Published in final edited form as:

Perspect ASHA Spec Interest Groups. 2019 April 15; 4(2): 240–256. doi:10.1044/2019_PERS-SIG1-2018-0013.

Treatment Targets for Co-Occurring Speech-Language Impairment: A Case Study

Philip N. Combitbs,

San Diego State University / University of California, San Diego

Jessica A. Barlow,

San Diego State University

Jennifer Taps Richard, and

San Diego Unified School District

Sonja L. Pruitt-Lord

San Diego State University

Abstract

Purpose.—The intersection of speech and language impairments is severely understudied. Despite repeatedly documented overlap and co-occurrence, treatment research for children with combined phonological and morphosyntactic deficits is limited. Especially little is known about optimal treatment targets for combined phonological-morphosyntactic intervention. We offer a clinically focused discussion of the existing literature pertaining to interventions for children with combined deficits and present a case study exploring the utility of a complex treatment target in word-final position for co-occurring speech and language impairment.

Method.—Within a school setting, a kindergarten child (age 5;2) with co-occurring phonological disorder and developmental language disorder received treatment targeting a complex consonant cluster in word-final position inflected with third-person singular morphology.

Results.—For this child, training a complex consonant cluster in word-final position resulted in generalized learning to untreated consonants and clusters across word positions. However, morphological generalization was not demonstrated consistently across measures.

Conclusion.—These preliminary findings suggest that training complex phonology in word-final position can result in generalized learning to untreated phonological targets. However, limited improvement in morphology and word-final phonology highlights the need for careful monitoring of cross-domain treatment outcomes and additional research to identify the characteristics of treatment approaches, techniques, and targets that induce cross-domain generalization learning in children with co-occurring speech-language impairment.

Keywords

phonology; morphology; speech sound disorder; language disorder

Two of the most prevalent communication disorders in preschool and early school age children are phonological disorder (PD), a type of speech-sound disorder (Law, Boyle, Harris, Harkness, & Nye, 2000), and developmental language disorder (DLD), a type of language impairment also referred to as specific language impairment (Bishop et al., 2017). Both PD and DLD are of unknown etiology, occurring independently of a primary motivating condition, and both functionally impair the development, manipulation, and production of the linguistic units of language. The primary distinction between PD and DLD lies in the types of units affected. In PD, phonological units (e.g., speech sounds and sequences) are impacted, whereas in DLD, the impact is seen in larger units (e.g., morphemes, words, and phrases). Despite affecting different language components, PD and DLD both prevent development of a child's linguistic skills in a timely manner, which can impact their communication and literacy skills and later academic, socio-emotional, and occupational outcomes (e.g., Beitchman, Wilson, Brownlie, Walters, Inglis, et al., 1996; Beitchman, Wilson, Brownlie, Walters, & Lancee, 1996).

Because PD has typically been associated with the domain of speech and DLD with the domain of language, the assessment and treatment of each has most frequently been investigated independently. However, there is a body of evidence that links PD and DLD and demonstrates the considerable co-morbidity of these disorders. Investigators in the areas of PD (Paul & Shriberg, 1982; Rvachew, Gaines, Cloutier, & Blanchet, 2005) and DLD (Bishop & Edmundson, 1987; Botting & Conti-Ramsden, 2003; Haskill & Tyler, 2007; van Daal & van Balkom, 2004) have repeatedly documented co-occurring deficits, such that difficulty with language (i.e., morphosyntax) is frequently reported in children with PD, and children with DLD often have co-occurring speech-sound production deficits.

Prevalence estimates for co-occurring PD and DLD (hereafter, PD-LD) vary greatly. For instance, Shriberg and Kwiatkowski (1994) found between 10% and 77% of 3-to-6-year-old children with speech production deficits demonstrate expressive language concerns (e.g., low utterance length, grammatical morpheme errors, limited vocabulary). In two epidemiological studies reviewed by Pennington and Bishop (2009), children with DLD were 3.3 (Shriberg, Tomblin, & McSweeny, 1999) or 6.1 (Beitchman, Nair, Clegg, Ferguson, & Patel, 1986) times more likely to also have PD. Although these estimates vary, the substantial co-occurrence of phonological and morphosyntactic impairments is well documented, which muddies the distinction between traditional speech and language disorders and demands that this co-occurrence be addressed in the clinical literature.

Converging evidence also suggests that PD and DLD may, at least in some cases, have similar or overlapping etiologies (e.g., Pennington & Bishop, 2009). PD and DLD are associated with multiple cognitive-linguistic deficits, including some that regularly occur in children with either disorder, such as impaired phonological working memory (Archibald & Joanisse, 2009; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004). Heritability has been demonstrated for PD and DLD (Pennington & Bishop, 2009), and is especially linked to instances of co-occurring PD and DLD (Lewis, Freebairn, & Taylor, 2000b). Some have suggested that, in children with co-occurring PD and DLD (henceforth PD-LD), low intelligibility characteristic of PD is often identified before characteristics of DLD (e.g., Panagos, 1974), whose presentation is known to change across the life span (e.g., Conti-

Ramsden, St Clair, Pickles, & Durkin, 2012). The literature also suggests that children with PD-LD are more severely impaired and are more likely to experience lasting cross-domain deficits than those with PD or DLD alone (Bishop & Edmundson, 1987; Haskill & Tyler, 2007; Ingram, 1976; Lewis, Freebairn, & Taylor, 2000a; Macrae & Tyler, 2014). Furthermore, children with co-occurring PD-LD also demonstrate poorer language and literacy outcomes in adolescence than those with non-comorbid PD or DLD (Lewis et al., 2015).

Overlapping vs. Co-Occurring Disorders

The issue at hand is a group of children with deficits distributed across the non-mutually exclusive domains of phonology and morphosyntax. Notably, not all children with overlapping morphophonological error patterns fit the profile of a child with co-occurring PD-LD. For instance, a child might present with DLD, whose omission of word-final grammatical morphemes, such as 3rdSg *-s* or past tense *-ed*, mimics a pattern of final consonant deletion or cluster reduction (e.g., *goes* /gouz/ as [gou]; *stopped* /stapt/ as [stap]), which is a relatively common phonological process in children with PD (Ingram, 1989). This scenario could presumably be identified as a case of DLD—and not PD—by examining word-final production of [-s], [-z], [-t], [-d] in non-morphemic word-final contexts. A notably lower marking rate for 3rdSg [-z] in a word like *goes* /gouz/ than for non-morphemic [-z] in a word like *hose* /houz/ would suggest difficulty with production of the grammatical marker, unrelated to production of word-final [-z].

Alternatively, a child might present with PD, whose limited or absent production of phonemes in coda position, certain consonants, or consonant clusters results in limited or absent marking of word-final grammatical morphemes. For instance, a child who does not produce [s] in words of any type would also omit 3rdSg [-s] in *she walks*; however, in this instance, the underlying deficit would lie in phonology and not in morphosyntax. In this case, a thorough examination of the child's phonological system, especially productions of [-s], [-z], [-t], [-d] in word-final position would permit identification of phonological constraints impacting morpheme production, and this could be compared to morphosyntactic knowledge in less phonologically constrained contexts, such as vowel-final verbs (e.g., *goes* /gouz/) or other non-word-final tense and agreement morphemes, like copula or auxiliary *be*.

A third profile would be that of a child with PD-LD—co-occurring phonological and morphosyntactic deficits above and beyond surface-level overlap in cases where these two domains intersect. A child with co-occurring PD-LD would demonstrate morphological deficits beyond contexts where phonology would impact morphology and vice versa. These children would demonstrate deficits in both morphosyntax and phonology in contexts other than their overlap in word-final position, such as errored case marking and low word-initial consonant accuracy. Given that PD, DLD, and PD-LD can resemble each other when viewed through certain lenses, thorough cross-domain assessment should be conducted to reduce the risk of an incomplete or inappropriate diagnosis.

Cross-Domain Treatment: Approaches, Techniques, and Targets

Several studies have documented approaches that resulted in quantifiable improvement in both phonology and morphosyntax following intervention for PD-LD. Cross-domain improvements were documented in one study that sequenced or alternated treatment domains (Tyler, Lewis, Haskill, & Tolbert, 2003) and in three studies that combined phonological and morphological treatment in the same session or activity (Bellon-Harn, Hoffman, & Harn, 2004; Tyler et al., 2003; Tyler & Sandoval, 1994). Interestingly, several studies also reported cross-domain improvement following morphosyntactic treatment only (Hoffman, Norris, & Monjure, 1990; Hoffman, Norris, & Monjure, 1996; Matheny & Panagos, 1978; Tyler et al., 2003) or phonological treatment only (Matheny & Panagos, 1978). Additional studies using combined treatment approaches for this population only found well-documented improvement in one of the two linguistic domains (i.e., phonology: Hodson et al., 1989; morphosyntax: Fey et al., 1994; Tyler et al., 2002). Consequently, cross-domain improvement may be achievable for children with PD-LD, although methodological variations across studies make it difficult to determine which domain(s) should be targeted for optimal results.

