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Phonological intervention in Greek-speaking preschoolers with speech sound disorders: Implementing phonological similarity and density

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Abstract

Purpose: The study examined speech gains in three bilectal Cypriot-Greek speaking children with speech sound disorders. The study is based on theoretical frameworks that are on par with word-level characteristics and is motivated by the sparsity of cross-language studies in speech sound disorder intervention.

Method: A multiple-baseline, single-participant design was implemented across three participants with speech sound disorders aged 3;2–4;0 years across baseline (pre-test), intervention, post-test, and follow-up phases. Intervention was administered twice a week for two months. Treatment stimuli were selected based on phonological density and phonological similarity grouped in word clusters. Outcomes were measured using a 49-word pictorial production probe list. Maintenance gains were examined with 20 non-treated stimuli during a follow-up session. Dependent variables included phonetic inventory size, proportion of consonants correct, and percentage of whole word matches. Intelligibility was measured via the Intelligibility in Context Scale.

Result: Phonological gains were observed across all measures with effect sizes ranging from 1.2 to 2.7.

Conclusion: Implementing phonologically dense stimuli may facilitate speech outcomes in children with speech sound disorders cross-linguistically.

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Keywords: *speech sound disorders; phonological intervention; phonological density; Cypriot-Greek; cross-linguistic ssd*

Introduction

Communication disorders can affect anyone regardless of age, linguistic, social, and cultural background. A speech sound disorder (SSD) is no exception as it is considered one of the most frequent paediatric communication disorders, constituting a significant size of the caseload serviced by speech- language pathologists (SLPs) (Bowen, 2015; Mcleod & Baker, 2014). Despite variability across studies, the incidence and prevalence of SSD in school-age children are estimated to range from 3% to 16% with figures reaching 40% in the presence of concomitant communication impairments such as development language disorder (DLD) and autism spectrum disorders (ASD) (Broomfield & Dodd, 2004; Eadie et al., 2015; Petinou, 2021; Shriberg et al., 1999; Wren et al., 2016). Given the high prevalence rates, SSD warrants timely intervention, especially during a significant developmental age period at which phonological acceleration and normalisation occur (Shriberg et al., 1994). Preschoolers with atypical speech errors are more likely to present with phonological challenges that persist into the school years. Thus, early diagnosis of SSD in tandem with a detailed analysis of error types can form the springboard for prioritising early intervention services and for choosing the appropriate intervention approach.

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Empirically, interventions relevant to SSD fall into two overarching categories, including motor-articulation-based interventions and linguistically-based phonological approaches. In general, the former approaches focus on promoting correct speech production via auditory discrimination and accurate articulatory placement movement, whereas the latter incorporate phonological processing rules with a focus on promoting phonological distinctiveness, phonological reorganisation, and enhancement of the underlying representation of sounds (Sosa & Stoel-Gammon, 2012). Nevertheless, factors related to successful SSD intervention outcomes remain complex and vary across studies (Baker & McLeod, 2011). The superiority of a given intervention approach remains equivocal with investigations reporting contradictory findings. This is because children with SSD form a heterogeneous group in terms of speech error profiles, underlying aetiology, and severity of the disorder (Dodd et al., 2005; McLeod & Baker, 2014).

From a cross-linguistic perspective, findings revealed remarkable variability in the use of therapy approaches used by SLPs practicing across various geographical regions (Europe, Middle East, South Africa, and Australia) with the majority of clinicians using phonologically-based therapy, auditory discrimination (e.g. minimal-pair therapy), core vocabulary, articulation-based interventions, and phonological awareness (McLeod & Goldstein, 2012; Oliveira et al., 2015). The consensus is that factors affecting the choice and implementation of the optimum therapy approach vary significantly among SLPs across languages and cultures. Several such factors include the clinician's experience and familiarity with certain interventions, knowledge regarding the taxonomy of SSD speech error types, availability or resources and capitalisation of research findings, the complexity of the processes involved in the implementation of evidence-based approaches, and knowledge regarding selection and implementation of appropriate therapy stimuli (Baker & McLeod, 2011; Brumbaugh & Smit, 2013).

Regarding taxonomy, investigators suggest that subgrouping SSD into distinct categories is possible if one considers error types. Profiling SSDs into distinct categories is of paramount importance because it informs differential diagnosis and supports the selection of the appropriate intervention approach. It also allows predictions regarding long-term speech and language outcomes, SSD severity, and prognosis of intervention outcomes (Dodd et al., 2018; Petinou-Loizou et al., 2024; Waring & Knight, 2013; Wren et al., 2016). A key observation to emerge is that preschoolers with atypical speech errors are more likely to present with phonological challenges that persist into the school years.

From a theoretical perspective, developmental psycholinguistic research with a focus on lexical organisation and word-level structures (e.g. word frequency, phonological similarity, and density) provides a platform for advancing specific hypotheses regarding the impact of specific intervention stimuli as optimum triggers for inducing phonological gains in children with SSD (Gierut & Morrisette, 2012; Storkel et al., 2010). One such property is phonological density neighbourhood (PDN) (e.g. the number of words differing in phonological patterns by 1-phone which is deleted, added, or altered) (Vitevitch & Luce, 1999). Phonologically *dense* neighbourhoods contain many words with overlapping segmental structures (e.g. rat overlaps with mat, bat, cat, sat, rat, fat, tar, pat, etc.), whereas phonologically *sparse* neighbourhoods contain only a few words with phonological overlaps (e.g. room, rule, root). Research findings suggest that the dual nature of PND differentially affects the development of phonological and lexical skills such that similar-sounding words residing in dense neighbourhoods align with phonological accuracy skills and lexical development (Sosa & Stoel-Gammon, 2012). Preschoolers imitate more accurately segments from words belonging to dense neighbourhoods as opposed to segments from word targets resting in sparse neighbourhoods (Beckman et al., 2007). Furthermore, vocabulary databases from cross-linguistic child corpora including French, Dutch, and English indicate that the early productive lexicons of typically developing toddlers are comprised of words from dense neighbourhoods (Stokes et al., 2012). Repeated phonological schemes shared by words resting within dense neighbourhoods promote stronger phonological and lexical representations in the sense that words with overlapping phonological structures 'force' a child to engage in a finer-grained sub-lexical (phonological) processing, which in turn, appears to induce the sharpening' of lexical representations responsible for promoting expressive phonological and lexical accuracy skills (Beckman et al., 2007; Storkel et al., 2010).

