Received: 27 January 2023 | Accepted: 18 August 2024

DOI: 10.1111/1460-6984.13110

International Journal of Language & Communication Disorders

REVIEW

Intervention studies with group design targeting expressive phonology for children with developmental speech and language disorder: A systematic review and meta-analysis

Sari Kunnari[1] | Susana Sanduvete-Chaves[2] | Salvador Chacon-Moscoso[2,3] | Dina Caetano Alves[4,5] | Martina Ozbič[6] | Kakia Petinou[7] | Anna-Kaisa Tolonen[1] | Krisztina Zajdó[8] | Pauline Frizelle[9] | Carol-Anne Murphy[10] | David Saldana[2] | Marja Laasonen[11]

[1]Research Unit of Logopedics, University of Oulu, Oulu, Finland

[2]Department of Experimental Psychology, Universidad de Sevilla, Sevilla, Spain

[3]Departamento de Psicología, Universidad Autónoma de Chile, Temuco, Chile

[4]School of Health, Polytechnic Institute of Setúbal, Setúbal, Portugal

[5]Center of Linguistics, School of Arts and Humanities, University of Lisbon, Lisbon, Portugal

[6]LOGOS, private clinical practice, Sežana, Slovenia

[7]Department of Rehabilitation Sciences, Cyprus University of Technology Limassol, Limassol, Cyprus

[8]Department of Special Education/Speech-Language Therapy, Széchenyi István University/The University of Győr, Győr, Hungary

[9]Department of Speech and Hearing Sciences, University College Cork, Cork, Republic of Ireland

[10]School of Allied Health, University of Limerick, Limerick, Ireland

[11]Department of Logopedics, School of Humanities, University of Eastern Finland, Kuopio, Finland

Correspondence
Sari Kunnari, Research Unit of Logopedics, University of Oulu, Oulu, 90014, Finland.
Email: sari.kunnari@oulu.fi

Funding information
Foundation for Science and Technology; Government of Andalusia; Government of Chile; European Union

Abstract

Background: Phonological difficulties are prevalent in children with speech and/or language disorders and may hamper their later language outcomes and academic achievements. These children often form a significant proportion of speech and language therapists' caseloads. There is a shortage of information on evidence-based interventions for improving phonological skills in children and adolescents with speech and language disorder.

Aims: The aim of this systematic literature review and meta-analysis was to systematically examine the effects of different intervention approaches on speech production accuracy and phonological representation skills in children with speech and language disorders.

Methods: A preregistered systematic review (International Prospective Register of Systematic Reviews ID: CRD42017076075) adhering to Preferred Reporting

Items for Systematic Reviews and Meta-Analyses guidelines was completed. Seven electronic databases (PubMed, Web of Science, ERIC, PsychINFO, Cochrane Library, SCOPUS and Linguistics & Language Behavior Abstracts) were searched for studies related to oral language interventions with children with developmental speech and/or language disorder (mean age ranging from 3–18 years) published between January 2006 and August 2022. The included articles reported intervention studies with a group design in which speech production accuracy was the outcome measure. Studies were appraised using the Cochrane risk of bias tool, and individual effect sizes were calculated using standardised means differences when enough data was available. A meta-analysis was conducted obtaining the average standardised mean difference *d*. Heterogeneity, influence of possible moderator variables and publication bias were explored.

Results: The 23 studies that met the inclusion criteria presented low-medium risk of bias. Nine effect sizes were obtained from seven of these studies that presented a pre-post-test with a control group design. Medium-high average effect sizes were found in phonological accuracy. Heterogeneity was found between individual effect sizes. Significant moderator variables and publication bias were not detected.

Conclusions: The results of this meta-analysis indicate positive effects on speech production accuracy. Based on this review, further improvements in the quality of reporting for intervention research are required in developing the evidence base for practice.

KEYWORDS
intervention, language disorder, meta-analysis, phonology, speech disorder, systematic review

What this paper adds

What is already known on the subject

- An increasing number of interventions is available for children and adolescents with developmental speech and/or language disorders. Previous reviews suggest relatively low levels of evidence of interventions having phonology as an outcome measure.

What this paper adds to the existing knowledge

- This review and meta-analysis summarise the intervention evidence from a substantial body of group design studies, indicating positive results from a range of interventions with phonological outcomes. It highlights the need to systematically implement and replicate different intervention procedures to understand factors that will maximise positive outcomes and to grow the evidence base for best practice.

What are the potential or actual clinical implications of this study?

- Tentative evidence is emerging for the effectiveness of various approaches in enhancing speech production accuracy skills of children and adolescents with developmental speech and/or language disorder.

INTRODUCTION

Language acquisition is a complex process extending over a long period. A central component of acquiring an ambient language is to learn the speech sounds of the language and their organization into a system (i.e., phonology). For most children, the acquisition of phonology is relatively easily accomplished before children enter formal schooling, but some may encounter significant difficulties.

Developmental language disorder (DLD) is a common neurodevelopmental disorder with no known differentiating condition (e.g., hearing loss, brain injury or genetic syndrome) and with persisting language difficulties (Bishop, 2017; Bishop et al., 2017). It can co-occur with other neurodevelopmental disorders, but their causal connection to language problems is unclear. DLD may cover a broad range of problems affecting speech, language and communication, such as difficulties in the areas of phonology, semantics, morphology, syntax, narrative and discourse skills and/or pragmatics (see Venn diagram in Bishop et al., 2017). Phonology is one area of impairment in DLD, but the diagnostic label excludes children with phonological problems without broader language difficulties or evidence of poor prognosis. Thus, the term Speech Sound Disorder (SSD) has been used for cases that do not warrant a diagnosis of DLD. However, in some cases, judging prognostic indicators may be difficult. Current evidence suggests that more than one-third of young children with DLD or SSD exhibit co-occurring features of both conditions (Rodgers et al., 2023).