Perhaps less clear to a clinician faced with providing intervention for a child with PD-LD are which techniques to use or which linguistic structures to target in intervention. In the aforementioned studies, a variety of intervention techniques were successfully employed, including focused stimulation or drill, minimal pair contrasting, elicited production, cloze techniques (Tyler et al., 2002; Tyler et al., 2003), phonological and auditory awareness activities (Gillon, 2000; Tyler et al., 2003), naturalistic play, and storytelling (Hoffman et al., 1990; Hoffman et al., 1996). Although no single approach has emerged as most effective, fortunately, the implication is that a variety of intervention activities can achieve cross-domain improvement.

There is especially little evidence as to the characteristics of the linguistic structures that should be targeted in treatment for children with PD-LD. In several of the studies reviewed above, phonological or morphosyntactic targets were described only broadly as complex discourse, narrative structures, or phonological processes (Bellon-Harn et al., 2004; Hoffman et al., 1996). In the work by Tyler and colleagues (Tyler et al., 2002; Tyler et al., 2003; Tyler & Sandoval, 1994), phonological processes and morphosyntactic errors were directly targeted by training specified linguistic structures. For example, in Tyler et al. (2002), treatment for one child targeted /fl-/ and /kl-/ to address initial cluster reduction and targeted past tense *-ed*, irregular past tense, possessive *'s*, and auxiliary *be* to address grammatical morphology errors. In each of these studies, treatment targets were scheduled using a cycles approach (Hodson & Paden, 1991), which necessarily involves the use of multiple targets. However, this limits our ability to retrospectively identify the influence of a given linguistic target (e.g., /fl-/ or past tense *-ed*), as it cannot be separated from the influence of other simultaneous or cycled targets.

Treatment Target Complexity and Generalization

Because treatment research targeted for children with PD-LD is still relatively sparse, and the studies that do exist have a) broadly targeted one or more domains, b) not specified treatment targets, or c) employed multiple simultaneous or cycled targets, attention has yet to shift to the impact of characteristics of the stimuli or treatment targets that are trained in combined phonological-morphosyntactic interventions. This is an important consideration for effective intervention because of the impact that a given treatment target or stimulus may have on generalization learning (Cummings & Barlow, 2011; Gierut & Morrisette, 2010; Plante et al., 2014; Van Horne, Fey, & Curran, 2017).

Introducing linguistic structures into an impaired system by training linguistically complex exemplars is an effective approach for treatment of disorders in multiple linguistic domains (e.g., syntax; Thompson, Shapiro, Kiran, & Sobecks, 2003; morphology; Van Horne et al., 2017; phonology; Gierut, 2008). Per this complexity-based approach, new language structures are learned by exposure to input that demonstrates a greater extent of higher-level variations. Presumably, relatively complex exemplars in the input require the child's existing language knowledge to expand in accommodation of the new, complex input (Gierut, 2007). In practice, the primary advantage of a complexity-based approach is that it is expected to result in simultaneous generalization learning of simpler, untreated components of the language (e.g., Storkel, 2018a). Within the phonological domain, teaching complex sound targets results in greater generalized learning across sound manner classes (e.g., stops, fricatives, nasals) than the traditional approach of teaching simpler targets first (e.g., Tambyraja & Dunkle, 2014). Further, complex consonant cluster targets, such as /spl-/ in *splash*, appear to result in the greatest amount of generalization learning, improving accuracy of other consonant clusters and singleton consonants and, consequently, resulting in higher consonant accuracy and overall intelligibility (Elbert, Dinnsen, & Powell, 1984; Gierut, 1999; Gierut & Champion, 2001).

Within the domain of morphosyntax, treatment using complex stimuli has been shown to result in improved generalization learning in adults with aphasia at the sentence level (e.g., Thompson, Ballard, & Shapiro, 1998) and children with DLD at the morphological level (Van Horne et al., 2017). In their recent study, Van Horne et al. (2017) targeted past tense morphology in children with DLD using a set of verb stimuli classified as difficult or easy based on their phonological, semantic, and frequency characteristics. Children trained first using the more difficult and ostensibly more complex stimuli made greater improvement, including generalized learning to untreated verbs, than the children trained first with the easier, or simpler, stimuli. Strategic manipulation of the complexity of treatment targets and stimuli has thus been associated with improved generalization learning, not only for children with PD, but also individuals with language impairments, including DLD.

Complex Treatment Targets for PD-LD

The apparent effectiveness of complex consonant clusters in word-initial position for treatment of PD leads us to consider how complex treatment targets can be applied to children with co-occurring PD-LD. In English, there is overlap between complex phonology

and morphology in word-final verb tense markers (e.g., 3rdSg *-s* and past tense *-ed*). For example, suffixation of *[-s]* or *[-z]* in a 3rdSg-inflected verb not only adds morphological content to the verb, it also increases its phonological complexity by adding a coda consonant (e.g., *fly+s* /flaɪz/) or forming a consonant cluster (e.g., *eat+s* /its/; *help+s* /hɛlps/).

To our knowledge, there has been no isolated investigation of treatment outcomes for children with PD-LD as a result of training a complex morphophonemic consonant cluster (e.g., a tense-inflected word-final cluster). There is, however, some precedent for targeting morphophonemic word-final clusters in this population. In their treatment study, Tyler and Sandoval (1994), targeted the phonological processes of final consonant deletion or cluster reduction in six preschool-age children with PD-LD with the expressed intention of improving the production of grammatical morphemes that occur in word-final consonants and clusters. The children in their study received one of three interventions: a) a phonological intervention targeting phonological processes using elicited imitation and minimal pair contrasts, b) a narrative-based intervention targeting various grammatical morphemes and expanded utterances using focused stimulation and recasting, or c) a combination of both interventions in the same session.

Because the interventions in Tyler and Sandoval (1994) involved a cycles approach to treatment targets, the independent effectiveness of targeting complex word-final phonology and morphology together is impossible to determine in this study. Notwithstanding, two participants, S1 and S6, were treated by expressly targeting word-final cluster reduction in morphologically complex contexts in one of their cycles. Participant S1 received the direct phonology treatment and was trained to produce */-ps/* and */-ts/* to target final cluster reduction among his other cycled targets. Following 12 weeks of treatment, S1's frequency of occurrence of final cluster reduction was reduced from 100% at baseline to 21%. His production accuracy of five two-element final clusters (including the two treated clusters) increased from 0% at baseline to 58%.

Participant S6, who received the combined phonological and narrative-based intervention, was similarly trained to produce */ts/* to target final cluster reduction among his other cycled targets. Following 12 weeks of treatment, S6's frequency of occurrence of final cluster reduction was reduced from 100% at baseline to 0%. His production accuracy of five two-element final clusters (including the one treated cluster) increased from 0% at baseline to 100%. Notably, S1 and S6 outperformed the other four children who were not trained on word-final consonant clusters in terms of overall consonant accuracy improvement and elimination of phonological processes, although they also had greater receptive language skills, Percentage of Consonants Correct (PCC), and mean length of utterance (MLU) at baseline than other participants.

Although the impact of treatment targeting final cluster reduction and, indirectly, complex final clusters in Tyler and Sandoval's (1994) study cannot be isolated from the impact of other cycled targets, the children who were trained to produce two-element morphophonemic final clusters as part of their intervention outperformed many of the other participants following treatment, which suggests that targeting morphologically inflected final clusters might be beneficial for children with PD-LD and warrants further investigation.

A Case Study

Following these suggestive results, we will directly explore the use of a single morphophonologically complex treatment target by describing the execution and outcome of a school-based case study conducted with a young child with PD-LD. The treatment target and treatment protocol will be described, and treatment outcomes will be presented and discussed as they relate to morphophonological learning and the variable profiles of children presenting with overlapping characteristics of PD and LD or co-occurring PD-LD.

The study participant was a child in kindergarten, herein referred to as “Max,” who demonstrated a profile of co-occurring PD-LD. At the beginning of the school year, Max presented with spoken language deficits in the areas of phonology and morphosyntax, including—but crucially not limited to—overlapping errors in phonology and morphology in word-final position (i.e., final consonant deletion/cluster reduction and word-final grammatical morpheme omission). Although Max presented with an overlapping deficit pattern that could be associated with either PD or LD independently, his phonological and morphosyntactic deficits were not exclusive to this overlap, as described below. Thus, Max had co-occurring PD-LD, rather than limited overlapping features of LD ultimately attributable to PD.