In light of the aforementioned, a pioneering line of research over the past ten years has provided new insights into the effects of phonological density regarding speech gains in children with SSD. Investigations mainly from English-speaking children with protracted phonological systems reported positive phonological gains and system-wide generalisations when the intervention protocol included phonologically dense stimuli (Morrisette & Gierut, 2002). According to Gierut and Morrisette (2012), SSD participants exhibited significant phonological changes from pre-test relative to post-test conditions on dependent measures including the size of phonetic inventory, proportion of consonants, and intelligibility ratings. Overall, research findings pertinent to intervention underscore the positive impact of stimuli selected from dense neighbourhoods as these appear to act as optimum triggers for inducing system-wide expressive phonological and lexical gains (Gierut & Morrisette, 2012; Petinou, 2021; Petinou & Theodorou, 2018).

Currently, most investigations have focused only on English-speaking children and less is known about the impact of word-level cues within a cross-linguistic context. Such investigations remain sparse, especially in understudied linguistic varieties as the majority of published research concerns mainly English-speaking children (McLeod & Goldstein, 2012; Petinou, 2021; Petinou & Theodorou, 2018). Cross-linguistic investigations of atypical phonological development have underlined the role of typological properties of a given language in speech output phenotypes such as that different properties respective to each language (e.g. word inflections, morphophonology, prosodic, and segmental variables) warrant careful consideration in goal setting and stimuli construction (McLeod & Verdon, 2017). Recent studies have evaluated the effects of PND in bilectal Cypriot-Greek-(CG) speaking children with SSD and reported phonological gains. Specifically, a series of multiple baseline single-participant designs reported significant speech improvement through the implementation of PDN stimuli in one four-year-old boy with SSD (Petinou & Theodorou, 2018) and two four-year-old participants with the diagnosis of child apraxia of speech (CAS) secondary to ASD (Petinou, 2021) reported significant phonological gains on variables including the increase of phonetic inventory size, reduced percentage of phonological process use and increases in proportion of consonants correct. Such findings form the impetus for extending and elaborating further on the impact of PDN framework vis-a-vis stimuli selection when treating CG-speaking children with SSD. Selecting stimuli based on theoretical frameworks is imperative in research because this will inform goal setting and selection of intervention stimuli in clinical practice.

The present study aspired to add to this line of research through the selection and implementation of phonologically dense stimuli on inducing expressive phonological gains in bidialectal CG-speaking children with SSD. Because word-level variables in the form of phonological density prompt sub-lexical (phonological) learning and support expressive phonological gains, the present study hypothesised that there would be differential phonological learning in all three participants across all dependent variables. If true, the experimental manipulations of word-level variables in the form of phonologically dense stimuli during intervention for SSD are expected to result in differential phonological learning. The current study predicted that the participants would exhibit significant phonological gains and would benefit from the PDN advantage and phonological similarity entwined in the selected intervention stimuli.

The Cypriot-Greek dialectal linguistic variety

CG is spoken by the Grecophone population of Cyprus, an island situated in the Eastern Mediterranean Sea, and it is classified as a South Eastern variety of Modern Greek (Mackridge, 1985). This population is diglossic in the sense that CG is the vernacular form (the 'low' variety), used in everyday communication, whereas standard modern Greek (the 'high variety), is used in educational settings, government bodies, and the media. CG youngsters come in touch with standard modern Greek early on through the media (cartoons, advertisements, etc.). However, a more official contact with standard modern Greek occurs during the early years of schooling (around 4;0–6;0 years of age). According to Rowe and Grohmann (2013), CG-speaking children can be considered as discrete bi-dialectal rather than bilingual speakers of the two varieties. CG contains 36 segments including stops, fricatives, affricates, nasals, and glides in word-initial and word-internal positions (Armostis, 2009). Many segments surface as geminate sounds (long) which are used contrastively with their singleton (short) counterparts: e.g. [l] as in ['fila] "you kiss" vs. ['fil:a] "leaves". The gemination contrast in the case of CG voiceless plosive and affricate segments is enhanced by an aspiration contrast, as such geminates are realised with aspiration, while singletons are realised as unaspirated: e.g. ['kupa] a traditional Cypriot snack food versus ['kup^{h}:a] "bowl". CG voiced stops surface almost exclusively as voiced unaspirated stops or as prenasalised segments, such as [ku'^{m}bin] "button" versus [ku'pin] "paddle". The syllable word structure of CG typically involves more than one syllable, with stress falling on the ultimate, penultimate, and antipenultimate syllable. Phonotactically, CG words either end in a vowel or in/n/or/s/ (except for loanwords, which may end in other consonants) (Armostis, 2009).

Method

Research design

The study employed a single-participant multiple baseline design across three participants to evaluate the effects of the intervention on phonological gains (Kazdin, 2010; Skelton & Hagopian, 2014). The investigation adhered to the parameters of the multiple-baseline across participants which included: a) Replication of treatment effects across three independent conditions (e.g. participants), b) staggered length of baseline phase before the implementation of treatment, and c) a minimum of two data points per baseline phase and a minimum of five data points per treatment phase (Kratochwill & Levin, 2014). Staggered baseline sessions were administered to ensure the stability of performance for each dependent variable during the baseline. In this design, dependent measures regarding the skills targeted in the intervention phase are administered to participants several times during the baseline and intervention phases. The design included the following phases: a) Baseline (pre-test), b) intervention (with the last intervention session as the post-test measure), and c) follow-up.

Participants

The participants were three bi-dialectal CG-speaking children aged between 3;2–4;0 years. Participant 1 was female (3;6 years) and Participants 2 (age 3;2 years) and 3 (4;0 years) were male. Two children were recruited from the clinical caseload of the Cyprus University of Technology (CUT) Rehabilitation Clinic and one from a private speech and language centre in the city of Limassol, Cyprus. Initial assessments for Participant 1 were assessed by a certified SLP from the private sector and assessments for Participant 2 and Participant 3 were performed by two undergraduate students in the Department of Rehabilitation Sciences (Speech-Language Therapy program) under the supervision of certified clinical supervisors. For all three participants, SSD profiles were documented via the administration of the Phonological Assessment Test of the Panhellenic Association of Logopaedics (PAL) adapted to CG phonetic characteristics (Levanti et al., 1998). Assessment testing was supplemented with a 15-minute free language sample collection during which each child was asked to name 10-word targets depicted on pictures. In the absence of standardised phonological testing tools in CG, assessment is usually performed using non-standardised word lists and/or based on the adapted versions of standardised batteries from standard modern Greek. In such cases, adaptations of probes include a modification of the production of certain word stimuli in the form of aspirated voiceless stops, affricates, and palatal fricatives to comply with segmental and phonological characteristics of the CG variety.