The terminology describing SSDs has varied and changed over time (Dodd, 2014; Stringer et al., 2023). McLeod and Baker (2017) define SSDs as difficulties with speech production and/or perception consisting of both phonological and motor speech disorders that are not typical of the child's age, cognitive capacities and language background. Phonological speech disorders reflect a cognitive-linguistic difficulty in learning a consistent phonological system of a language, while motor speech disorders (i.e., articulation disorder, childhood apraxia of speech (CAS) and childhood dysarthria) reflect difficulty with the coordination and production of accurate mouth movements, respiration and/or phonation required for fluent speech. Both disorders may affect speech intelligibility. Stringer et al. (2023), in their recent focused literature review, proposed three levels of diagnostic labels for SSDs. At level 1, SSD is used as an overarching term for all childhood speech disorders. At level 2, SSD is divided into SSD with unknown origin and SSD associated with a medical condition and/or underlying deficit (e.g., hearing loss, cerebral palsy or cleft palate). At level 3, SSD is further divided into a motor difficulty that affects articulation and a linguistic difficulty that affects phonology. The focus of the current review is on phonology (i.e., excluding SSDs associated with medical conditions or underlying deficits or motorically based difficulties).

It has been estimated that approximately 7% to 10% of children exhibit language disorder (Norbury et al., 2016; Tomblin et al., 1997), with many more children experiencing delayed speech and language development in the preschool or early school years. In a longitudinal cohort study, McKean et al. (2017) showed that almost 19% of 7-year-old children met the criteria for low language in a large sample investigating speech and language impairments. McLeod and Harrison (2009) found that about 25% of parents had concerns about their child's speech and language production. Furthermore, the comorbidity of DLD and SSD has been found to be high. Broomfield and Dodd (2004) reported that about two-thirds of children with receptive language difficulty and over half of children with expressive language difficulty have co-occurring SSD. Correspondingly, Eadie et al. (2015) found a 40% comorbidity of language disorder and SSD at the age of 4 years. Research has emphasised especially a link between DLD and phonological SSDs due to their shared linguistic deficits (Bishop et al., 2017; Rodgers et al., 2023). Developmental speech and language disorders may persist into adolescence and even adulthood despite intervention and may hamper academic achievements, social-emotional health and employment (e.g., Law et al., 2009; Lewis et al., 2015; Norbury et al., 2016).

Intervention approaches

Children with phonological problems often form a significant proportion of speech and language therapists' caseloads (Joffe & Pring, 2008; McLeod & Baker, 2017; Mullen & Schooling, 2010). When determining a suitable approach for each individual, several factors (e.g., child's age, error type, severity of the condition and underlying cause) need to be taken into account (Cabbage & DeVeney, 2020; Waring & Knight, 2013). As phonological problems vary widely according to underlying aetiology and severity, various approaches reflecting different theoretical accounts have been used for intervention.

One way of grouping these approaches is to divide them into perceptually based (i.e., input-oriented), phonologically based and motorically based (i.e., output-oriented) approaches (see e.g., Cabbage & DeVeney, 2020; Rvachew & Brosseau-Lapré, 2018). Children with phonological disorders may have difficulties with phonological processing, and a minority of them may as well have auditory processing difficulties (Rvachew & Brosseau-Lapré, 2018, p. 446). These difficulties often manifest as poor speech perception and phonological awareness skills. Therefore, perceptually based approaches (e.g., ear training or focused stimulation procedure) that strengthen acoustic-phonetic representations of words are needed. In the literature, links between children's speech production difficulties measured with the percentage of consonants correct (PCC), among other variables and underlying phonological representations have been identified (Sutherland & Gillon, 2007). Children may also have limitations in phonological knowledge (Dodd et al., 2008). This in turn suggests underlying deficits in relevant cognitive-linguistic processes. In this case, phonologically based approaches (e.g., contrastive approaches) that aim to reorganise a child's linguistic system may be beneficial. For inconsistent speech disorder, core vocabulary intervention targeting lexical consistency may be used. When children have concomitant phonology and morphosyntax difficulties, the morphosyntactic approach—targeting, for example, the production of finite morphemes—can also be used alongside other phonological approaches (McLeod & Baker, 2017). Motorically based approaches (e.g., traditional articulation intervention or use of production cues) are also used to supplement perceptually and phonologically based approaches. The aim of motorically based approaches is to improve children's motor speech control to establish articulatory placements and movements (Cabbage & DeVeney, 2020).

Two surveys of clinical practice in the United Kingdom for phonological disorders have indicated that several intervention approaches are used to promote speech and language abilities and to remove barriers to participation in society (Hegarty et al., 2018; Joffe & Pring, 2008). The three approaches used most often by clinicians were auditory discrimination, minimal pair intervention and phonological awareness interventions. Furthermore, Hegarty et al. (2018) identified traditional articulation therapy as one of the most popular approaches to remediating phonological disorders. In addition to the approaches listed above, McLeod and Baker (2014) identified four other frequently used approaches in their survey of Australian speech-language pathologists (i.e., cued articulation, auditory bombardment, Nuffield Centre Dyspraxia Programme and core vocabulary). The findings from the surveys mentioned also indicated that eclectic intervention, blending different approaches is quite often adopted in clinical practice instead of a single approach. In any case, accurate diagnosis and labelling of subtypes of DLD and SSD are crucial for the choice of effective approaches (Stringer et al., 2023).

Effectiveness of intervention

Three previous reviews were identified that examined the effectiveness of intervention approaches for phonological disorders. In Baker and McLeod's (2011), narrative review of children with SSD, 134 eligible studies with different research designs and participants ranged in age between 1.11 and 10.5, and with or without concomitant difficulties (e.g., hearing loss, cleft lip and/or palate or stuttering) were identified. Studies described seven distinct approaches for target selection and 46 for intervention. Most studies indicated relatively low levels of evidence, and the benefits of different approaches were difficult to interpret, because various research outcomes and designs were employed. Wren et al. (2018) expanded the work of Baker and McLeod (2011) by conducting a systematic review of interventions for preschool children that categorised the included studies ($n = 26$) according to the procedure used in the intervention (i.e., environmental, auditory–perceptual, cognitive–linguistic, production and integrated approaches), and by including speech motor difficulties as well as phonological difficulties. The approaches were organised according to the area targeted in the intervention (i.e., the area where change was expected to occur). Wren et al. found initial evidence for the effectiveness of auditory–perceptual and integrated intervention approaches for children with SSD. A recent scoping review by Rodgers et al. (2022) explored evidence for interventions for preschool children with co-occurring phonological SSD and expressive language difficulties. They found emerging evidence for both integrated (i.e., speech and language) and single-domain (i.e., either speech or language) interventions.