A speech-language pathologist (SLP) faced with a child, like Max, with PD-LD must choose treatment approach(es) and target(s) to address both of the child’s impacted language domains. Should an SLP decide to approach treatment of phonology and morphosyntax simultaneously, there is little guidance as to effective targets to train during treatment. Max’s treatment presented here is a direct response to the scarcity of treatment target efficacy evidence available to guide target selection for SLPs treating children with PD-LD. Furthermore, Max’s treatment was conducted as it would occur in typical school-based services; intervention was provided in a small group with another child of similar age, occurred on-site at his elementary school, and was scheduled according to his Individualized Education Program (IEP) requirements and academic schedule.

Specifically, Max received 14 weeks of direct phonological treatment targeting one word-final consonant cluster in real and nonce stimulus verbs inflected with a 3rdSg morpheme (e.g., *he helps*). The goal of treatment target selection was to identify a linguistically complex structure, /-lps/, with phonological and morphological content whose accuracy was low at baseline. With this complex target, we expected to observe generalization learning beyond the treated consonant cluster in Max’s language production via his phonological system, his morphological system, or both. The impact of this approach was determined by post-treatment generalization learning of phonological and morphological structures as measured by singleton consonant, cluster, and grammatical morpheme accuracy outside of treated contexts.

Method

Participant

Max was a monolingual, English-speaking child (male, age 5;2) attending a public kindergarten. In the summer prior to this study, he received an IEP identifying speech and language concerns and participated in a preschool speech improvement class (a general education service; Montgomery, Dunaway, & Taps, 2005) targeting structured conversation, including words with initial /fl-/ and /skw-/ sounds. However, upon entry to kindergarten in the fall, he received no speech-language services other than the intervention described here.

Max's speech-language skills were assessed using a battery of elicitation probes (described below) and a language sample collected at baseline. Max's elicited productions were characterized by low consonant accuracy and notable word-final morpheme omissions, including 0% marking of regular monosegmental 3rdSg, past tense, and plural morphemes. His pre-treatment singleton and cluster accuracy, and word-final morpheme marking rates from baseline probes are shown in Table 1. His pre-treatment phonetic inventory of singleton consonants and clusters in word-initial and word-final positions from these same probes are given in Table 2. Specifically, Max's Percentage of Consonants Correct-Revised (PCC-R) was 43.3%. Speech-sound production accuracy was especially low for word-initial clusters (25.7%) and singletons and clusters in final position (31.2% and 7.6%, respectively), and he did not mark (i.e., produce) any instances of word-final [-s, -z, -t, -d] morphemes in elicitation probes. His inventory of singletons and clusters (see Table 2) was also limited, especially in word-final position—with notable absence of final [-s] and [-z], which are used for regular 3rdSg and plural marking.

Phonological and morphosyntactic characteristics of Max's elicited productions were similar to those attested in his conversational connected speech. Per a 152-utterance language sample, Max presented with highly unintelligible speech and low consonant accuracy in addition to notable morphosyntactic deficits, including 0% regular 3rdSg and past tense marking, and frequent omission of plural marking, copula and auxiliary *be*, and functor words (e.g., *to*), and incorrect case marking, (e.g., *him* for *he*). His MLU in morphemes was 3.18.

Max's phonological characteristics, including highly unintelligible speech and low consonant accuracy, are indicative of moderate-to-severe PD, and his omission of grammatical morphemes, including those that are not restricted by complex phonology (e.g., auxiliary and copula *be*, articles, and prepositions) is consistent with a profile of DLD. Per his initial IEP report, based primarily on performance-based assessment and parent report, Max did not have any other co-occurring motor, social-emotional, behavioral, or health concerns. Max also passed a binaural hearing screening at the beginning of the school year. Together, these phonological and morphosyntactic deficits in the absence of other concomitant impairment indicate a co-occurring PD-LD profile.

All baseline/generalization probes and intervention sessions, as described herein, were administered by a certified SLP or graduate student clinician under the former's supervision. All data collection and treatment were conducted on-site at Max's school.

Generalization Probes

A set of morphophonological generalization probes was administered prior to treatment to establish baseline performance, as described above, and at time points during and post-treatment. A complete probe administration occurred before and after each treatment phase and after each break during which no treatment occurred, as shown in Table 3. A subset of the generalization probe administered at baseline was administered twice to establish baseline stability from September to mid-October.

The probe battery consisted of the singletons and initial clusters in single-word elicitation probes of the In-Depth Phonological Assessment (Taps Richard, 2012) and a word-final probe sampling final clusters and regular word-final morphology (plural, 3rdSg, and past tense) in a variety of word-final phonological contexts (i.e., preceded by different types of consonants, clusters, and vowels). Word lists for the generalization probe are available in the appendix. The complete battery elicited 312 words and sampled every singleton consonant at least three times in initial, medial, and final position; 28 initial clusters and 30 final clusters were sampled at least twice. Each grammatical morpheme was sampled, at minimum, 13 times in its monosegmental form (i.e., /-s/, /-z/, /-t/, /-d/) across a variety of phonological contexts.

Elicitation probes were administered from a notebook or folder with images (four per page) or a tablet screen (one image at a time). Max's productions were elicited without a model whenever possible; however, when he did not know the target or produced a non-target word, the target was elicited via delayed imitation of the examiner's model: "Is it ____ [target word] or ____ [unrelated word]?" or "This is a ____ [target word]. Tell me what this is." Word-final tense morpheme production was elicited using cues adapted from the Third Person Singular and Past Tense probes of the Rice/Wexler Test of Early Grammatical Impairment (Rice & Wexler, 2001), with a single practice item preceding each block of 3rdSg or past tense elicitations. These elicitations were in the following form: "Look at this woman. Tell me what she does: she ____ [3rdSg target]" or "She's jumping. Now she's done. Tell me what she did: she ____ [past tense target]".

Treatment Target and Stimuli

Max's treatment target was selected by adapting procedures for selecting complex word-initial phonological treatment targets (Morrisette, Farris, & Gierut, 2006). These procedures take into account child-specific and linguistic factors that affect the complexity and generalizability of potential treatment targets, including the child's knowledge of each component segment (i.e., accurate or inaccurate use and stimulability) and the linguistic complexity of the target. For additional information related to using complex phonological targets in treatment, readers are referred to Storkel (2018a). In adapting these procedures for a morphophonemic word-final target, a three-element cluster was selected because of its phonological complexity and the absence of any three-element clusters in Max's pre-treatment inventory. The target exemplar, /-lps/, was selected because of the complexity of these sounds in combination and Max's poor pre-treatment knowledge of the component sounds in word-final position. Finally, the 3rdSg morpheme was selected rather than the

plural morpheme because 3rdSg is generally acquired later (Brown, 1973) and is typically more severely impacted in children with DLD (Leonard, 2014).

Treatment stimuli were a set of seven verb phrases (four real and three nonce verbs). Both types of verbs were selected because nonwords have been shown to induce generalization learning more readily than real words in children with PD (Cummings & Barlow, 2011; Gierut & Morrisette, 2010; Storkel, 2018b). However, less is known about the impact of nonwords—particularly nonce verbs—in treatment for children with PD-LD; thus, both were included in Max's set of stimuli. For the first phase of treatment, stimulus verbs were preceded by the third-person pronoun *he* to create short, grammatically correct phrases (e.g., *he helps*, *he malps*) appropriate for imitation and drill-based activities, although the subject-agent was varied during the second phase of treatment. All consonants in stimulus phrases, except for the cluster target, were attested in the child's pre-treatment phonetic inventory to encourage focused learning of the targeted novel cluster. The stimulus phrases used in this study are given in the appendix.

Treatment Protocol

Max received 14 weeks of treatment provided in 30-minute small-group sessions twice per week, as is typical for school-based services. The small group consisted of the participant and one other child receiving treatment with a non-morphemic phonological target. The treatment followed a drill-play format (Shriberg & Kwiatkowski, 1982) with a production phase (Phase I) followed by an extension phase (Phase II). During the production phase, Max was introduced to four of the treatment stimuli and began producing target words following the clinician's verbal model with 1:1 clinician feedback. Explicit articulatory instruction was introduced and used as needed, including verbal, tactile, and kinesthetic cues, to elicit correct target forms (Bauman-Waengler, 2008; Secord, 2007). Max successfully imitated the target cluster across multiple attempts by the end of the first week of treatment; thus, for the remainder of the production phase, Max produced target verb phrases spontaneously or through elicitation but without an immediate verbal model. As the production phase progressed, corrective feedback was intermittently delayed or withheld to provide opportunities for self-monitoring and self-correction (Ertmer & Ertmer, 1998; Shriberg & Kwiatkowski, 1990). The role of 3rdSg *-s* was not explicitly instructed during this phase. Treatment materials included toys and picture cards depicting target verbs. Activities used to generate target productions included matching, sorting, and structured play. Max produced the treatment target, on average, 81 times per session (range = 24–150) across both phases of treatment. The end of Phase I (week 8) coincided with the beginning of an academic break during which five weeks of no treatment occurred. Any change in speech-sound or word-final morpheme production during this period of no treatment was monitored by administering the generalization probe before and after the break.