All three participants presented with phonological profiles consistent with SSD. Specifically, the assessment indicated restricted phonetic inventories, production of errors on more than six segments, absence of fricative and affricates segments, use of immature syllable structures, restricted use of trisyllabic and multisyllabic words, and a significant occurrence of phonological processes use. The most prevalent syllable structure used by all was consonant-vowel (CV), vowel-consonant (VC), vowel-consonant-vowel (VCV), and consonant-vowel-consonant-vowel (CVCV) in its reduplicated form (e.g. [‘mam: a], [ta’ta]). Occurrences of phonological processes included high percentage of word-initial onset deletion [“milo] (apple) -> [i’”lo], regressive assimilation [‘^{m}bala] -> [‘lala], and cluster reduction [‘stoma] (mouth)-> [‘t^{h}:oma]. The data concerning protracted phonological profiles in CG were consistent with patterns reported by Petinou and Okalidou (2006) and Petinou (2021) regarding speech patterns in late-talking toddlers and in children with SSD respectively. Information regarding the developmental history of each participant was obtained via a parental questionnaire completed before the baseline phase. Participants came from middle socioeconomic strata (Cyprus Statistical Bulletin, 2012), were from monolingual home environments, and presented with unremarkable developmental history according to information from parental questionnaires. No significant history of otitis media with effusion (OME) was reported. At the outset of the investigation, none of the participants were receiving any form of speech-language pathology intervention. Non-verbal cognitive abilities were within the typical range as measured by the Brief IQ screener of the Leiter International Performance Scale-R (Roid & Miller, 1997). In addition, participants presented with typical receptive language as measured via the standardised Greek version of the Peabody Picture Vocabulary Test-Revised (PPVT-R) (Simos et al., 2011). Before the baseline sessions, each participant passed a hearing screening at 500, 1000, 2000, and 4000 Hz presented at 25 dB HL according to the guidelines suggested by the American National Standards Institute (1990) using an INVENTIS™ portable audiometer. Oral motor function was typical. Table I presents the participant information. A brief description of each child’s phonological skills as per the initial assessment before enrolment in the current study is presented below.

Participant 1: The child presented with severe phonological output in the form of restricted syllable structure favouring VCV and CVCV, reduced phonetic inventory with only five established segments including [m], [n], [k], [g], and [j]. Her speech was also characterised by structural and systemic phonological processes such as word-initial consonant deletions, unstressed syllable deletion, cluster reduction, backing to velars, and stopping of fricatives respectively such as [‘^{m}bala] “ball” -> [‘lala], [pa’tata] (potato) -> [pa’tata], [‘skala] (stairs) -> [‘kaja], [‘^{m}bota] (boot)-> [[‘koka], [‘sup^{h}:a] (soup)-> [‘kupa]. Her phonological skills were immature of her chronological age, according to developmental databases from typically developing bilectal CG-speaking toddlers (Petinou & Armostis, 2016; Petinou & Theodorou, 2015). She was stimulable for the segments [x], [p], [f], and [d]. Her mean length of utterance (MLU) in words was 2.1 corresponding to the

Table I. Participant information.

Subject	Age & sex	IQ leiter scale composite score	PPVT-R standard score
Participant 1	3;6 F	109	90
Participant 2	3;2 M	100	85
Participant 3	4;0 M	98	88

chronological age of 24 months based on developmental data in CG-speaking toddlers (Voniati, 2016).

Participant 2: The child presented with restricted output in the form of immature syllable structure favouring VC, CV, and VCV, restricted phonetic inventory with only seven established segments including [m], [n], [p], [b], [t], [d] and [j]. His speech was also characterised by structural and systemic phonological processes such as word-initial consonant deletions, unstressed syllable deletion, and stopping of fricatives respectively such as ['katʰ:os] (cat) -> ['ato], [ka'ko] (bad) ['to:], ['spiti] (home) ['pʰ:iti], ['soma] (body) ['toma]. His phonological skills were immature for his chronological age in comparison to developmental databases from typically developing bilectal CG-speaking toddlers (Petinou & Armostis, 2016; Petinou & Theodorou, 2015). He was stimulable for the segments [k], [l], [s] and [f]. His MLU was 1.1 corresponding to the chronological age of 22 months based on developmental data in CG-speaking toddlers (Voniati, 2016).

Participant 3: The child presented with restricted output in the form of immature syllable structure favouring CV and VCV, restricted phonetic inventory with only six established segments including [m], [n], [k], [x], [g] and [j]. His speech was also characterised by structural and systemic phonological processes such as word-initial consonant deletions, unstressed syllable deletion, stopping of fricatives, and remarkable occurrence of backing to velars such as ['tuto] (this) ['kuko], ['pitʰ:a] (pita bread) ['jika]. His phonological skills were immature for his chronological age in comparison to developmental databases from typically developing bilectal CG-speaking toddlers (Petinou & Armostis, 2016; Petinou & Theodorou, 2015). He was stimulable for the segments [k], [l], [s] and [f]. His MLU was 1.1 corresponding to the chronological age of 22 months based on developmental data in CG-speaking toddlers (Voniati, 2016).

Materials

Stimuli

Baseline and post-test assessment stimuli. These included a list of 49 single-word probes administered during the baseline (pre-test) and the last session (post-test). The probes were depicted on coloured digitised pictures inserted into a Microsoft PowerPoint file for presentation and consisted of 29 bi-syllabic, 10 tri-syllabic, and 10 multi-syllabic stimuli. The list attempted to sample most singleton consonants of CG across all possible word positions and stress patterns. Affricate segments and consonant clusters were not assessed. The particular probe list has been used for similar research investigations in CG-speaking children with SSD (Armostis et al., 2023; Petinou, 2021). The probe list and follow-up stimuli are reported in Supplemental Material 1.