In addition to these three systematic reviews focusing specifically on interventions for phonological disorders, Law et al. (2004) conducted a meta-analysis of interventions targeting phonology, syntax or vocabulary for children with primary speech and language disorders. They included data from randomised controlled trials only. Their findings suggested that interventions for phonological disorders were effective. The effect size increased either when parent-implemented interventions or interventions lasting less than 8 weeks were excluded. Furthermore, Law et al. (2012, 2015) conducted a study in which they synthesised the evidence underpinning interventions for children with speech, language and communication needs, using different data sources such as online surveys to practitioners, research literature and parent reports. They identified 58 interventions used in England by speech and language therapists (SLTs) to improve speech and language skills. The level of evidence for the interventions used by SLTs varied considerably, with 5% considered to have strong evidence, 56% moderate evidence and 39% an indicative level of evidence. Reviews focusing on the effectiveness of a specific type of intervention (e.g., non-speech oral motor treatment; Lee & Gibbon, 2015; McCauley et al., 2009) or intervention outcomes for children with CAS (e.g., Ballard et al., 2015; Morgan et al., 2018; Murray et al., 2014) or multilingual children with speech and language difficulties (Crowe et al., 2021) have also been reported. As the current review excluded studies concerning CAS and multilingualism, these reviews are not discussed in detail.

The studies summarised here have provided valuable information and insights into the specific questions they address. The present systematic review and meta-analyses will expand the previous reviews by systematically examining the evidence for different intervention approaches having phonology as an outcome measure with participants across a wide age range (i.e., $M = 3–18$ years). For the meta-analysis, the PCC score was used as an outcome variable and found to be a good indicator of phonological ability (Fabiano-Smith & Hoffman, 2018). Unlike the previous reviews, the present review will focus on group design studies to run meta-analyses when sufficient information is available.

Aims

To our knowledge, no meta-analysis has previously synthesized the available evidence regarding speech production accuracy in children with developmental speech and/or language disorder. The aim of this study was therefore to identify, appraise and systematically synthesise quantitative evidence from group design interventions to treat children's developmental speech and/or language difficulties and for which phonology was an outcome measure. The review attempts to extend previous research by addressing the following questions:

1. Which approaches to intervention are used to treat phonological difficulties in preschool and school-age children with developmental speech and/or language difficulties?
2. What is the overall treatment effect of interventions on children's phonological skills?
3. Are there any associations between potential moderator variables (i.e., percentage of males, mean age in the treatment group, setting, practitioner, model of delivery, theoretical approach, level of service delivery, use of computer-based software and unit of allocation) and the individual effect sizes?

METHODS

The systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021) and is one of a series completed as part of European COST Action 1406 (see also Frizelle et al., 2021a, 2021b; Law et al., 2019). It was preregistered with the International Prospective Register of Systematic Reviews (ID CRD42017076075; Kunnari et al., 2017), an international prospective register of systematic reviews. The review is the first of three applying a similar methodology and focusing on interventions for children with developmental speech and/or language disorder, with phonology as an outcome measure. This first review focuses on group studies with speech production outcomes. The focus of the other reviews is on papers in which phonological processing outcomes are reported and on single case study designs.

Search procedure

A systematic and comprehensive literature search common for several COST Action IS1406 reviews with differing foci (i.e., vocabulary, phonology, morpho-syntax, pragmatics and dosage) was conducted to identify empirical peer-reviewed articles in any language related to speech and/or language interventions with children with DLD. A search strategy is detailed in Supplementary Material S1. Although the search in this initial stage was mainly focused on children with language disorders, we ensured that the search also captured relevant studies with children with SSD when the reviews with differing foci were split into different domains (see selection procedure). The following quality-controlled databases were used: PubMed, Web of Science, ERIC, PsychINFO, SCOPUS, and Linguistics & Language Behavior Abstracts. The search was limited to peer-reviewed studies published between January 2006 and August 2022 (an initial database search covering studies published between January 2006 and December 2015, followed by four updated searches).

Inclusion and exclusion criteria

The inclusion criteria common for all COST Action IS1406 reviews with different foci were:

- Peer-reviewed article published in any language between January 2006 and August 2022.
- Participants with a mean age of ≥ 3 and ≤ 18 years and identified as having a DLD or an equivalent term (i.e.,

performance falling below 1 SD in one or more domains using a standardised assessment method).
- Examined an oral intervention, which measured outcomes in the domains of vocabulary, phonology, morpho-syntax and/or pragmatics.

The exclusion criteria common for all COST Action IS1406 reviews with different foci were:

- Participants had autism spectrum disorder, a hearing impairment, an intellectual disability, a brain injury, a physical disability or a learning disability.

The inclusion criteria specific to the current review were:

- Peer-reviewed article published in English between January 2006 and August 2022
- Any group design study that provided data on expressive phonology outcomes.
- Monolingual (i.e., at least 90% of the study participants were required to be monolingual) participants identified as having a DLD or an equivalent term (i.e., performance falling below 1 SD on one or more domains) and/or clinically significant SSD based on articulation/phonology assessment or other standardised articulation/phonology measure.

The exclusion criteria specific to the current review were:

- Participants with a diagnosis of CAS, childhood dysarthria or articulation disorder (i.e., motorically based disorders) according to judgement by the authors or were bi/multilingual.
- Studies with single case design.
- Studies that provided data on phonological processing outcomes only.

Selection procedure

Stage 1. The aim of the initial search common for several COST Action IS1406 reviews was to identify articles examining evidence for different intervention approaches for children with DLD across different language domains. DLD was defined as a significant delay in oral language skills in a child's first language relative to those of children of the same age. All combinations of terms describing participants' age, disorder and intervention were searched for in each database (see Appendix A for a detailed search string). These database searches resulted in 17 005 studies (see Figure 1).