During the extension phase (Phase II), the same phonological sequence was targeted; however, three additional treatment verbs (one real and two nonce verbs) were introduced, and production opportunities were extended to the sentence, conversation, and narrative levels through roleplay and collaborative storytelling. This phase continued to target accurate production of the target cluster; however, the role of 3rdSg *-s* was explained

explicitly at the start of the extension phase, and Max was encouraged to combine treatment verbs with other 3rdSg subjects (e.g., *Laura gulps; the dog telps*). The conclusion of phonological treatment (week 14) also coincided with the beginning of an academic break, during which five weeks without treatment occurred. As before, change occurring during the five-week period after treatment was monitored by performance on the generalization probe.

During both phases of intervention, progress was monitored using a 1–7 visual analog scale (Munson, Schellinger, & Urberg Carlson, 2012) that evaluated production of the trained three-element word-final cluster in treatment words. Each treatment target word was elicited once at the end of treatment sessions with no clinician model or feedback. Max's production of the target cluster was evaluated from 1 (only a single segment, not in target cluster) to 7 (three correct target segments). A sample rating scale can be found in Figure 1.

Outcome Measures

Phonetic transcriptions of baseline and generalization probes were the primary source of data for the outcome measures in this study. All probes were transcribed on-line by the administering clinician or supervised graduate student using narrow phonetic transcription and audio recorded for later transcription by a research assistant trained in phonetic transcription of child speech to determine transcription reliability. Audio recordings were consulted for any words that were unclear to the on-line transcriber to amend missing or incomplete transcriptions. Transcription reliability for consonants, including word-final morpheme segments, was calculated for 30% (662 words) of the transcribed generalization probes at 85% (Shriberg & Lof, 1991).

Treatment outcome was defined as generalization learning in the phonological and morphological domains in non-treated contexts. Because phonological generalization from a complex target is expected to occur across contexts and sound classes, Max's outcome measure in the phonological domain was defined as production accuracy for all singletons and clusters in non-treated words that were produced with 0% accuracy prior to treatment. An additional clinical measure, Percentage of Consonants Correct-Revised, and a descriptive measure, phonetic inventory in each word position, were also collected. Max's outcome measure in the morphological domain was defined as regular monosegmental 3rdSg, past tense, and plural marking rate in non-treated words in the generalization probes. Probe transcriptions were analyzed for consonant accuracy, morpheme marking, and PCC-R using Phon (Rose & Hedlund, 2017), a free and open-source software for phonological analysis. Phonetic inventories were collected with the AutoPATT plugin (Combiths, Amberg, & Barlow, 2016) for Phon. Additional language sample measures (MLU in morphemes and grammatical morpheme marking rates) were derived from pre- and post-treatment language samples orthographically transcribed and coded for morpheme use by SLP graduate students using the Systematic Analysis of Language Transcripts (SALT) software and guidelines (Miller & Iglesias, 2012).

Results

Baseline Stability

In this case study, Max's baseline stability served as his own control. A stable baseline prior to treatment provides a point of comparison by which subsequent changes can be attributed to treatment, rather than maturation. Relative stability of his phonological and morphological systems prior to treatment, defined as <10% change during baseline, was established across a set of probes administered in the month of September (Baseline 1) and another set administered in early-mid October (Baseline 2). Treatment did not commence until after completion of Baseline 2 probes. Singleton and cluster accuracy from an overlapping subset of 54 probe words across staggered pre-treatment time points (Table 4) indicates stability during the 28-day period prior to participation in this study. Regular monosegmental 3rdSg, plural, and past tense morpheme production was also measured and remained stable at 0% across Baseline 1 and Baseline 2 pre-treatment probes.

Treatment Progress

Visual analysis of accuracy on the treated target in trained stimulus phrases (Figure 2) indicated that learning of the targeted morphophonological structure, /-lps/ was occurring during treatment sessions. In-session performance rose to ceiling by week 14 of treatment, demonstrating Max's progress in trained treatment verbs over the course of the intervention.

Phonology

With treatment targeting a complex word-final morphophonological sequence, we expected generalization learning to occur in Max's phonological system, his morphological system, or both. Composite accuracy scores were calculated for all singletons and clusters that were produced with 0% accuracy prior to treatment (herein referred to as 0%-at-baseline sounds) by word position (initial, final) and type (singleton, cluster) after each treatment phase, as shown in Figure 3. Max's 0%-at-baseline singletons in word-initial position demonstrated the most observable change, improving from 0% to 43% by the end of treatment. Composite accuracy for 0%-at-baseline initial clusters, final singletons, and final clusters improved between 10%–22% over the course of treatment.

Tables 5 and 6 display accuracy for each 0%-at-baseline singleton or cluster in word-initial and word-final position, respectively, after Phase I and Phase II of treatment. In word-initial position, six 0%-at-baseline singletons showed improvement following treatment. Of these, [z-], [g-], and [ʃ-] improved the most, with accuracy improving from 0% at baseline to 57%–80% post-treatment. Seven 0%-at-baseline consonant clusters showed improved accuracy following treatment, including [sl-] and [tw-], which rose from 0% to 100% accuracy following treatment.

In word-final position, despite many singletons produced with 0% accuracy prior to treatment, only one of these singletons appear to have been impacted by treatment. Greater improvement was seen in word-final [-l], which improved from 0% to 67% accuracy post treatment. As with word-final singletons, clusters in word-final position were limited prior to treatment. With treatment, Max demonstrated improved accuracy in eight 0%-at-baseline

final clusters, although improvement was generally limited and, in the case of [-lk], [-lps], [-mps], and [-mpt], was not persistent into the second phase of phonological treatment. Although Max demonstrated only transient improvement in three-element final clusters and two-element liquid + stop clusters, more persistent improvement occurred within the nasal + stop class of two-element final clusters.

The expansion of Max's phonetic inventory in each word position was also monitored as a descriptive measure of treatment progress. His phonetic inventory by word position following word-final treatment also reflects generalized learning to other untreated consonants and clusters. Inclusion in the phonetic inventory at any timepoint for a given word position was determined by two or more occurrences at a given probe point. In initial position, Max added four singletons [θ-, ʃ-, f-, g-] and five clusters [gl-, dɹ-, gɹ-, kw-, sl-] to his phonetic inventory. In final position, he added four clusters [-lt, -nd, -ɹd, -ɹp] to his phonetic inventory.

Grammatical Morphology

In addition to targeting the participant's phonological system, the word-final treatment also indirectly targeted word-final grammatical morphology in the form of 3rdSg inflection. Per his performance on the generalization probes (shown in Table 7), Max demonstrated only nominal improvement to regular 3rdSg and past tense and no improvement to plural morphology. However, Max's productions in a 397-utterance post-treatment language sample do suggest growth in his morphological system following treatment (shown in Table 8). Comparing his pre- and post-treatment language samples, Max's MLU in morphemes increased from 3.18 to 3.39, marking rate for regular 3rdSg increased from 0% to 5%, regular past tense increased from 0% to 53%, copula *be* increased from 8% to 50%, present progressive increased from 10% to 100%, and auxiliary *do* increased from 57% to 64%. Because baseline stability was only established for performance in the generalization probes—not for language sample measures, Max's apparent improvement in morphological productions from his language sample cannot be attributed to treatment above and beyond maturation.

Treatment Impact and Effect Size

Because generalization in the phonological domain was observed following treatment, the impact of intervention on Max's phonological system was further described with two clinically relevant metrics: PCC-R and standard mean difference (SMD) effect size following Gierut, Morrisette, and Dickinson (2015). These measures were calculated to determine the impact of treatment and quantify change in Max's overall speech-sound production accuracy. Furthermore, PCC-R, as scored for each consonant in each word of the generalization probes, served as a binary outcome measure suitable for logistic regression comparisons of PCC-R before and after each treatment phase and each five-week break in treatment. Significantly different change during treatment phases in the absence of significant change during breaks without treatment would support the impact of treatment on Max's phonological system, above and beyond identifiable maturation effects.

PCC-R was calculated at each probe administration and compared pre-to-post treatment phases and pre-to-post breaks (shown in Table 9). PCC-R after Phase I of treatment (Post Phase I; PCC-R = 55.8%) was significantly higher than at baseline (Baseline; PCC-R = 43.3%, $p < 0.01$), and PCC-R improved significantly during Phase II of treatment (Post Phase II; PCC-R = 60.9%, $p < 0.01$). Because a young child's sound system can be expected to experience maturational growth over time, pre-to-post treatment differences—alone—cannot identify a causal impact of word-final phonological treatment on PCC-R improvement. However, PCC-R remained stable at baseline (see Table 4), and PCC-R did not increase during either 5-week break without treatment (see Table 9). This suggests that the improvements in PCC-R after Phase I and Phase II of treatment can be attributed to the effect of word-final phonological treatment and not to maturation.

