than 85% (Shriberg et al, 1997) or ICS average total score of 4.6 or higher (McLeod et al., 2012). Short-term IEP goals will be addressed in the Linguistic Context section within the subsection on Words, Sentences, and Conversation.

Linguistic Context

Minimal Pairs

Real words. Once intervention targets have been selected for a contrastive approach, the next step is identifying the minimal pairs, triplets, quadruplets, or quintuplets, depending on the approach. Generally, the maximal and multiple oppositions approaches have selected from five to eight word sets (Allen, 2013; Gierut, 1989, 1990, 1991; Topbaş & Ünal, 2010; Williams, 2005). Elbert et al. (Elbert et al., 1991) specifically addressed how many word sets are needed to generalize the treated sound to untreated words in the same word position, using a conventional minimal pair approach. They showed that 59% of children generalized the treated sound to untreated words following intervention with just three word sets. For the children who did not show generalization, additional word sets were added to intervention. With the addition of two new words sets (i.e., five total words sets), 21% of children generalized the treated sound to untreated words. With the addition of three more new words sets (i.e., 10 total word sets), 14% of children generalized the treated sound to untreated words. Finally, one child (7%) never showed generalization. Taken together, 80% of children showed generalization after intervention of three to five word sets. Thus, I suggest identifying five minimal pairs, triplets, quadruplets, or quintuplets for the intervention targets.

Supplemental Material S8 provides a minimal pair spreadsheet for identifying word sets targeting singletons in word-initial position. Instructions are in the Read Me worksheet, and Supplemental Material S9 provides an instructional video for the spreadsheet. This resource was used to identify maximal opposition word sets for Ethan, as shown in Table 2. An additional paid resource is the Sound Contrasts in Phonology (SCIP) app, which contains a library of words and pictures as well as a search feature to identify word sets (Williams, 2021). This resource was used to identify multiple oppositions word sets for Ethan

Table 2. Word sets for Ethan for maximal opposition and multiple oppositions.

Word set	Maximal opposition θ–r	Maximal opposition g–l	Multiple oppositions t-kl, θr, st
1	thumb-rum	gore-lore	toes-close, throws, stows
2	thought-rot	game-lame	tone-clone, trone, stone
3	thug-rug	gab-lab	two-clue, threw, stew
4	thing-ring	gate-late	tick-click-[θrɪk],[a] stick
5	thong-wrong	gong-long	[tæʃ][a]-clash, thrash, stash

Note. Maximal opposition word set examples were generated using the supplemental materials available with this article (see Supplemental Material S8). Multiple oppositions word set example was generated using the Sound Contrasts in Phonology app (Williams, 2021).

[a]Nonword.

because his targets included clusters. Sample multiple oppositions stimuli for Ethan are shown in Table 2.

In reviewing example word sets for Ethan in Table 2, it should be noted that some of the words may not be known by Ethan or may not be age- (e.g., ream) or school-appropriate (e.g., thug, rum). There were only 11 word set options for θ r, making it difficult to prioritize functional words. Likewise, for the multiple oppositions approach, only three minimal quadruplets using real words could be identified. Ethan's final two quadruplets involve one nonword per quadruplet. The SCIP app provides a nonsense picture for these nonwords. Taken together, the words selected for contrastive intervention approaches may not be functional or real words. It may be important to explain to families and IEP team members that, in these approaches, words are selected to highlight sound contrasts to help accelerate learning of speech sounds. That is, the approaches do not focus on building the correct production of functional vocabulary. For this reason, highly unintelligible children with limited functional communication may need a different approach that focuses on functional communication.