Intervention stimuli. Intervention stimuli were constructed in the form of word-clusters, designed according to three criteria including: a) PDN, b) phonological overlap/similarity, and (c) characteristics of children's knowledge of word targets on the bases of segmental stimulability. For PNP density, the stimuli were chosen from a word database based on orthographic corpus in standard modern Greek created by the Institute of Language and Speech Processing (ILSP) in Athens, Greece, openly available for research purposes via the Golden Corpus website of ILSP (Kyparissiadis et al. (2017). To calculate PDN, the Phonological Levenstein Distance measure (PLD20) was used according to protocols provided by Kyparissiadis et al. (2017). PLD20 was derived by calculating the mean distance from the 20 closest neighbours to identify a word's phonological similarity with its closest phonological neighbours in the target language as defined by a specific corpus (Suárez et al., 2010). The mean PLD20 as well as the mean frequency of all the words in the database list (in the form of zipfFreq) was calculated for each target stimulus included in the word cluster members to be used for each participant. Specifically, if a particular word cluster was used for two out of the three participants or for all participants the mean frequency of the words did not change. Preliminary analyses showed that across the three children the PDN, as well as the frequency of words did not differ statistically (PDN: $F(2, 170) = .27$, $p = .77$; zipfFreq: $F(2, 179) = .83$, $p = .44$). Two-syllable and three-syllable words differed in terms of the frequency with two-syllable words occurring more frequently than three-syllable words ($F(1, 167) = 12.34$, $p < .01$), and they also differed in terms of PLD20, with two-syllable words belonging to more dense neighbourhoods (i.e. having a smaller distance from their closest neighbours) than three-syllable words ($F(1, 167) = 121.04$, $p < .001$). This pattern was the same across children. The mean PLD20 for two-syllable ($M = 1.60$, $SD = .20$) and three-syllable words ($M = 2.14$, $SD = .40$) indicate dense neighbourhoods consisting of words with close distance from the target words. Similarly, the mean frequency for two-syllable words ($M = 3.55$, $SD = .86$) and three-syllable words ($M = 3.09$, $SD = .83$) indicate high-frequency words in the language, both being well above the third quartile of zipfFreq scores for the entire set of words for GreekLex2 (3rd quartile = 2.86). For criterion b), phonological overlap, the words in each of the word clusters were created by replacing one phoneme from each two-syllable word target and two phonemes from three-syllable target stimuli. All word members within a given cluster consisted of phonologically dense stimuli bearing phonological overlap by at least one or two segments. Specifically, two-syllable members within each word-cluster differed by one or two phonemes (e.g. ['ᵐbala] "ball", ['sala] "hall", ['ɣala] "milk", ['vale] "put"), with corresponding three-syllable counterparts differing by one or two phonemes (e.g. [ba'loni] "ballon", [ma'lon:i] "argue", [sa'loni] "living room", [sa'lami] "salami"). For criterion c) of segmental stimulability, the author considered the child's articulatory knowledge of segmental stimulability. The impetus for using stimulability measures follows from Rvachew and Nowak (2001) who suggested that children taught most-knowledge/early-acquired targets might potentially show the highest treatment outcomes as opposed to individuals who are taught non-stimulable segments. Thus, the construction of each word member within a given cluster included at least one stimulable phoneme (usually in the word-initial position). The selected word targets formed the basis of intervention probes and were grouped in blocks of disyllabic and trisyllabic clusters of four-word members. A total of 48-word clusters were constructed across all participants (16-word clusters for each child including eight disyllabic and eight trisyllabic clusters). The disyllabic clusters were randomly selected and were taught during the first eight intervention sessions (first month of intervention) followed by comparable procedures with the implementation of the three-syllable clusters during the second month of the intervention. Each experimental session allowed the implementation of two clusters. Sixteen separate phonologically dense/phonologically similar word cohorts (clusters) were created for each child depending on the child's stimulability for at least one segment within each experimental word. The complete list of experimental word stimuli organised in clusters according to phonological density values is reported in Supplemental Material 2.

Dependent variables

The dependent variables included the following measures: a) Phonetic inventory size (PIS) including all established consonantal singleton segments, b) proportion of consonants correct (PCC), and c) percentage correct of whole word matches (WWMs) (Ingram, 2002). For the percentage of WWMs, a binary coding system with a metric scoring of 0 for no production/no response or incorrect match and 1 for a total match. An additional measure included the intelligibility in context scale (ICS) adapted in Greek (McLeod, 2020). The ICS is a parent-report questionnaire consisting of seven items that rate the degree to which the child's speech is understood by others. The ICS was scored on a Likert scale of 1–5 (1 = always unintelligible, 2 = usually unintelligible, 3 = sometimes unintelligible, 4 = rarely unintelligible, 5 = never unintelligible).

Procedures

Parental briefing. The parents of all children expressed interest and willingness to participate in the study. Before commencing intervention, caregivers were briefed on the study's procedures and signed a written consent. The intervention sessions were completed at CUT "TheraLab" research laboratory. The author and two clinically supervised undergraduate students unfamiliar with the specific details of the study administered all intervention sessions. The study was approved by the Cyprus National Bioethics Committee protocol CBNC/2020/014.

Baseline. Each participant was randomly assigned to a baseline session. The baseline phase included a series of measures collected over five weeks. Participant 1 received two baseline sessions, Participant 2 received three baseline sessions, and Participant 3 received four baselines. The baseline sessions lasted approximately 30 min and each child was tested with the 49-word probe described earlier. Each participant was asked to name the picture presented on the computer screen. PowerPoint pictures were randomly presented. In cases where elicitation was not possible via spontaneous naming, a delayed imitation response was prompted by the researcher. Phonetic and phonological skills as per the dependent variables measured were analysed with the use of the automated computerised algorithm Testing of Phonological Skills (TOPS) (Armostis et al., 2023). All baseline measures remained stable across sessions for each participant with a difference of +/- 10% of scores across baseline measures as suggested by a visual inspection of performance plots.

Intervention phase. The intervention phase consisted of 16 45 min individual sessions administered bi-weekly for approximately two months. The disyllabic targets were randomly selected and were taught during the first eight sessions of the intervention phase (first month of intervention) followed by comparable procedures with the implementation of the three-syllable word-cohort clusters (second month of the intervention). Target words were depicted using hand-drawn coloured pictures created by the author from several online resources used for previous research projects. Figure 1 depicts stimuli of word clusters including the following targets:

- [k a l a ‘m a r i] seafood delicatessen
- [k a l a 'm a c i] straw
- [k a l a 'θ a c i] small basket
- [k a 'l a m i] fishing pole

Establishment of rapport between child and researcher along with a brief explanation of the activities occured. The intervention sessions included specific steps that were followed by each researcher in the following way:

(1) Familiarisation of the child with each target word from the cohort cluster by placing all pictures in front of them and introducing each target via the carrier phrase, "Here you see a ______".

Figure 1. Pictorial depiction of word-stimuli.

(2) Oral presentation by the researcher of each word five times and prompting of the child to pay attention to what they will hear via the carrier phrase, “Now listen carefully! Brr Brr Brr wind your ear so you can hear!”.
(3) Prompt the child to produce the target word by giving them three chances to do so.
(4) Shifting to a new set of word cohorts once the child provided accurate production of each word 3/5 times (imitated responses were accepted as correct).