Stage 2. All citations retrieved from the search process were uploaded to the EPPI-Reviewer 4 software developed for literature reviews. The search results were screened by title and abstract for eligibility criteria based on date, target group, level of evidence or evaluation of an intervention by C.A.M., D.S. and P.F. Twenty percent were initially double-screened for reliability (C.A.M. and D.S. for the first search and C.A.M. and P.F. for updated searches). There was a 96% agreement rate, and disagreements were reconciled at this stage and all subsequent stages by consensus. This yielded 1358 papers.

Stage 3. As the focus of the current review is on phonology outcomes, the studies were next screened for relevance specifically to phonology. In this stage, the included results from the first stage search and screen were checked for the inclusion of key papers linked to theme-relevant (i.e., phonology) terms (phoneme* OR phonolog* OR articulat* OR speech OR phonet). Two independent reviewers (S.K. & M.L.) screened 100% of the papers. The agreement rate was 93%. This stage yielded 796 papers. Full paper copies of these potentially relevant studies were then retrieved for further systematic screening. To identify any additional potentially relevant papers, supplementary hand searches and citation chaining of the reference lists of all the papers included in the full-text stage were undertaken by one author (A.K.). In addition, relevant systematic reviews were also cross-checked.

Stage 4. At the full-text stage, studies were screened for eligibility based on their full content by the same independent reviewers as in the previous stage. The agreement rate was 94%. This full-text stage yielded 208 papers for data extraction.

Stage 5. Full texts were further screened to include (a) group design, (b) papers with a specific focus on speech production outcomes and (c) articles published in English. Studies with single case designs and phonological processing outcomes were excluded because they were the focus of two forthcoming reviews. In addition, studies where the authors explicitly reported that the participants' speech difficulties were associated with motorically based disorders (i.e., CAS, childhood dysarthria and articulation disorder) were excluded because these disorders are not considered to have a cognitive-linguistic basis. Furthermore, all non-English articles were excluded because the authors were unable to recruit native speakers of the other languages in question. The agreement rate at this stage was 100%, yielding 23 papers.

Data extraction

Full-text articles that met the inclusion criteria were read in detail, and data were extracted. The extracted data included the following variables: study design (e.g., randomised controlled trials, quasi-experimental, cohort

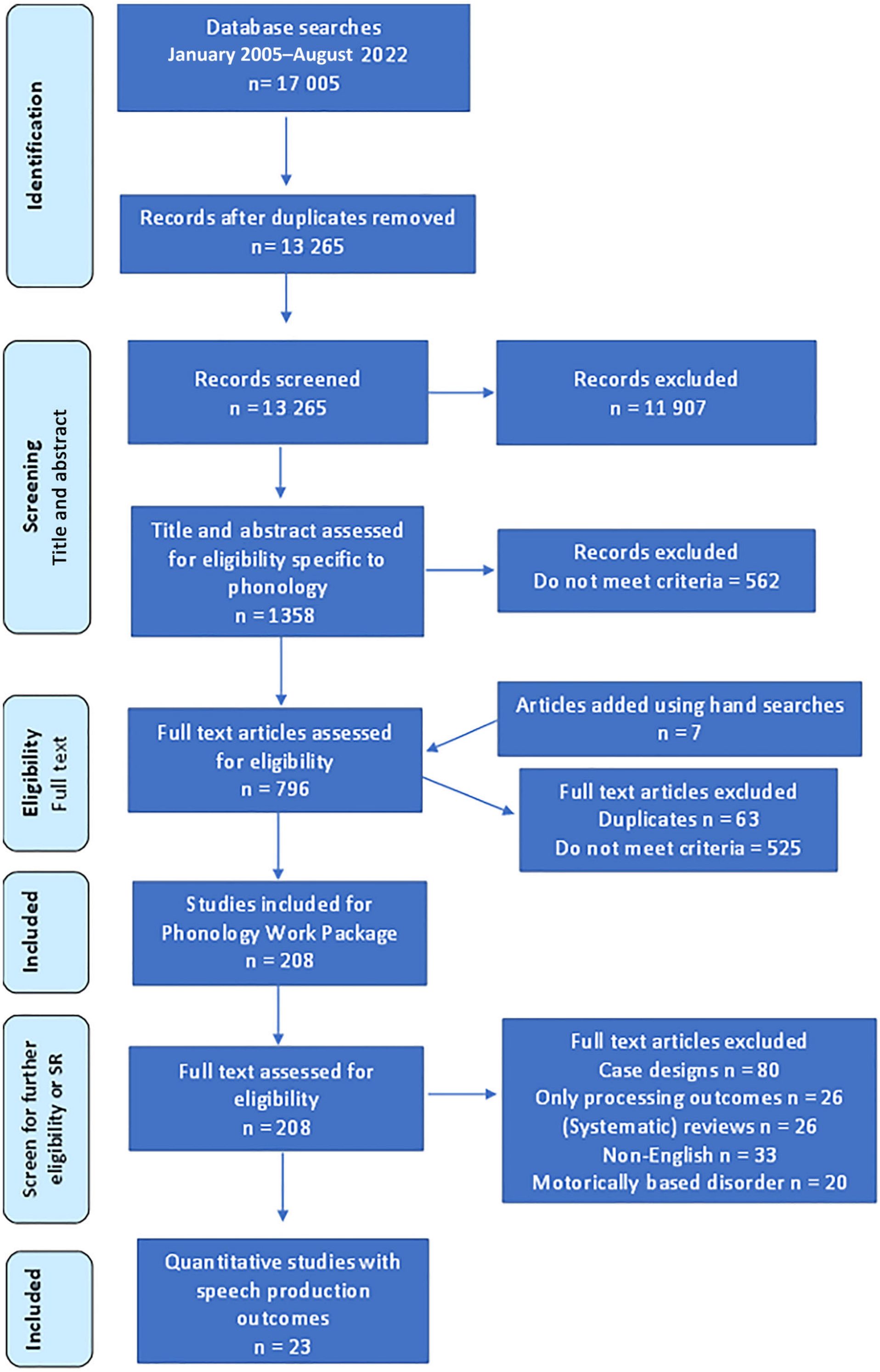

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart of the process of study selection. Abbreviation: SR, systematic review.

analytical, case design), participant details (e.g., number, sex, mean age at intervention baseline), intervention details (e.g., setting, practitioner/s, ingredients, model of delivery, theoretical approach, level of service delivery and software used), and outcome measures (nature of measures, values, main findings). The outcome variables were those described in our pre-registration and present in the data (e.g., speech production accuracy, speech intelligibility, phonemic inventory). The methods used to measure outcomes at the pre- and post-assessment stages and intervention effect were the following: two groups (pre- and post-assessment mean, standard deviation, and N for the groups) and one group (pre-post mean and standard deviations or their differences and N for the group). The complete extraction table is available from the authors if required. A total of six coders completed the data extraction independently: two coders (D.C.A. and M.O.) extracted the study design and participant details, two coders (S.K. and K.Z.) the intervention details, and two coders (M.L. and K.P.) the outcome measures. Any disagreement was resolved by consensus.