Nonwords. At this point, it seems important to comment on the use of nonwords in phonological intervention. As noted, the multiple oppositions approach occasionally requires that nonwords be used to create word sets. In addition, much of the maximal opposition research was done using nonword sets rather than real word sets (Gierut, 1990, 1991; Gierut & Neumann, 1992). Typically, when nonwords are used in phonological intervention, they are assigned a meaning (Gierut, 1990, 1991; Gierut & Neumann, 1992; Williams, 2021) and may be incorporated into a story that is read weekly to introduce and reinforce the meaning (Gierut, 1990, 1991; Gierut & Neumann, 1992). In this way, the nonwords are "turned into" real words by assigning them to meanings that are less familiar to children (e.g., unusual actions and objects) and as proper names of characters. Children are not told that the words are "funny words" that are only used in the speech room because that might hinder phonological learning. Multiple studies suggest that nonwords are at least as effective as real words (Cummings et al., 2019; Cummings & Barlow, 2011; Gierut et al., 2010; Gierut & Morrisette, 2010) and might even have some advantages over real words in terms of accelerating early gains (Gierut et al., 2010; Gierut & Morrisette, 2010) or creating more consistent gains across children (Cummings et al., 2019). Nonwords may facilitate phonological learning because the child does not need to overcome or suppress prior experience producing the word incorrectly (Storkel, 2018b). The child can learn the correct production of the word with the supports provided by the SLP. Thus, accurate production of the word is established from the first encounter with the word.

SLPs may want to try the use of nonwords with a contrastive intervention approach, particularly maximal opposition where nonwords have been used extensively in research. Supplemental Material S10 provides a nonword story template and an example nonword story for intervention of θ–r for Ethan. Supplemental Material S11 provides the pictures to accompany the story. As with nonfunctional real words, the SLP should be ready to explain to families and the IEP team why nonwords are being used in intervention. One brief explanation is that nonwords focus the child on producing the target sound correctly without having to overcome past misarticulation of the word, accelerating speech sound learning.

Words, Sentences, Conversation

The contrastive approaches typically start intervention at the word level. Maximal and multiple oppositions use imitation practice to a criterion (e.g., 70%–75% accuracy usually across several training sets or sessions) followed by spontaneous practice to a criterion (e.g., 70%–90% accuracy across several training sets or sessions; Allen, 2013; Gierut, 1990, 1991; Gierut & Neumann, 1992; Topbaş & Ünal, 2010; Williams, 2000a, 2005, 2012). As noted previously, conventional minimal pair shows more variability in starting point with some versions beginning with spontaneous production of words to a criterion, but other versions beginning with imitation to criterion (Miccio et al., 1999; Miccio & Ingrisano, 2000) or even training of the words individually initially, rather than in their minimal pair sets (Powell et al., 1991; Tyler et al., 1987). Finally, some versions begin with training the sound in isolation or consonant–vowel syllables to establish accurate production (Miccio et al., 1999; Tyler et al., 1987).

The choice of starting point likely will depend on the child's skill in producing the selected target sounds. If a child is readily stimulable for the sound (i.e., can produce the sound accurately with a model), then starting with spontaneous practice of paired words is likely appropriate because the child can self-correct with minimal cueing. If the child can produce the sound with SLP cues and/or articulatory instructions, then starting with imitation practice of paired words is likely appropriate because the SLP will provide those cues before or after the child's production attempt. Finally, if the SLP is unable to elicit a correct production of the target sound(s), then the SLP may want to begin by establishing the child's skill in producing the sounds in isolation or syllables. Note that establishing stimulability would have a relatively low criterion for advancement (e.g., 30% accuracy or higher). Specifically, stimulability tests often classify a child as stimulable for a sound if they accurately produce the sound in three or more of 10 attempts (i.e., 30% accuracy) following an SLP's model (Miccio, 2002). Stimulability testing and/or a diagnostic intervention session to explore cues

and instructions to elicit accurate production of the targets would be informative in choosing a starting point.