The carrier phrase prompting the child to pay attention to the word stimuli was produced orally five consecutive times before each word-stimulus introduction (five times for each of the four words in the cluster), which were randomly presented.

Participants were randomly praised for their cooperation during the session, but no direct praise was given for a specific response. In the case of no response, the participant was prompted to produce the target words via phonetic/articulatory prompting (e.g. when given the word-initial onset) or through delayed imitation. Correct and incorrect productions were inserted into a log database Microsoft Excel spreadsheet algorithm. A new set of word clusters was introduced once the child exhibited 60% (3/5 times) performance accuracy, that is correct production, on each word stimulus. If a child failed to reach the 3/5 criterion for a word, the researcher repeated the child’s ‘failed’ production word five more times. Each experimental session allowed the implementation of two to three sets of word clusters depending on the child’s performance.

Post-test phase. The post-test sessions took place one week after each participant completed the last intervention session. All participants returned to the intervention location and were administered the 49-probe list following the same procedures used during the baseline phase.

Follow-up phase. A follow-up session was conducted one month after the completion of the post-test phase. During the follow-up session, a different probe list consisting of 10 non-treated word stimuli was administered to assess the stability and generalisation of phonological gains. Pre-test, post-test, and follow-up assessment probes are reported in Supplemental Material 2.

Data recordings

Recording: Each session was audio-recorded using a Marantz PMD-222 digital recorder. An Audio-Technico flat unidirectional microphone was placed on the experimental table directly in front of the child. Recorded speech samples were phonetically transcribed using the International Phonetic Alphabet (International Phonetic Association, 2016) using the broad transcription. Unintelligible or ill-recorded utterances were excluded from the analyses. The expressive phonological gain was established based on performance averaged across all baseline (pre-test) measures relative to performance on the last intervention session (post-test).

Transcription reliability. For test-retest reliability, a second assessor trained in phonetic transcription analysed approximately 10% of randomly selected recorded samples coding as per the initial and final intervention sessions. Reliability on the relevant categories was based on the number of agreements divided by the sum of agreements and disagreements after the two transcribers had jointly listened to the targets and had compared their transcriptions for PIS (80%), PCC (90%), phonological processes (90% and 80% for unstressed syllable deletion and word-initial onset deletion respectively), WWMs (100%), and syllable structure use (100%). Reliability of data insertion for all participant productions collected across pre and post-test sessions were 100%.

Treatment fidelity

Two graduate students from the program of Rehabilitation Sciences at CUT were trained to complete treatment fidelity from four video recording sessions involving the first two baselines and the first two intervention sessions of Participant 1. Note that these were the only sessions that were video recorded (parental consent was mainly granted for audio recordings). The ratings involved the administration of probes and the administration of intervention steps. This was to ensure that the assessment and intervention steps were administered consistently. Compliance/agreement ratings for probe administration were 100% and for administration steps 90%.

Result

To explore the effectiveness of the intervention, performance on the test was compared between the baselines, the post-test, and the follow-up, separately for each child. All analyses were performed using non-parametric tests specific to the McNemar test to investigate differences in WWM scores and calculated a log Odds Ratio to estimate the ratio between pre-intervention (baselines) and post-test (post-test and follow-up) performance. The WWM performance of each child during baseline, post-test, and follow-up is presented in Table II. To analyse performance for the PCC for each child, percentages were arcsine transformed by calculating the arcsine values. Differences between all the baseline scores, the post-test scores, and the follow-up scores, were explored using the non-parametric repeated measures ANOVA, and post-hoc tests were performed using the non-parametric Wilcoxon Rank test. To estimate the effect sizes a repeated- measure Cohen's *d* (drm) (paired-mean difference) was calculated, which acknowledges the correlation between repeated measures, thus controlling for an overestimated effect size (Lakens, 2013). The PCC performance of each child during baseline, post-test, and follow-up, is presented in Table II. The values for ICS and PIS size were analysed using descriptive statistics. Supplemental Material 3 reports WWMs scores for each participant as a function of pre and post-test performance.

Participant 1

For Participant 1, the McNemar test indicated that WWM performance improved after the intervention, compared to baseline WWM, both during the post-test test ($\chi 2df(1) = 10.3$, $p = .001$, log Odds ratio = 2.56, $p = .002$) and the follow-up test ($\chi 2df(1) = 10.3$, $p = .001$, log Odds ratio = 2.56, $p = .002$). This indicates that in log terms, performance was more than 2.5 times greater in post-test and follow-up testing, compared to baseline performance. No difference in WWM performance was found between the post-test and follow-up test ($\chi 2df(1) = 3.6$, $p = .06$, log Odds ratio = 1.39, $p = .109$). Child 1's PCC performance during the two baselines, the post-test test, and the follow-up test is illustrated in Figure 2. The Friedman repeated measures ANOVA indicated a significant difference in PCC performance ($\chi 2df(3) = 21.6$, $p < .001$). The non-parametric Wilcoxon's paired t-test was used to explore this difference. Post-hoc tests showed that post-test PCC performance was significantly increased compared to the first ($W = 32.5$, $p < .001$, drm = 1.43) and second ($W = 59$, $p < .001$, drm = 1.33) baseline performance. Similarly, performance in the follow-up test was significantly greater compared to performance in the first ($W = 10$, $p = .002$, drm = 1.34) and second ($W = 9$, $p = .001$, drm = 1.42) baseline measures. No differences were found between baseline 1 and baseline 2 performance ($p = 0.79$). Similarly, no significant differences were revealed between post-test and follow-up performance ($p = 0.54$). Overall, results for Participant 1 indicate a significant gain in WWM and PCC performance as a result of the intervention as depicted in Figure 2. This performance gain was evident in both the post-test test and the follow-up test. The ICS index increased from 1 (pre-test) to 4 (post-test) suggesting improved intelligibility

Table II. Mean and standard deviation in parentheses for dependent variable measures across three subjects as a function of baseline (pre-test), post-test, and for follow-up sessions.