Using the Cochrane risk of bias tool (Higgins et al., 2017), the included studies were assessed for quality by two independent coders (S.K. and K.Z.). The tool assesses risk of bias using the following categories: selection bias for random sequence generation and for allocation concealment, performance bias, detection bias, attrition bias, reporting bias and other possible bias. Each item of bias was rated as low risk (0 points), high risk (2 points) and unclear risk (1 point), with a total risk of bias score ranging from 0 to 14. In addition, an indicator for the fidelity of intervention (i.e., whether the intervention was delivered as intended) was used. Any disagreements between coders were resolved by consensus.

Data analysis

In preparation for analysis by the type of outcome measure reported, we obtained scores for speech production accuracy (i.e., PCC). This dependent variable was used to examine the effectiveness of an intervention. We used this specific dependent variable because of the availability of the data (it was the variable most commonly reported to measure speech production accuracy in the studies included). The individual effect size was calculated using standardised means differences (d), which indicates the number of standard deviations of difference that there is between the results of the two groups being compared (treatment and control group). The average standardised means differences were then calculated for pre-test—post-test comparison with a control group) and each dependent variable. In all cases, $p < 0.05$ was considered a significant result, and following Cohen's classification (1988), 0 was considered a null effect size, around $\pm$ 0.2 low, around $\pm$ 0.50 medium and around $\pm$ 0.80 high.

To measure heterogeneity, we considered three calculations: a Q statistic with $p < 0.05$ was interpreted as the individual effect sizes differed statistically between studies; I^2 was interpreted as the percentage of explained variability that could be attributed to study differences (around 25% would be deemed a low percentage variability, around 50% medium and around 75%, high); and the predictive interval was interpreted as the lowest and the highest possible effect size obtained in the population.

When there was heterogeneity, meta-regression was used to study the possible relationship between the quantitative moderator variables and the individual effect size; where the moderator variable was qualitative (such as the setting of intervention – preschool, school, or clinic – or the model of delivery – direct or indirect), a comparison across groups was carried out.

Finally, to show publication bias, funnel plots were created. White symbols were the observed values, while black symbols were those that were imputed. When the white diamond was close to the black diamond, we concluded that there was no meaningful publication bias (Borenstein, 2019; Borenstein et al., 2009).

RESULTS

Study characteristics

Of a database of 17 005 papers, 23 studies met the inclusion criteria for this review. Table 1 provides a summary of the included studies' descriptive characteristics. Forty-three percent of these 23 studies originated from the United States or Canada. Other contributing studies were from the United Kingdom, Australia, Portugal, Brazil, Finland, Germany and Turkey. A total of 925 children were represented in these 23 studies. The sample sizes varied from 14 to 126 children, and the range of the children's mean ages was from 3 to 17 years. In the two articles where specific mean ages were not presented, the age was presented in ranges: between 5 and 15 years old, and from preschool to 15 years old. In all the studies (in which the information was stated), there were more boys (n = 582, 66.5%) than girls (n = 293, 33.5%) in the samples. The participants in the studies were characterised to have DLD only (n = 4, 17.4%), both speech and language disorder (n = 5, 21.7%), either speech and/or language disorder (n = 7, 30.4%), or SSD only (n = 7, 30.4%). Fifty-two percent of the studies were randomised controlled trials (n = 12), 17% were quasi-experimental (n = 4) and 30% were cohort studies (n = 7) in design.

Intervention characteristics and outcomes

Interventions were intended to develop several phonological skills relevant to this review (e.g., speech accuracy, speech intelligibility, speech stimulability; see Table 1). Interventions were delivered either in educational (n = 12, 52.2%) or clinical (n = 9, 39.1%) settings. In two

TABLE 1 Description of included studies.

Study	Study design	Participants (*N*, age)		Setting	Agent of delivery	Intervention approaches	Phonological outcome measures	Main findings
Allen (2013)	RCT	54	3.0–5.5	E	SLT	Two groups receiving multiple opposition approach with different dose frequency and a control group receiving storybook intervention	PCC	Multiple opposition group with a more intensive dose frequency had significantly better outcomes than two other groups.
Catt et al. (2011)	Cohort study	20	Preschool–15 years	C	SLT student	Thematic language intervention	Articulation score	Articulation scores improved significantly.
Dodd et al. (2008)	RCT	19	3.11–6.05	C	SLT	Minimal vs. non-minimal contrasts	PCC, PVC, PPC, number of error patterns	Positive outcomes in terms of speech accuracy and number of error patterns but no group differences.
Ebbels et al. (2017)	Cohort study	72	9.2–17.0	E	SLT	Individual speech and language intervention	Speech sound production	The targeted areas improved significantly.
Farquharson et al. (2020)	Cohort study	126	5–8 years	E	SLT	Business-as-usual therapy	PCC	Children made significant gains in PCC.
Fey et al. (2010)	RCT	23	6–8 years	C	SLTs and SLT students	a. Fast ForWord-Language and Narrative-Based Language Intervention group b. NBLI/FFW-L group, and c. wait/NBLI group	PPC	The intervention groups significantly outperformed the no-treatment wait/NBLI group.
Gabel et al. (2013)	Cohort study	71	5–15 years	E	SLT	Telepractice speech-language intervention	Speech sound production, speech intelligibility	85% made progress in speech sound production, and 67% in speech intelligibility.
Gierut et al. (2010)	Retrospective cohort study	60	3.1–7.5	C	SLT	Treating sounds in error with nonword vs. real word stimuli	Speech accuracy	Generalization accuracy of the treated sounds exceeded that of untreated sounds, and nonwords induced greater and more rapid generalization than real words.