Treatment effect size was determined using SMD based on change in accuracy of all 0%-at-baseline singletons and clusters following Gierut et al. (2015), calculated as [mean accuracy across all baseline probes] – [mean accuracy across all mid and post-treatment probes] / [pooled population standard deviation at baseline]. Because a population standard deviation cannot be determined for a single child, the population standard deviation from Gierut et al. (2015; $SD = 0.02$) was used as the denominator in the effect size calculation. The effect size of Max's treatment was 7.85—a moderately large effect (large effect range: 6.32–27.83) for treatment of PD according to the benchmarks established from the treatment outcomes of 135 preschool children.

Discussion

There is a paucity of evidence-based support for SLPs faced with the assessment and treatment of children with overlapping or co-occurring speech and language impairments. Children with PD may present with speech production patterns that resemble morpheme omission errors typical of DLD, such as final consonant deletion or final cluster reduction, and—conversely—children with DLD may omit word-final grammatical morphemes, mimicking word-final phonological processes. There is, however, a considerable subgroup of children who present with co-occurring PD-LD beyond the morphophonological overlap that occurs in word-final position. Treatment research for this population has, so far, demonstrated that a variety of combined, sequenced, or alternating intervention approaches and various intervention techniques can lead to improved outcomes in phonology and morphosyntax for these children. However, identification of the treatment target characteristics that impact treatment outcomes for children with PD-LD is only just emerging, and the results of this case study highlight some of the considerations to be addressed in future investigations.

Generalization in the Phonological Domain

In this preliminary case study, we describe an intervention for PD-LD in which a morphophonologically complex consonant sequence was trained in word-final position. The study participant, “Max,” was a five-year-old child presenting with low consonant production accuracy, an especially restricted word-final phonetic inventory, and morphosyntactic omission and agreement errors, including zero-marking of word-final

grammatical morphemes. He received 14 weeks of treatment targeting a three-element consonant cluster, /-lps/, in word-final position. Third-person singular (3rdSg) morphology was embedded in the target by training morphologically rich treatment verb phrases, such as *he helps*.

Max's improvement post-treatment in the phonological domain follows the expectations of a complexity-based approach, which predict expanded phonological knowledge in the form of generalized learning to untrained, simpler linguistic structures (e.g., Gierut & Champion, 2001). After training to produce a complex word-final cluster, Max's phonological system expanded, especially in simpler contexts. Following treatment, he demonstrated the most accuracy improvement in untreated word-initial singletons and clusters. Accuracy improvement in word-final position was large for some sounds and clusters but overall was limited and less consistent. Qualitatively, his phonetic inventory following treatment expanded to include four new singletons, five new word-initial clusters, and four new word-final clusters. Given training with a complex word-final target, the asymmetric improvement favoring initial position may seem unexpected. However, given the greater complexity of word-final position relative to initial position (Levelt & van de Vijver, 2004), generalization to simpler structures is expected before generalization of the treatment target or other complex structures is observed (Gierut & Champion, 2001; Taps Richard, Barlow, & Combiths, 2017).

Cross-Domain Generalization

Despite considerable improvement to his phonological system, post-treatment change in Max's morphosyntactic skills was inconsistent. Improvement was notable only in qualitative changes to untreated morphemes in a post-treatment language sample but was unattested in performance on the generalization probes sampling monosegmental regular 3rdSg, past tense, and plural. Learning of the targeted structure, 3rdSg, did not generalize to untreated verbs in generalization probes or a language sample. Furthermore, lack of demonstrated baseline stability for morpheme production in a language sample combined with no significant morphological improvement in the generalization probes suggest that learning did not generalize to the morphological domain. Because 3rdSg morphology was included in the trained cluster, this finding was unexpected but not unprecedented. Cross-domain generalization learning has been attested in several studies; however, there seem to be limits to the directionality of this effect. Studies that simultaneously targeted phonology and morphosyntax in the same session (Tyler et al., 2003) and sequenced a phonology and morphosyntax intervention (Tyler et al., 2002) also demonstrated a similar pattern of post-treatment phonological improvement in the absence of morphosyntactic growth.

However, the limited morphosyntactic improvement in this case study stands in contrast to the outcomes of the children in Tyler and Sandoval (1994), who clearly demonstrated both phonological and morphosyntactic improvement following a cycled treatment that included some training of morphophonemic final clusters. These different treatment outcomes may be attributable to factors related to the participants, the treatment approach, and/or the treatment targets. Participants S1 and S6 (Tyler & Sandoval, 1994) were treated for the phonological process of final consonant cluster reduction by training two-element final clusters in plural-

inflected nouns among other cycled targets. During one of his recurring cycles, S1 received direct phonological intervention that included production of plural-inflected nouns with final clusters, similar to Max's intervention presented here. Although S6's cycles also included training of plural-inflected nouns with final clusters, he received a combination of direct phonological intervention and a narrative-language intervention that differs more substantially from Max's phonologically based intervention. Consequently, only S1 received treatment comparable in its approach to the treatment described in this study.

Given their pre-treatment measures, S1 and S6 (Tyler & Sandoval, 1994) may better fit the profile of children with PD whose morphology errors are ultimately attributable to phonological processes, and thus may not be indicative of co-occurring PD-LD. Both participants had language comprehension and expressive vocabulary scores in the normal range prior to treatment. Notably, S1 also demonstrated average MLU for his age. As suggested by the authors, the dramatic improvement of the children's grammatical morpheme production following treatment of word-final phonological processes suggests that phonology was the primary impediment to their production of word-final grammatical morphemes. Thus, participant-internal factors related to impairment profiles may also have contributed to their improvement in the morphological domain.

In addition to potentially different impairment profiles, differences in treatment targets may have impacted the generalizability of learning into the morphosyntactic domain. In Max's intervention, a three-element cluster inflected with 3rdSg was targeted because of its relatively high complexity. Alternatively, in Tyler and Sandoval (1994), two-element clusters with plural -s inflection were targeted. Although both targets are complex, two-element clusters are less complex than three-element clusters (Greenberg, 1978), and plural morphology is acquired earlier than 3rdSg, and is arguably less complex (Brown, 1973).

Furthermore, there is precedent for limitations to the amount or type of complexity that may contribute to greater generalization learning. For instance, Gierut and Champion (2001) identified less predictable generalization patterns following treatment for PD targeting three-element initial clusters, such as /skw-/, /skɹ-/, or /spl-/. The authors suggested that the unpredictable generalization patterns for these highly complex targets could be explained by each child's pre-treatment knowledge of the components of the cluster target. Concisely, functional pre-treatment knowledge of two component phonemes resulted in greater generalization learning following treatment. The authors proposed that some knowledge allowed the children to better attend to multiple structural components and generalize learning to a wider variety of other consonant clusters.

Like these initial cluster targets (Gierut & Champion, 2001), Max's word-final treatment target was highly complex. Although he did demonstrate some knowledge of the component singletons /l/ and /p/, he demonstrated poor knowledge of both /l/ and /s/ in word-final position. Thus, it is reasonable to suggest that Max's limited functional knowledge of word-final morphology and of the target's component phonemes impacted his ability to attend to both the phonological and morphological components of his treatment target. Because children presented with novel phonological and grammatical input will, by default, track the input's phonological rather than grammatical characteristics (Plante, Vance, Moody, &

Gerken, 2013), it is then less surprising that generalization learning occurred primarily within the phonological domain.

Another potentially impactful difference between Max's treatment and that of S1 and S6 (Tyler & Sandoval, 1994) relates to the variability of the treatment stimuli. Recent findings suggest that treatment of grammatical morphology is more effective when the form and context of the trained structure is highly variable. Presumably, this variability allows children to attend to the stable component of the input (i.e., the grammatical target; Leonard & Deevy, 2017; Plante et al., 2014). Because Tyler and Sandoval targeted phonological processes, multiple consonant cluster exemplars were employed (at least for S1), and treatment stimuli were not limited to a set of pre-determined words. In the case of 3rdSg morphology, regular variants have several phonological forms ([-s], [-z], and [-ɪz]). However, only one variant, [-s], was targeted in Max's intervention, and this form was trained in a limited set of seven treatment verb phrases. It is possible that low variability in the treatment stimuli, in addition to Max's pre-treatment knowledge and PD-LD profile, impacted his ability to attend to and generalize learning of the morphological component of his treatment target.