Dependent Measures	Baseline (pre-test) Mean (SD)	Post-test Mean (SD)	Follow-up Mean (SD)	X^2	*p* value	ES
Participant 1						
WWMs	8% (.20)*	62% (.31)*		10.3	<.001	2.72
	8% (.22)**		75% (0.44)**	11	<.001	2.61
PCC	20% (.31)*	62% (.31)*		59	<.001	1.44
	20% (.31)**		71% (.32)**	10	<.001	1.55
PIS	6	12	–			
ICS	1	4	–			
Participant 2						
WWMs	6% (.24)*	47% (.50)*		20	<.01	1.70
	6% (.24)**		60% (.33)**	6.23	<.01	1.70
PCC	33% (.19)*	63% (.34)*		68	< .01	1.62
	33% (.19)**		63% (.36)**	11	<.01	1.63
PIS	3	9	–			
ICS	1	3	–			
Participant 3						
WWMs	6% (.22)*	41% (.50)*		17	<.001	2.20
	6% (.22)**		55% (.51)**	6.40	<.05	2.20
PCC	35% (.26)*	64% (.37)*		30	<.001	1.11
	35% (.26)**		70% (.31)**	99	<.001	1.34
PIS	7	15	–			
ICS	2	5	–			

Note. WWMs: Whole Word Matches; PCC: Proportion of Consonants Correct; PIS: Phonetic Inventory Size; ICS: Intelligibility in Context Scale; ES: Effect size.

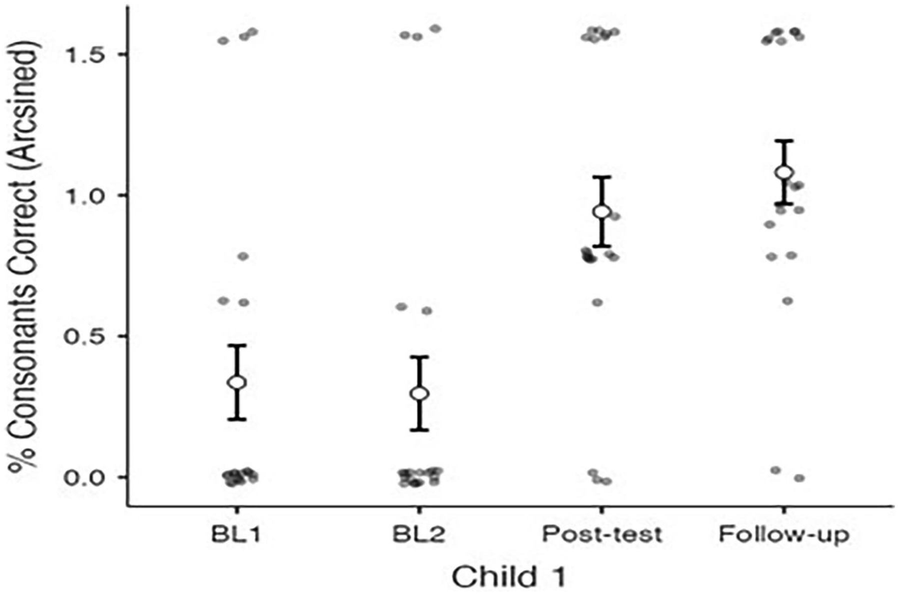

Figure 2. Participant 1 percentage of consonants correct performance in Baseline 1, Baseline 2, Post-intervention test, and Follow-up test.
Notes. White dots illustrate mean Arcsined value of percentage of consonants correct. Grey dots show raw data and error bars indicate ±1 standard error of the mean. BL; Baseline.

along with an increase in phonetic inventory from 4 established segments to 12.

Participant 2

The McNemar test indicated that Participant 2's WWM performance improved at post-test (χ2df (1) = 20, p < .001, log Odds ratio = N/A) and follow-up testing (χ2df(1) = 6.23, p = .013, log Odds ratio = 1.70, p = .022), compared to baseline performance. WWM performance did not differ between the post-test and follow-up tests (χ2df (1) = .11, p = .74, log Odds ratio = −0.22, p = 1). Figure 3 presents the PCC performance of Participant 2 in the three baselines, post-tests, and follow-up tests. Differences in PCC were evident, as indicated by the significant Friedman repeated measures ANOVA test (χ2df (4) = 18.3, p = .001). Post-hoc analyses indicated that post-test test performance significantly increased compared to baseline 1 (W = 60, p < .001, drm = .82), baseline 2 (W = 55.5, p < .001, drm = .88), and baseline 3 (W = 68.5, p < .001, drm = .87). Follow-up assessment performance was greater compared to baseline, however, this improvement did not reach significance (all ps > 0.06). Further, no differences were found in performance across the three baselines (all ps > 0.9) or between post-test and follow-up performance (p = .22). In summary, the performance of Participant 2 in WWM and PCC improved as a result of the intervention. The performance improvement was significant in the post-test, however, during follow-up, the improved performance did not reach significance. The ICS index increased from 1 (pre-test) to 3 (post-test) suggesting slightly improved intelligibility, along with an increase in phonetic inventory from 3 to 9 established PIS segments.

Participant 3

Improved performance in WWM compared to baseline, was also evident in Participant 3, as indicated by the significant McNemar for both post-test (χ2df (1) = 17, p < .001, log Odds ratio = N/A) and follow-up (χ2df (1) = 6.40, p = .011, log Odds ratio = 2.20, p = .021) tests. No differences between post-test and follow-up WWM performance were revealed (χ2df (1) = 0, p = 1, log Odds ratio = 0, p = 1). The PCC performance of Participant 3 for all four baseline tests, the post-test test, and the follow-up test are depicted in Figure 4. The Friedman repeated measures ANOVA showed significant differences in the PCC performance for Participant 3 (χ2df (5) = 30.4, p < .001). As indicated by the post-hoc analyses, PCC performance in the post-test was significantly increased relative to baseline 1 (W = 494, p < .001, drm = .89), baseline 2 (W = 463.5, p < .001, drm = .85), baseline 3 (W = 460.5, p < .001, drm = .81), and baseline 4 (W = 500.5, p < .001, drm = .8). Likewise, PCC performance was significantly increased in the follow-up test compared to baseline 1 (W = 103.5, p = .014, drm = .83), baseline 2 (W = 104.5, p = .012, drm = .83), baseline 3 (W = 103.5, p = .014, drm = .79), and baseline 4 (W = 99.5, p = .026, drm = .78). No indication of differences across all four baselines were found (all ps > .1), nor between post-test and follow-up tests (p = .93). Parallel to Participants 1 and 2, the results for Participant 3 infer to a performance gain due to the intervention. The improved performance of Participant 3 was found both in post-test and follow-up testing. The ICS index increased from 2 (pre-test) to 5 (post-test) suggesting improved intelligibility along with an increase in phonetic inventory from 7 to 15 established segments.