(Continues)

TABLE 1 (Continued)

Study	Study design	Participants (*N*, age)		Setting	Agent of delivery	Intervention approaches	Phonological outcome measures	Main findings
Gordon et al. (2021)	Quasi-experimental	18	4.1–6.11	C, E, H	Unclear	Slow mapping process	Phonological precision score	Performance improved across days with an average increase in phonological precision of 7% from one day to the next.
Heikkilä et al. (2018)	Quasi-experimental	20	7.2–10.8	E	SLT	Audio-visual vs. auditory training	Oromotor sequences	Verbal motor skills improved in both groups after training.
Jesus et al. (2019)	RCT	22	3.6–6.6	E	SLT	Novel tablet-based vs. traditional tabletop approach to phonological intervention	PCC, PVC, PPC	Both tabletop- and tablet-based interventions were effective in improving PCC and PPC scores, with an intervention effect only evident for PVC in the tablet group.
Lancaster et al. (2010)	RCT	15	3.0–6.6	C	SLT, parents	An eclectic approach (three groups: children treated by SLTs, children treated at home by parents or untreated children)	Composite deviancy score	Children treated by therapists showed strongly significant gains. Lesser but significant gains were made by children treated by their parents; no change was found in untreated children.
Lourenço et al. (2020)	Quasi-experimental	14	4.2–5.7	E	SLT	Narrative intervention group vs. control group	PCC	PCC scores improved in both groups. However, the PCC of the narrative group did not significantly differ from that of the control group. Thus, narrative language intervention for improving phonology was not supported.

(Continues)

TABLE 1 (Continued)

Study	Study design	Participants (*N*, age)		Setting	Agent of delivery	Intervention approaches	Phonological outcome measures	Main findings
Lousada et al. (2013)	RCT	14	4.0–6.7	C	SLT	Phonological vs. articulation intervention	PCC	Both interventions were effective in improving the participants' PCC scores, with the children receiving phonological intervention showing a more significant improvement in PCC score than those receiving the articulation intervention.
McLeod et al. (2020)	RCT	101	3–6 years	E	SLT	Three intervention conditions: direct intervention, face-to-face advice, and a purpose-built website (device) group	PCC, ICS	Post-intervention speech (PCC) was significantly higher in the therapy group than in the advice group, and the device group. However, there was no statistically significant difference in post-intervention intelligibility between the groups.
Mecrow et al. (2010)	Quasi-experimental	35	4.2–6.10	E	Specialist teaching assistants	An enhanced consultative model	PCC	The DEAP percentage of phonemes correct showed a significant change in raw scores but not in standard scores.
Murphy et al. (2015)	RCT	39	7.8–9.7	C	Unclear	Computerized nonverbal auditory training	PCC	Both the trained groups demonstrated larger absolute gains in PCC scores than in the untrained groups. However, the difference was not significant.
Rvachew and Brosseau-Lapré (2015)	RCT	85	4-year-olds	C + H	SLT students and parents	Four groups: Output-oriented intervention and articulation practice home program, output-oriented intervention and dialogic reading home program, input-oriented intervention and articulation practice home program, and input-oriented intervention and dialogic reading home program	PCC, change in targeted match ratio	All four groups achieved measurable progress in articulation accuracy over the 12-week period of the intervention, whereas a nonrandomized comparison group made minimal gains during the same period.

(Continues)

TABLE 1 (Continued)

Study	Study design	Participants (N, age)		Setting	Agent of delivery	Intervention approaches	Phonological outcome measures	Main findings
Siemons-Lühring et al. (2021)	RCT	32	3.5–5.5	C	SLT	PhonoSens treatment procedure	PCC, number of phonological processes	The PCC scores improved significantly, and there was a reduction in phonological processes.
Özcebe et al. (2021)	Cohort study	22	4.5–6.6	E	SLT	Stimulability intervention	Articulation and phonology scores, percentage of stimulability, and speech intelligibility	There was a significant difference in the total number of articulation errors of children between Time 1 and Time 2 and an increase in stimulability ratings.
Tyler et al. (2006)	Cohort study	20	3.0–5.11	E	SLT students	Phonological intervention procedures for two groups differing in the consistency/variability of errors	target composite percentage, generalization composite percentage, and PCC	outcome measures reflected a change in target accuracy, while generalization to an untreated word position and PCC change did not significantly differ for the two groups.
Tyler et al. (2011)	RCT	30	3.10–5.2	C	SLT students	Integrated phoneme awareness/speech intervention vs. speech/morphosyntax intervention	PCC and cluster accuracy	Both intervention groups made statistically significant gains in speech accuracy measures.
Wren and Roulstone (2008)	RCT	33	4.2–7.10	E	SLT	Phonological intervention for three groups: computer; tabletop; and no therapy groups	articulation score and PCC.	Although all three groups made significant progress, there were no significant differences between the groups, and the difference between groups can at best be described as a trend.

Abbreviations: C, clinic; DEAP, Diagnostic Evaluation of Articulation and Phonology; E, education; FFW, Fast ForWord-Language; H, home; ICS, Intelligibility in Context Scale; PCC, percentage of consonants correct; NBLI, Narrative-Based Language Intervention; PPC, percentage of phonemes correct; PVC, percentage of vowels correct; RCT, randomised control trial; SLT, speech-language therapist (or SLT assistant).

studies (8.7%), the intervention occurred in more than one setting. Interventions were most often delivered by SLTs or SLT students (n = 18, 78.3%). Two studies involved combinations of agents, SLTs (or SLT students) and parents (8.7%). In one study, the intervention was delivered by specialist teaching assistants (4.3%), and in two studies, by a researcher whose background was unspecified (8.7%). The studies differed greatly in terms of the intervention approaches used and the measures to examine outcomes. Applying the classification of intervention approaches presented by Wren et al. (2018), approaches that combined two or more of the procedures (i.e., environmental, auditory–perceptual, cognitive–linguistic or production) were involved in most of the studies (n = 16, 69.6%). In the remaining studies, either cognitive–linguistic (n = 5, 21.7%) or auditory–perceptual (n = 2, 8.7%) approaches were used. Combined approaches included different combinations of, for example, phonological awareness, vocabulary, grammar, phoneme production, stimulability and dialogic reading training. Cognitive-linguistic approaches involved multiple opposition and minimal pair approaches and narrative-based interventions, whereas auditory-perceptual approaches focused on computerized nonverbal auditory training (e.g., rapidly changing acoustic features of the speech stream).