Limitations

The development and execution of this case study closely followed the clinical process as it might occur in school-based practice. A unique profile of phonological and morphosyntactic deficits was identified in a child, for which little treatment efficacy information was currently available. In accordance with the principles of evidence-based practice, a treatment program based on treatment methodologies already shown to be effective in related populations was customized to address the child's unique needs. Although every effort was made to maintain the validity of this study, certain limitations were unavoidable. The study design, including the treatment protocol and baseline/outcome measurements for this study were developed and executed within the confines of a school environment. Hours spent on treatment and generalization probes were obligated to meet the requirements of the child's IEP and school schedule. However, school breaks between treatment phases and after treatment did permit comparison of change in outcome measures during treatment with the impact of maturation when no treatment was occurring. Also in accordance with the participant's IEP, treatment was provided in a small group, as typically occurs in school settings (Mullen & Schooling, 2010). In this case, one other child of similar age simultaneously received treatment for PD targeting word-initial consonant clusters /skw-/ , /spl-/ , /stɪ-/ , and /θɪ-/ . Although Max's second-hand exposure to the other child's initial cluster target was unavoidable, two clinicians were often present to provide directed intervention for each child. When Max attempted a word including the other child's target, no feedback was given, and he was redirected to his own target. Importantly, Max also showed no improvement in the other child's specific word-initial cluster targets over the course of treatment.

Clinical Implications

This exploratory case study suggests that treatment targeting complex three-element clusters in word-final position may be feasible for children with PD-LD, at least for generalization

learning within the phonological domain. Perhaps more importantly, these results call for future work to investigate the generalizability of complex exemplars trained in intervention for children with PD-LD. As has been shown separately for treatment of PD and DLD, strategic manipulation of the target stimuli can produce better treatment outcomes (Cummings & Barlow, 2011; Gierut, 2008; Plante et al., 2014; Van Horne et al., 2017), and the generalization principles behind this work should also apply to children with PD-LD. It will be important for future work to clarify the speech-language profiles of children with PD-LD and differentiate overlapping characteristics of PD and DLD from co-occurring PD-LD. Future intervention research should manipulate the phonological complexity of treatment targets as a function of children's pre-treatment linguistic knowledge and may choose to determine the impact of target characteristics that have been successful for treatment of DLD, such as variability of the target grammatical form and its context (Plante et al., 2014) or complexity of the stimulus word (Van Horne et al., 2017).

As our ability to identify impairments and disorders improves, comorbidity is becoming the norm rather than the exception, and SLPs faced with the assessment and treatment of children who present with combined speech and language deficits require strategic tools to provide this population with optimal treatment outcomes. Unfortunately, the knowledge our field has accumulated regarding efficacious approaches, targets, and stimuli for PD and DLD is yet to be systematically examined in children with PD-LD. In the meantime, an SLP should ensure that phonology and morphosyntax are thoroughly assessed in children with speech or language deficits so that co-occurring deficits can be either ruled out or targeted. When there is reasonable expectation of overlap or co-occurrence, an SLP should be cautious upon interpreting standardized scores from broad expressive language or phonology measures, as these may be influenced by overlapping characteristics of the non-targeted domain. In these cases, sub-scores targeting non-overlapping phonological and morphosyntactic skills may be consulted, or these scores may be supplemented with other probes or performance-based measures. For instance, a phonology probe should include sounds that commonly occur in English inflectional morphology (i.e., /t/, /d/, /s/, /z/) in multiple word positions and in both inflected (e.g., *goes* /gouz/) and uninflected words (e.g., *buzz* /bʌz/). Similarly, assessment of tense and agreement morphology should allow for examination of morpheme production in a variety of phonological contexts (e.g., a combination of vowel-final stems: *see* /si/, *fly* /flaɪ/ and consonant-final stems: *jump* /dʒʌmp/, *wash* /wɒʃ/). Differences in either domain that are modulated by the other should be considered when interpreting these phonological and morphological assessments.

When co-occurring impairment is identified, a variety of simultaneous or sequenced treatment approaches may be effective; however, treatment targets should be monitored concurrently with progress in any impaired language domains to ensure that generalization is occurring in the targeted domains. Given limited research in this area and the results of this case study, targets may need to be modified if improvement appears to asymmetrically impact one domain over another.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors thank Max, his family, and the supportive staff and faculty at his school. We are also grateful to members of the Phonological Typologies Lab and the Child Language Development, Disorders, and Disparities Lab at San Diego State University—in particular, Taylor Kubo, Alyssa Pitts, Doris Yeung, Taylor Trosper, Emily Reynolds, and Elaine Drexler for their contributions to data analyses. We also thank Yvan Rose and Greg Hedlund, creators of Phon. The first author was supported by the Lipinsky Fellowship in Language and Communicative Disorders, and an NIH NIDCD T32 [DC007361]. Additional funding was provided by an NIH NIDCD RO3 [DC012141] and a Price Philanthropies research grant awarded to the fourth author.

References

- Archibald LMD, & Joanisse MF (2009). On the sensitivity and specificity of nonword repetition and sentence recall to language and memory impairments in children. *Journal of Speech, Language, and Hearing Research*, 52(4), 899–899.
- Bauman-Waengler J (2008). *Articulatory and Phonological Impairments: A Clinical Focus* (3rd ed.). Boston: Allyn & Bacon.
- Beitchman JH, Nair R, Clegg M, Ferguson B, & Patel PG (1986). Prevalence of psychiatric disorders in children with speech and language disorders. *Journal of the American Academy of Child Psychiatry*, 25(4), 528–535. [PubMed: 3489024]
- Beitchman JH, Wilson B, Brownlie EB, Walters H, Inglis A, & Lancee W (1996). Long-term consistency in speech/language profiles: II. Behavioral, emotional, and social outcomes. *Journal of the American Academy of Child and Adolescent Psychiatry*, 35(6), 815–825. [PubMed: 8682763]
- Beitchman JH, Wilson B, Brownlie EB, Walters H, & Lancee W (1996). Long-term consistency in speech/language profiles: I. Developmental and academic outcomes. *Journal of the American Academy of Child and Adolescent Psychiatry*, 35(6), 804–814. [PubMed: 8682762]
- Bellon-Harn ML, Hoffman PR, & Harn WE (2004). Use of cloze and contrast word procedures in repeated storybook reading: Targeting multiple domains. *Journal of Communication Disorders*, 37(1), 53–75. [PubMed: 15013379]
- Bishop DVM, & Edmundson A (1987). Language-impaired 4-year-olds: Distinguishing transient from persistent impairment. *Journal of Speech and Hearing Disorders*, 52(May), 156–173. [PubMed: 3573746]
- Bishop DVM, Snowling MJ, Thompson PA, Greenhalgh T, Adams C, Archibald L, . . . house A (2017). Phase 2 of CATALISE: a multinational and multidisciplinary Delphi consensus study of problems with language development: Terminology. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 58(10), 1068–1080.
- Botting N, & Conti-Ramsden G (2003). Characteristics of children with specific language impairment In Verhoeven L & Balkom H. v. (Eds.), *Classification of Developmental Language Disorders: Theoretical Issues and Clinical Implications* (pp. 23–38): Psychology Press.
- Brown R (1973). *A First Language: The Early Stages*. Cambridge, MA: Harvard University Press.
- Combitbs PN, Amberg R, & Barlow JA (2016). Phonological analysis software in assessment and treatment of speech-sound disorders Paper presented at the Convention of the American Speech-Language-Hearing Association, Philadelphia, PA.
- Conti-Ramsden G, St Clair MC, Pickles A, & Durkin K (2012). Developmental trajectories of verbal and nonverbal skills in individuals with a history of specific language impairment: From childhood to adolescence. *Journal of Speech, Language, and Hearing Research*, 55(6), 1716–1716.
- Cummings AE, & Barlow JA (2011). A comparison of word lexicality in the treatment of speech sound disorders. *Clinical Linguistics & Phonetics*, 25, 265–286. [PubMed: 21158502]
- Elbert MF, Dinnsen DA, & Powell TW (1984). On the prediction of phonologic generalization learning patterns. *Journal of Speech and Hearing Disorders*, 49, 309–317. [PubMed: 6748626]
- Ertmer DJ, & Ertmer PA (1998). Constructivist strategies in phonological intervention: Facilitating self-regulation for carryover. *Language, Speech, and Hearing Services in Schools*, 29(2), 67–67.
- Fey ME, Cleave PL, Ravida AI, Long SH, Dejmaj AE, & Easton DL (1994). Effects of grammar facilitation on the phonological performance of children with speech and language impairments. *Journal of Speech and Hearing Research*, 37, 594–607. [PubMed: 8084191]