Contrastive approaches vary their end points. Some programs end after the child has met the criterion for spontaneous practice of words (Gierut, 1990, 1991; Gierut & Morrisette, 2010; Topbaş & Ünal, 2010). Some require training beyond the word level, such as in phrases or sentences or discourse (Allen, 2013; Baker & McLeod, 2004; Crosbie et al., 2005; Hoffman et al., 1990; Ruscello et al., 1993). Others monitor generalization to untreated words (Elbert et al., 1991; Miccio et al., 1999; Tyler et al., 1987; Williams, 2000a, 2005) or conversation (Williams, 2000a, 2005) and then adjust intervention based on whether generalization is occurring. As previously noted, most children generalize the correct production of target sounds to untreated words (Elbert et al., 1991). Likewise, following conventional minimal pair intervention, children showed significant improvement in PCC in conversation at a 3-month follow-up point (Elbert et al., 1990). This study (Elbert et al., 1990) also noted that generalization to single word productions occurred early (i.e., significant changes in pre- to post-intervention scores), and generalization to conversation lagged (i.e., significant changes from post-intervention to follow-up).

Given that generalization might occur, I recommend training to a set criterion for spontaneous practice of paired words (e.g., 70%–90% accuracy across several training sets or sessions). At that point, generalization should be tested to inform decisions about next steps in intervention, as described by Williams (Williams, 2000a, 2005). Specifically, Williams recommends administering a single-word probe to test whether the child is producing the treated sounds in untreated words. If the child's production of the treated sounds in untreated words is below 90%, she recommends that intervention focusing on the selected sounds continue with spontaneous practice at the word level but that new words be added to intervention and/or that new pictures be selected for the current treated words. On the other hand, if the child's production of the treated sounds in untreated words is 90% or better, then a conversation sample is collected to assess the accuracy of the treated sounds in conversation. If the child produces the treated sound with less than 50% accuracy, then intervention would focus on training beyond the word level (e.g., sentences or conversation). If the child produces the treated sound with 50% accuracy or better in conversation, then this round of intervention is complete and the child's speech is reassessed to determine whether the child can be dismissed from intervention or whether a new intervention plan should be created. In the latter case, the SLP would conduct all the intervention planning steps described in this article again.

Returning to IEP goals, short-term IEP goals should reflect the just described strategy. Short-term IEP goals for Ethan's θ–r maximal opposition intervention might include the following: (a) Ethan will produce untreated words targeting θ and untreated words targeting r with 90% accuracy on a single word probe, and (b) Ethan will produce untreated words targeting θ and untreated words targeting r with 50% accuracy in a conversational sample with the SLP. Note that the data that determine next steps in intervention are used to write the short-term IEP goal, thus reflecting those critical decision points in intervention.

Intervention Intensity

Intervention intensity, in terms of sessions per week, length of session, and number of trials per session, has varied widely within and across studies (Sugden et al., 2018). As detailed by Sugden et al., conventional minimal pair studies have used one to four sessions per week with 30- to 90-min sessions targeting 25–150 trials per session. Maximal opposition studies have used two to three sessions per week with 30- to 60-min sessions. Trials per session have not been noted. Multiple oppositions studies have used one to three sessions per week with 30- to 45-min sessions targeting 65–100 trials per session. Williams (2012), in her review of multiple oppositions data, notes that the average number of trials per session was 61–82 trials. She also noted that early sessions that incorporated many drill activities tended to target 60 responses per 30-min session. In contrast, later sessions that used more naturalistic activities tended to have a lower intensity (i.e., 20 responses). Williams (2012) recommended targeting a minimum of 50 trials per session for children with SSD, but increasing this to a minimum of 70 trials per session for children with more severe SSD. Obviously, many factors affect how SLPs select service delivery options. These observations suggest that the contrastive approaches are likely appropriate for typical service delivery formats found in schools and provide guidance on setting trials per session intensity targets.

Conclusions

Many SLPs are likely already using the conventional minimal pair approach. This tutorial highlights that using the conventional minimal pair approach should be restricted to children with a small number of errors (i.e., older children or children with mild SSD). There is an opportunity for SLPs to use newer, more efficacious approaches with younger children and children with more severe SSDs. The maximal opposition approach is well suited for children with multiple errors across multiple sound classes. The multiple oppositions approach specifically targets global phoneme collapses that impact

intelligibility. Supplemental materials provide support to SLPs in adopting these newer approaches.

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