Regarding outcomes, various tools were used to measure changes in speech production skills, including formal assessment methods, spontaneous speech samples and custom-designed tasks. All 23 included studies reported pre- and post-intervention data on outcomes relevant to phonology. All studies reported positive findings; either statistically significant improvement or positive improvement based on mean scores on at least one phonology outcome measure. No studies reported a negative impact on outcome measures. Because procedures that combined several approaches were used in most of the studies, it was impossible to draw conclusions regarding the effectiveness of individual approaches.

Quality ratings

A comparison of the independent coding of the risk of bias revealed an intraclass correlation coefficient = 0.979, 95% confidence interval [CI] [0.971, 0.985]. Table 2 presents the quality ratings for each study in each item. Risk of bias in the studies ranged from 0 (null risk of bias) to 10 (M = 5.13, SD = 3.02). Overall, there was a low-medium risk of bias across studies with two items (attrition bias and reporting bias) with a median of 0 (low risk), and 1 (medium risk) for four items (selection bias: random sequence generation and allocation concealment, performance bias, and detection bias). Only one item (other bias) presented a mainly high risk of bias. In almost half the studies (n = 11, 47.8%), fidelity measures were reported explicitly; nevertheless, in nine (39.1%) of the studies, fidelity measures were not described.

Meta-analysis

Seven of the 23 included studies were included in the meta-analyses, generating nine individual effect sizes about speech production accuracy (PCC). The remaining studies were not included in the meta-analyses, because they did not present enough data to calculate the effect size, and information missing was not provided by the authors. Supplementary Material S2 includes the statistical data used to obtain the individual and average effect sizes.

The analysis included studies in which there was a treatment and a control group, and measurements at two time points (pre- and post-intervention). This analysis provided the opportunity to determine the effectiveness of the intervention on phonology outcomes relative to children who did not receive such treatment. More detailed information about the results obtained is available in Supplementary Material S3.

From the seven studies included in the meta-analysis, two (28.6%) presented a cognitive-linguistic approach, one (14.3%) an auditory-perceptual approach and the remaining four (57.1%) a combination of different approaches. The cognitive-linguistic approaches used in these studies were multiple opposition and minimal pair approaches (Allen, 2013; Dodd et al., 2008). The auditory-perceptual approach involved computerised nonverbal auditory training that focused on frequency discrimination, ordering, and backward-masking tasks (Murphy et al., 2015). The combined approaches included combinations of auditory bombardment, enhanced auditory self-monitoring, contrastive approaches, phoneme production training, and cued articulation (Jesus et al., 2019; Lousada et al., 2013; Siemons-Luehring et al., 2021; Wren & Roulstone, 2008).

Figure 2 shows the forest plot obtained based on the outcome PCC. All the individual effect sizes were positive, which implies that the effect was in favour of the experimental group. Two individual effect sizes were high, two medium and the remaining five, small. Only the two high individual effect sizes resulted significant, one highlighting with a d = 5.346, 95% CI [3.928, 6.7644], $p <$ 0.001).

The average effect size was high and statistically significant (d = 0.784, 95% CI [0.055, 1.513], p = 0.035), which implies that there was a meaningful improvement in speech production accuracy in favour of the group that

TABLE 2 Quality ratings of included studies (Cochrane risk of bias tool + Fidelity measures).

Study	Random	Allocation	Perform	Detection	Attrition	Reporting	Other	Fidelity
Allen (2013)	Low risk	Unclear	Low risk	Unclear	Low risk	Low risk	High risk	Yes, explicit
Catt et al. (2011)	Unclear	Unclear	Unclear	Unclear	High risk	Unclear	High risk	Yes, implicit
Dodd et al. (2008)	Low risk	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear	Yes, explicit
Ebbels et al. (2017)	High risk	Unclear	Low risk	Low risk	Low risk	Low risk	High risk	No
Farquharson et al. (2020)	High risk	High risk	High risk	Low risk	Low risk	Low risk	Unclear	Yes, explicit
Fey et al. (2010)	Low risk	Low risk	Low risk	Low risk	Unclear	Low risk	High risk	Yes, explicit
Gabel et al. (2013)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	High risk	No
Gierut et al. (2010)	High risk	Unclear	Unclear	Unclear	Low risk	Low risk	High risk	No
Gordon et al. (2021)	High risk	High risk	High risk	High risk	Low risk	Low risk	Unclear	No
Heikkilä et al. (2018)	High risk	Unclear	Low risk	Low risk	Low risk	Low risk	High risk	No
Jesus et al. (2019)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Yes, explicit
Lancaster et al. (2010)	Unclear	Low risk	Unclear	High risk	Unclear	Unclear	High risk	Yes, implicit
Lourenço et al. (2020)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear	No
Lousada et al. (2013)	Low risk	Unclear	Low risk	Low risk	Low risk	Low risk	High risk	Yes, explicit
McLeod et al. (2020)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Yes, explicit
Mecrow et al. (2010)	High risk	High risk	High risk	High risk	Low risk	Low risk	High risk	No
Murphy et al. (2015)	Low risk	Unclear	Unclear	Unclear	Unclear	Low risk	High risk	No
Rvachew and Brosseau-Lapré (2015)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Yes, explicit
Siemons-Lühring et al. (2021)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear	Yes, explicit
Özcebe et al. (2021)	High risk	High risk	High risk	Low risk	Low risk	Low risk	Unclear	No
Tyler et al. (2006)	Unclear	Unclear	Unclear	Unclear	Unclear	Low risk	High risk	Yes, implicit
Tyler et al. (2011)	Low risk	Unclear	Unclear	High risk	Low risk	Unclear	High risk	Yes, explicit
Wren and Roulstone (2008)	Low risk	Unclear	Low risk	Low risk	Low risk	Low risk	High risk	No

Note: Random = Selection bias: Random sequence generation; Allocation = Selection bias: Allocation concealment; Perform = Performance bias: Blinding of participants and personnel; Detection = Detection bias: Blinding of outcome assessment; Attrition = Attrition bias: Incomplete outcome data; Reporting = Reporting bias: Selective reporting; Other = Other sources of bias.