- Gierut JA (1999). Syllable onsets: Clusters and adjuncts in acquisition. *Journal of Speech, Language, and Hearing Research*, 42, 708–726.
- Gierut JA (2007). Phonological complexity and language learnability. *American Journal of Speech-Language Pathology*, 16, 6–17. [PubMed: 17329671]
- Gierut JA (2008). Experimental instantiations of implicational universals in phonological acquisition. In Dinnsen DA & Gierut JA (Eds.), *Optimality theory, phonological acquisition and disorders* (pp. 355–376). London: Equinox.
- Gierut JA, & Champion AH (2001). Syllable onsets II: Three-element clusters in phonological treatment. *Journal of Speech, Language, and Hearing Research*, 44, 886–904.
- Gierut JA, & Morrisette ML (2010). Phonological learning and lexicality of treated stimuli. *Clinical Linguistics & Phonetics*, 24, 122–140. [PubMed: 20100042]
- Gierut JA, Morrisette ML, & Dickinson SL (2015). Effect size for single-subject design in phonological treatment. *Journal of Speech, Language, and Hearing Research*, 58(5), 1464–1464.
- Gillon GT (2000). The efficacy of phonological awareness intervention for children with spoken language impairment. *Language, Speech, and Hearing Services in Schools*, 31, 126–141.
- Greenberg JH (1978). Some generalizations concerning initial and final consonant clusters. In Greenberg JH, Ferguson CA, & Moravcsik EA (Eds.), *Universals of human language* (Vol. 2: Phonology). Stanford, CA: Stanford University Press.
- Haskill AM, & Tyler AA (2007). A comparison of linguistic profiles in subgroups of children with specific language impairment. *American Journal of Speech-Language Pathology*, 16(3), 209–209. [PubMed: 17666547]
- Hodson BW, Nonomura CW, & Zappia M (1989). Phonological disorders: Impact on academic performance? *Seminars in Speech and Language*, 10(3), 252–259.
- Hodson BW, & Paden EP (1991). *Targeting Intelligible Speech: A Phonological Approach to Remediation* (2nd ed.). Austin, TX: Pro-Ed.
- Hoffman PR, Norris JA, & Monjure J (1990). Comparison of process targeting and whole language treatments for phonologically delayed preschool children. *Language, Speech and Hearing Services in Schools*, 21, 102–109.
- Hoffman PR, Norris JA, & Monjure J (1996). Effects of narrative intervention on a preschooler's syntactic and phonological development. *National Student Speech Language Hearing Association Journal*, 23, 5–13.
- Ingram D (1976). *Phonological Disability in Children*. New York: Elsevier.
- Ingram D (1989). *First Language Acquisition*. Cambridge, UK: Cambridge University Press.
- Law J, Boyle J, Harris F, Harkness A, & Nye C (2000). Prevalence and natural history of primary speech and language delay: Findings from a systematic review of the literature. *International Journal of Language & Communication Disorder*, 35(2), 165–188.
- Leonard LB (2014). *Children with Specific Language Impairment* (2nd ed.). Cambridge, MA: MIT Press.
- Leonard LB, & Deevy P (2017). The changing view of input in the treatment of children with grammatical deficits. *American Journal of Speech-Language Pathology*, 1–12. [PubMed: 28124070]
- Levelt CC, & van de Vijver R (2004). Syllable types in cross-linguistic and developmental grammars. In Kager R, Pater J, & Zonneveld W (Eds.), *Constraints in phonological acquisition* (pp. 204–218). Cambridge, UK: Cambridge University Press.
- Lewis BA, Freebairn L, Tag J, Ciesla AA, Iyengar SK, Stein CM, & Taylor HG (2015). Adolescent outcomes of children with early speech sound disorders with and without language impairment. *American Journal of Speech-Language Pathology*, 24(2), 150–163. [PubMed: 25569242]
- Lewis BA, Freebairn LA, & Taylor HG (2000a). Academic outcomes in children with histories of speech sound disorders. *Journal of Communication Disorders*, 33(1), 11–30. [PubMed: 10665511]
- Lewis BA, Freebairn LA, & Taylor HG (2000b). Follow-up of children with early expressive phonology disorders. *Journal of Learning Disabilities*, 33(5), 433–444. [PubMed: 15495546]

- Macrae T, & Tyler AA (2014). Speech abilities in preschool children with speech sound disorder with and without co-occurring language impairment. *Language, Speech, and Hearing Services in Schools*, 45(4), 302–302.
- Matheny N, & Panagos JM (1978). Comparing the effects of articulation and syntax programs on syntax and articulation improvement. *Language, Speech, and Hearing Services in Schools*, 9, 57–61.
- Miller J, & Iglesias A (2012). *Systematic Analysis of Language Transcripts (SALT)*, English & Spanish [Computer software] (Version 8). Madison, WI: Language Analysis Lab, University of Wisconsin.
- Montgomery J, Dunaway C, & Taps J (2005). Interview with Claudia Dunaway and Jennifer Taps. *Communication Disorders Quarterly*, 27(1).
- Morrisette ML, Farris AW, & Gierut JA (2006). Applications of learnability theory to clinical phonology. *Advances in Speech-Language Pathology*, 8, 207–219.
- Mullen R, & Schooling T (2010). The National Outcomes Measurement System for pediatric speech-language pathology. *Language, Speech & Hearing Services in Schools*, 41(1), 44–60.
- Munson B, Schellinger SK, & Urberg Carlson K (2012). Measuring speech-sound learning using visual analog scaling. *Perspectives on Language Learning and Education*, 19(1), 19–30.
- Panagos JM (1974). Persistence of the open syllable reinterpreted as a symptom of language disorder. *Journal of Speech and Hearing Disorders*, 39(1), 23–23. [PubMed: 4814822]
- Paul R, & Shriberg LD (1982). Associations between phonology and syntax in speech-delayed children. *Journal of Speech and Hearing Research*, 25, 536–547. [PubMed: 7162154]
- Pennington BF, & Bishop DVM (2009). Relations among speech, language, and reading disorders. *Annual Review of Psychology*, 60(1), 283–306.
- Plante E, Ogilvie T, Vance R, Aguilar JM, Dailey NS, Meyers C, . . . Burton R (2014). Variability in the language input to children enhances learning in a treatment context. *American Journal of Speech-Language Pathology*, 23(4), 530–545. [PubMed: 24700145]
- Plante E, Vance R, Moody A, & Gerken L (2013). What influences children's conceptualizations of language input? *Journal of Speech, Language, and Hearing Research*, 56(5), 1613–1625.
- Raitano NA, Pennington BF, Tunick RA, Boada R, & Shriberg LD (2004). Pre-literacy skills of subgroups of children with speech sound disorders. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 45(4), 821–835.
- Rice M, & Wexler K (2001). *Rice/Wexler Test of Early Grammatical Impairment*. San Antonio, TX: Psychological Corporation.
- Rose Y, & Hedlund G (2017). *Phon* (Version 2.2) [Computer software]. Retrieved from <https://www.phon.ca/phontac>
- Rvachew S, Gaines BR, Cloutier G, & Blanchet N (2005). Productive morphology skills of children with speech delay. *Journal of Speech-Language Pathology and Audiology*, 29, 83–89.
- Secord WA (2007). *Eliciting Sounds: Techniques and Strategies for Clinicians* (2nd ed.). San Diego, CA: Singular.
- Shriberg L, Tomblin JB, & McSweeney J (1999). Prevalence of speech delay in 6-year-old children and comorbidity with language impairment. *Journal of Speech, Language, and Hearing Research*, 42, 1461–1481.
- Shriberg LD, & Kwiatkowski J (1982). Phonological disorders II: A conceptual framework for management. *Journal of Speech and Hearing Disorders*, 47, 242–256. [PubMed: 7186560]
- Shriberg LD, & Kwiatkowski J (1990). Self-monitoring and generalization in preschool speech-delayed children. *Language, Speech, and Hearing Services in Schools*, 21(3), 157–170.
- Shriberg LD, & Kwiatkowski J (1994). Developmental phonological disorders I: A clinical profile. *Journal of Speech and Hearing Research*, 37, 1100–1126. [PubMed: 7823556]
- Shriberg LD, & Lof GL (1991). Reliability studies in broad and narrow transcription. *Clinical Linguistics & Phonetics*, 5, 225–279.
- Storkel HL (2018a). The complexity approach to phonological treatment: How to select treatment targets. *Language, Speech, and Hearing Services in Schools*, 1–19.