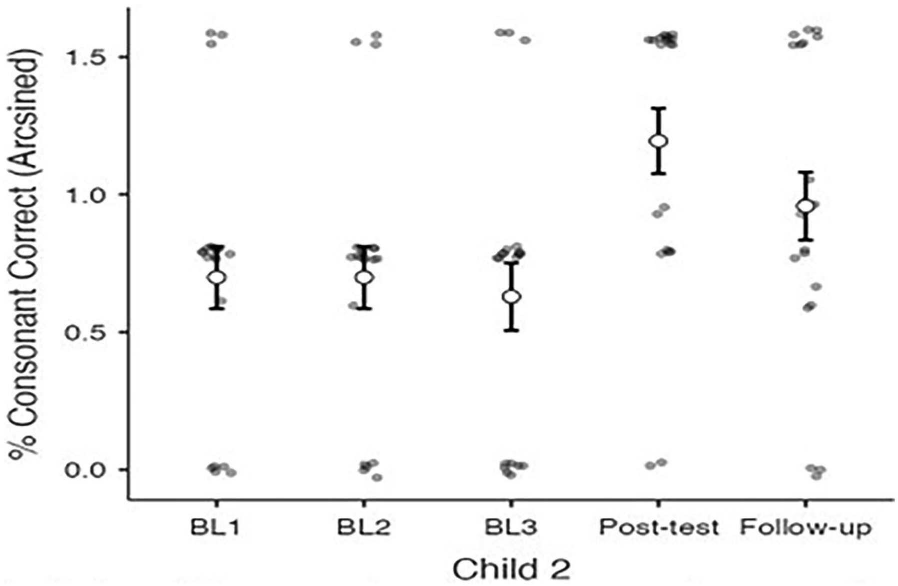

Figure 3. Participant 2 percentage of consonants correct performance in Baseline 1, Baseline 2, Baseline 3, Post-intervention test and Follow-up test.
Notes. White dots illustrate mean Arcsined value of percentage of consonants correct. Grey dots show raw data and error bars indicate ±1 standard error of the mean. BL; Baseline.

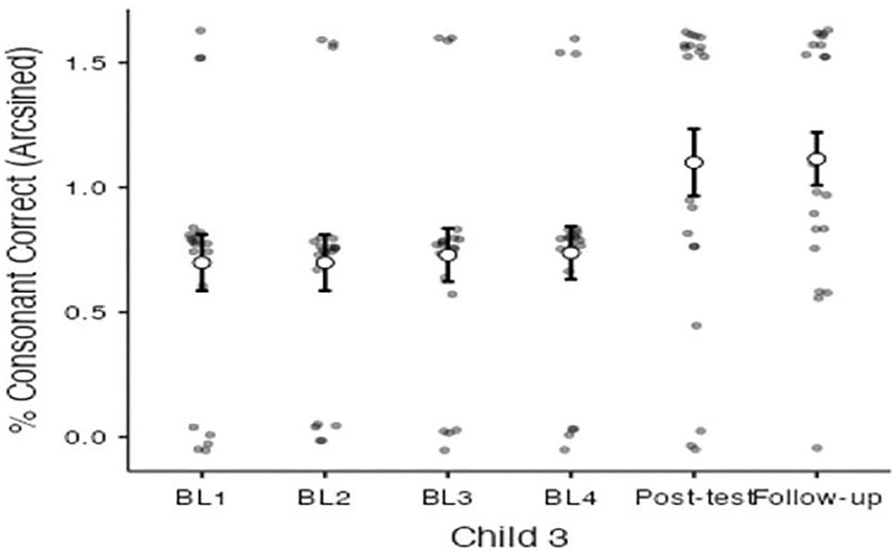

Figure 4. Participant 3 percentage of consonants correct performance in Baseline 1, Baseline 2, Baseline 3, Baseline 4, Post-intervention test, and Follow-up test.
Notes. White dots illustrate mean Arcsined value of percentage of consonants correct. Grey dots show raw data and error bars indicate ±1 standard error of the mean. BL; Baseline.

Discussion

The present study asked whether implementing phonologically dense stimuli during the intervention paradigm would result in phonological gains. The findings supported the predictions revealed by the differential learning in child performance between pre-test and post-test measures. Overall, the results corroborated data from English-speaking children with protracted phonological systems and supported the role of word-level properties as possible triggers for inducing and maintaining speech gains after intensive clinical intervention across all dependent measures (Gierut & Morrisette, 2012). Results from this investigation are also consistent with the findings reported by Petinou and Theodorou (2018) and Petinou (2021) regarding speech gains in bilectal CG-speaking children with SSD thus enhancing the potential clinical value of the intervention stimuli the study implemented. Specifically, an increased performance was observed across measures such as the production of whole word matches, and the PCC. Moreover, significant progress was recorded in intelligibility as measured by the ICS scale as well as on the increased size of phonetic inventories. Differential learning was maintained during the follow-up sessions. To the first approximation, the progress noted in expressive phonology could be attributable to the intervention and not to extraneous factors (e.g. developmental growth), given the implementation of a staggered multiple baseline single-participant research design. It is well established that the mechanism behind the underlying aetiology of SSD profiles remains complex and varies (for a review see Dodd et al., 2018). Similarly, treatment outcomes in SSD also remain complex and vary as a function of the severity of the disorder, error profiles, and limitations relevant to underlying representations (for a review see Bowen, 2015). In line with this, research findings, including data from cross-language investigations indicate that phonological interventions that integrate expressive and perceptual components of phonological knowledge such as listening and discrimination tasks were effective channels in inducing positive and long-term intervention outcomes (Gillon, 2017; Lousada et al., 2013). The approach used in the current study focused on phonological contrasts, thus possibly forcing the child to engage in phonological processing before they were required to express the target word stimuli. Specifically, the treatment outcomes observed in participant performance might have resulted from a combination of factors acting synergistically. These included the actual selection of stimuli designed to force the child to initially, tune into and process the phonological distinctiveness inherent to the members of word-stimuli clusters and then, engage in repeated production of 'multiple-member minimal pair' stimuli. During the last leg of the investigation, the researchers noted instances in which participants would self-correct their error productions, suggesting the operation of cognitive-linguistic awareness skills. Such speculations remain unexplored, thus further research is warranted to support and expand on such observations.