- Storkel HL (2018b). Implementing evidence-based practice: Selecting treatment words to boost phonological learning. *Language, Speech, and Hearing Services in Schools*, 1–15.
- Tambyraja SR, & Dunkle JT (2014). Target selection in speech therapy: Is a non-developmental approach more efficient than a developmental approach? (Vol. 8). Bloomington, MN: Pearson.
- Taps Richard J (2012). *In-depth Phonological Assessment (IPA)*. San Diego: SLPath.
- Taps Richard J, Barlow JA, & Combitbs PN (2017). Applying phonological complexity in the schools: Insights from 32 case studies Paper presented at the American Speech-Language Hearing Convention, Los Angeles, CA.
- Thompson CK, Ballard KJ, & Shapiro LP (1998). The role of syntactic complexity in training *wh*-movement structures in agrammatic aphasia: Optimal order for promoting generalization *Journal of the International Neuropsychological Society*, 4, 661–674. [PubMed: 10050370]
- Thompson CK, Shapiro LP, Kiran S, & Sobecks J (2003). The role of syntactic complexity in treatment of sentence deficits in agrammatic aphasia: The Complexity Account of Treatment Efficacy (CATE). *Journal of Speech, Language, and Hearing Research*, 46, 591–607.
- Tyler AA, Lewis KE, Haskill A, & Tolbert LC (2002). Efficacy and cross-domain effects of a phonology and a morphosyntax intervention. *Language, Speech, and Hearing Services in Schools*, 33, 52–66.
- Tyler AA, Lewis KE, Haskill A, & Tolbert LC (2003). Outcomes of different speech and language goal attack strategies. *Journal of Speech, Language, and Hearing Research*, 46(5), 1077–1094.
- Tyler AA, & Sandoval KT (1994). Preschoolers with phonological and language disorders: Treating different linguistic domains. *Language, Speech and Hearing Services in Schools*, 25, 215–234.
- van Daal J, & van Balkom H (2004). Subtypes of severe speech and language impairments: Psychometric evidence from 4-year-old children in the Netherlands. *Journal of Speech, Language, and Hearing Research*, 47, 1411–1423.
- Van Horne AJO, Fey M, & Curran M (2017). Do the hard things first: A randomized controlled trial testing the effects of exemplar selection on generalization following therapy for grammatical morphology. *Journal of Speech, Language, and Hearing Research*, 60(9), 2569–2569.

Sample Visual Analog Scale* Target Accuracy Data Collection Form

Treatment Word(s)	Date:	Date:	Date:
	1 2 3 4 5 6 7 ←————→	1 2 3 4 5 6 7 ←————→	1 2 3 4 5 6 7 ←————→
	1 2 3 4 5 6 7 ←————→	1 2 3 4 5 6 7 ←————→	1 2 3 4 5 6 7 ←————→

1 = one sound not in cluster (e.g., [w] for /-lps/)

2 = one sound in cluster (e.g., [p] or [l] for /-lps/)

3 = two sounds (not in cluster) (e.g., [wt] for /-lps/)

4 = two sounds (one not in cluster) (e.g., [wp] for /-lps/)

5 = two sounds (in cluster) (e.g., [lp] for /-lps/)

6 = 3 sounds (2 sounds in cluster accurate, other 1 approximation) (e.g., [lp_g] for /-lps/)

7 = three sounds correct (e.g., [lps] for /-lps/)

* Based on the work of Munson, Schellinger, & Urberg Carlson, 2012

Figure 1.

Sample target production rating scale.

Figure 2.
Production accuracy rating (1–7) of /-lps/ cluster production in target verbs by week.

Figure 3.
Composite accuracy of 0%-at-baseline singletons and clusters by word position.

Table 1.

Baseline percent correct singletons and clusters by position, PCC-R, and monosegmental regular grammatical morpheme marking rate.

	Phonology % Correct			Morphology % Marked	
	<i>Word-initial</i>	<i>Word-final</i>	<i>All positions</i>		
Singletons	62.8%	31.2%	47.4%	3rdSg	0.0%
Clusters	25.7%	7.6%	15.3%	Past Tense	0.0%
PCC-R	-	-	43.3%	Plural	0.0%

Table 2.

Baseline phonetic inventory of singletons and clusters, by word position.

	Singletons	Clusters
<i>Word-initial</i>	[b d h j k l m n p ɹ s t tʃ w]	[bl bɹ bw gɹ kl kɹ pl pɹ pw tl tɹ tw]
<i>Word-final</i>	[b d k l m n ŋ p ɹ t v ʔ]	[lp mp nt ɹm ɹn ɹt ɹʔ]

Table 3.

Schedule of baseline/generalization probes, periods of treatment, and breaks during which no treatment occurred.

Month	Probe/Treatment
<i>Sep</i>	Baseline Probes
<i>Dec</i>	Treatment Phase I
	Post Phase I Probes
	Break 1
<i>Jan</i>	Post Break 1 Probes
	Treatment Phase II
<i>Mar</i>	Post Phase II Probes
	Break 2
<i>Apr</i>	Post Break 2 Probes

Table 4.

PCC-R and regular word-final morpheme marking rate stability across baselines.

	Baseline 1	Baseline 2
PCC-R	41.5%	41.7%
3rdSg	0.0%	0.0%
Plural	0.0%	0.0%
Past Tense	0.0%	0.0%

Table 5.

0%-at-baseline word-initial singletons and clusters showing change over the course of treatment.

Sound	Baseline		Post Phase I		Post Phase II	
	Accuracy	95% <i>CI</i>	Accuracy	95% <i>CI</i>	Accuracy	95% <i>CI</i>
d ₃ -	0%	-	33%	(1, 66)	11%	(-11, 33)
g-	0%	-	11%	(-11, 33)	67%	(34, 99)
ʃ-	0%	-	29%	(-8, 65)	57%	(17, 97)
v-	0%	-	0%	-	17%	(-16, 49)
z-	0%	-	0%	-	80%	(41, 119)
θ-	0%	-	25%	(-7, 57)	38%	(2, 73)
fl-	0%	-	33%	(-32, 99)	33%	(-32, 99)
f.ɹ-	0%	-	0%	-	33%	(-32, 99)
kw-	0%	-	33%	(-32, 99)	75%	(26, 124)
sl-	0%	-	100%	-	100%	-
sm-	0%	-	0%	-	33%	(-32, 99)
sw-	0%	-	100%	-	50%	(-48, 148)
tw-	0%	-	33%	(-32, 99)	100%	-

Note. *CI*= confidence interval.

Table 6.

0%-at-baseline word-final singletons and clusters showing change over the course of treatment.

Sound	Baseline		Post Phase I		Post Phase II	
	Accuracy	95% <i>CI</i>	Accuracy	95% <i>CI</i>	Accuracy	95% <i>CI</i>
-l	0%	-	11%	(-11, 33)	67%	(34, 99)
-lk	0%	-	50%	(-48, 148)	0%	-
-lps	0%	-	33%	(-32, 99)	25%	(-24, 74)
-mps	0%	-	50%	(-7, 107)	0%	-
-mpt	0%	-	50%	(-48, 148)	0%	-
-nd	0%	-	33%	(-8, 75)	33%	(-8, 75)
-ŋk	0%	-	35%	(-24, 74)	75%	(26, 124)
-ɹd	0%	-	40%	(-8, 88)	40%	(-8, 88)
-ɹts	0%	-	33%	(-32, 99)	0%	-

Note. *CI* = confidence interval.

Table 7.

Regular word-final morpheme marking rates.

Morpheme	Baseline	Post Phase I	Post Phase II
3rdSg	0.0%	6.3%	5.6%
Plural	0.0%	0.0%	0.0%
Past Tense	0.0%	0.0%	8.3%

Table 8.

Morpheme marking rates from pre- and post-treatment language samples.

	<i>Pre Treatment</i>		<i>Post Treatment</i>	
	% Marked	Opportunities	% Marked	Opportunities
3rdSg	0%	3	5%	20
Plural	33%	3	83%	12
Past Tense	0%	3	53%	15
Progressive	10%	10	100%	25
Aux <i>do</i>	57%	7	64%	22
Copula <i>be</i>	8%	13	50%	22
Aux <i>be</i>	33%	3	0%	15

Note. 3rdSg = Third-person singular. Aux = Auxiliary.

Table 9.

PCC-R by timepoint with logistic regression results.

	PCC-R	95% CI	χ^2	p^{**}
Baseline	43.3%	(40.2, 46.5)	-	-
Post Phase I	55.8%	(52.7, 58.9)	29.8	<0.01 *
Post Break 1	53.6%	(50.4, 56.7)	1.0	1.00
Post Phase II	60.9%	(57.8, 63.9)	10.5	<0.01 *
Post Break 2	58.3%	(55.2, 61.4)	1.3	1.00

Note. χ^2 contrasts compared PCC-R at each post-treatment timepoint (i.e., Post Phase I, Post Phase II) to PCC-R prior to that treatment phase (i.e., Baseline, Post Break 1, Post Break 2). χ^2 contrasts also compared pre- and post each five-week period of no treatment (i.e., Break 1 and Break 2). Post-treatment timepoints are in boldface. *CI*= confidence interval.

* indicates significant difference in PCC-R between pre- and post-treatment phase.

** Bonferroni-adjusted p -values.