With the continuous and keen interest in cross-language phonological treatment, the current investigation adds to this line of research in the effort to maximise phonological learning skills and promote evidence-based practice as these parameters constitute the core of implementing best clinical practice processes. Findings from this investigation take on added significance by underscoring the importance of stimuli selection. An additional point related to the clinical implications postulates that systematic and focused intervention (e.g. use of specific stimuli), dosage, and frequency might lead to better and earlier positive outcomes (Skelton & Hagopian, 2014). In this context, the current investigation provides a more 'research-driven' quantification model through the use of the Greeklex2 (Kyparissiadis et al., 2017) which allows an objective calculation of metric values of each experimental stimulus. Such information bears clinical potential and informs evidence-based practice in various ways. First, the detailed list of word stimuli used in the study can be resourced by SLPs who serve children with SSD (e.g. in the context of Cyprus and Greece) and specific word targets can be implemented during intervention activities. Second, by using comparable clinical resources (e.g. word-list database) SLPs allow homogeneity in terms of assessment procedures and documentation of progress. It is well-documented that empirical research evidence, clinical expertise, availability of resources, knowledge of clinical outcomes, patient preferences, and practice contexts constitute the backbone of evidence-based practice (Hoffman et al., 2010). The present findings conform to the element of empirical evidence and clinical expertise which can be used to integrate knowledge in stimuli selection vis-à-vis the uniqueness of SSD profiles. Note that although the study enrolled a homogeneous' group of preschoolers who met comparable inclusionary criteria for SSD, phonological improvement varied across participants. Although all participants presented with parallel upward progress trajectories of performance, the magnitude of this progress varied as suggested by the differential effect size. Based on intake information, each child 'brought' along their idiosyncratic phonetic resources in the sense that among children, phonetic inventory sizes and intelligibility indexes were different. Thus, different sets of word stimuli were constructed to match each child's speech patterns. Such clinical profiles are not uncommon within paediatric populations, suggesting that child-specific-skill factors be taken into consideration when addressing intervention goals and when choosing appropriate intervention materials (i.e. intervention word targets).

A theme relevant to the current investigation focused on the importance of effect size (Gierut et al., 2015; Maggu et al., 2021). Effect size calculations form benchmarks for the magnitude of differential learning between baseline performance and post-intervention and determine the magnitude of phonological gains as a result of the intervention. Furthermore, effect size corresponds to the practical significance of SLPs when reviewing clinical outcomes (Gierut et al., 2015). The current study did report a significant effect, despite being interpreted as medium (range 1.2–2.7). A plausible explanation for the medium effect size might be attributed to the fact that the selection of the stimuli that were implemented, was based on phonetic stimulability (for one segment within each word target), by using the child's segmental knowledge. The impact of stimulability on inducing phonological gains has been debated (see Maggu et al., 2021 for a detailed description) in the sense that non-stimulable complex segments (e.g. later-developing segments) promote stronger effect size and a wide-system change as opposed to the clinical/intervention implementation of word-stimuli containing early-developing stimulable segments (Rvachew & Nowak, 2001). Even though the impact of stimulability versus complex frameworks on phonological progress remains under debate, it appears that both approaches bear clinical significance with the former, inducing faster phonological progress and the latter yielding stronger wide-system phonological gains accompanied by a stronger effect size (Gierut et al., 2015; Rvachew & Nowak, 2001). The current investigation did not employ a complexity approach but focused more on the child's phonological knowledge via the stimulability of only one segment within each word target. Along these lines, the implementation of a complex framework (use of less stimulable and later-developing segments) could have possibly yielded a stronger effect size. Nevertheless, the results suggested that participants benefitted from the use of the current stimuli as indicated by the progress observed within a short time frame, corroborating Rvachew & Nowak, 2001 findings who suggested faster progress. However, more research is warranted before effect size benchmarks are coined, thus leading to accurate interpretations. The present findings should be considered preliminary and should constitute initial indexes of phonological improvement in the context of dialectal CG-speaking children with SSD. Future studies should focus on delineating preliminary boundaries and benchmarks for the interpretation of effect size as a reliable and valid analytic metric that can be used by SLPs in the clinical context.

Limitations of the study

The results of the current investigation are limited by several factors. First, the study did not include a control group of children who were treated with a different set of experimental stimuli and a different experimental paradigm. Second, a set of control words as foils was not examined in measuring performance output. Consequently, the absence of production on 'foils might compromise the effectiveness and the 'exclusivity' of phonologically dense targets as the agents of phonological change. Third, phonological similarity/density was calculated from a database orthographic rather than speech corpora simply because such databases remain underexplored. In this case, neighbourhood density measures based on production rather than written targets might have altered the characteristics of intervention words, thus affecting the overall outcome. One more limitation of potential biases in data collection and participant performance had to do with the author's involvement through the intervention steps. Furthermore, the intervention sessions and the follow-up testing were administered by the same researcher (one familiar with the purpose of the study) who spent significant time with the participants. This personal interaction, which spanned more than three months, could pose a bias in terms of performance (i.e. the researcher cueing the child). Lastly, procedural fidelity was completed from a small number of data points and for only one participant. This shortcoming bears on the consistency of the administration of sessions and probes. Nevertheless, the robust changes across all children between baseline and (pre-test) versus intervention (post-test) phases justifies, to the first approximation, the positive impact of phonologically similar targets on expressive phonological gains. Future research should address such limitations.

Conclusion

It appears that the central components of word-level characteristics can be beneficial in a cross-linguistic context and can form a springboard for advancing theory-motivated phonological intervention protocols. In this study, the author contributed to this finding through preliminary, albeit significant findings. Future research is necessary to continue to tease apart optimum factors for the best clinical outcomes in line with the individual SSD profiles. From a theoretical stance, the word properties of intervention stimuli in the form of phonological density and phonological similarity, bear potential implications for inducing phonological gains. This is a crucial issue related to early and timely intervention, particularly during a natural period of accelerated phonological and lexical learning (i.e. preschool) (Shriberg et al., 1994). Moreover, it is important that the efficacy of an intervention protocol needs to be validated through theory-based and data-driven methodologies that can be experimentally manipulated. This is a pioneer investigation because it focused on an under-examined dialectal variety, was theory-based, and attempted to enrich the sparse research findings related to SSD in the cross-language/dialectal context. Cross-linguistic studies in children with SSD using phonologically dense word stimuli are crucial for understanding the universal and language-specific areas of typical and atypical speech acquisition patterns. By examining how children with SSDs from diverse language backgrounds process and use phonologically dense words, investigators can identify patterns and variations in speech production across languages. Such studies can shed light on the way linguistic factors, such as phonotactic rules and neighbourhood density, influence speech sound acquisition and error patterns. Furthermore, they can potentially provide insights into the role of language structure in shaping speech disorders, which can lead to more tailored, effective intervention strategies that consider both universal and language-specific elements in treating children with SSDs.

Declaration of interest

The author reports no conflict of interest and she is responsible for the content and the writing of the paper.

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