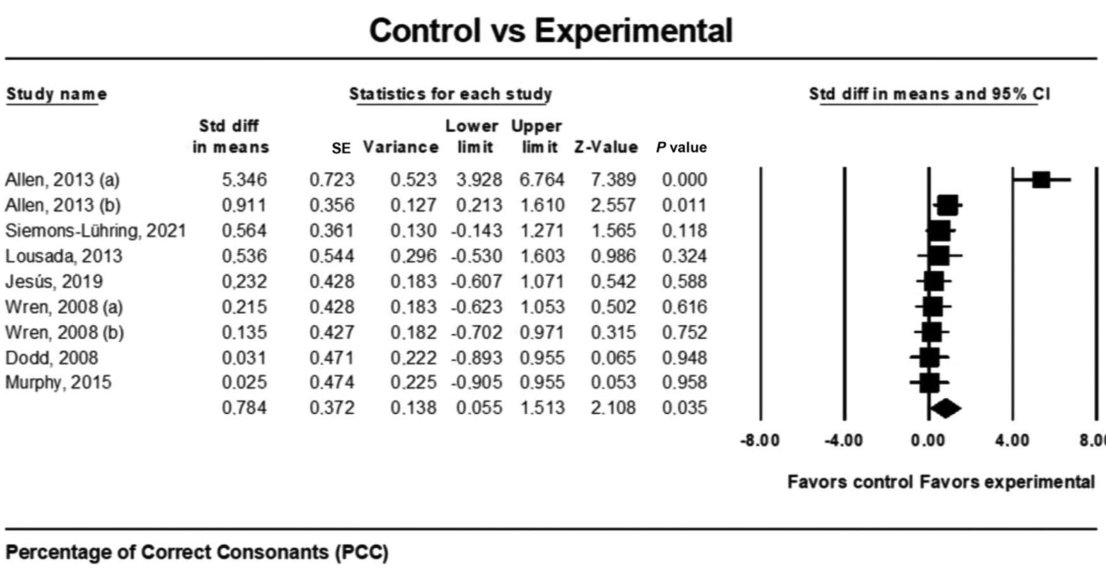

FIGURE 2 Forest plot of percentage of consonants correct.

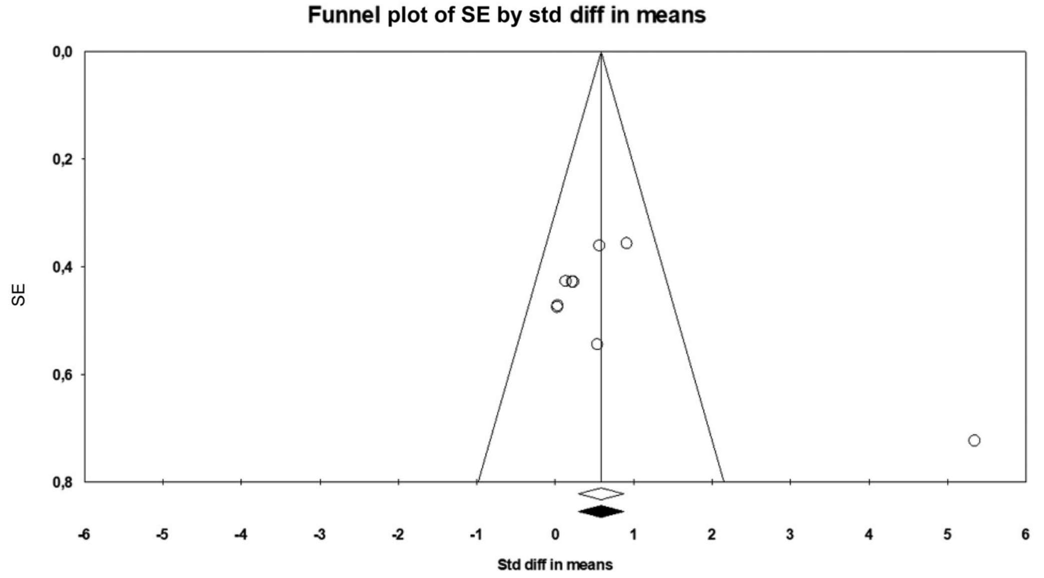

FIGURE 3 Funnel plot of percentage of consonants correct.

participated in the intervention. This result was not statistically significant due to the small size of available data from the selected studies. Usually, meta-analyses present a high dispersion of the studies included (wide amplitude between low and upper limit), which is overemphasised when the sample size is small.

The individual effect sizes were heterogeneous, Q (8) = 49.472, $p < 0.001$; $I^2 > 83.8\%$ (high heterogeneity); with a wide predictive interval, 95% CI [−1.766, 3.335]. None of the potential moderator variables studied yielded a statistically significant influence in the effect size (percentage of males, $z = 0.110$, $p = 0.915$; mean age in the treatment group, $z = -0.810$, $p = 0.419$; setting, $Q(3) = 2.834$, $p = 0.418$; practitioner, $Q(1) = 3.081$, $p = 0.079$; model of delivery, $Q(1) = 1.880$, $p = 0.170$; theoretical approach, $Q(2) = 1.840$, $p = 0.398$; level of service delivery, $Q(1) = 1.880$, $p = 0.170$; software, $Q(1) = 1.033$, $p = 0.309$. The unit of allocation could not be studied as a moderator variable because it was the same for all the included studies. Finally, the funnel plot (see Figure 3) presented no evidence of publication bias.

DISCUSSION

The main aim of the present review and meta-analysis was to identify intervention approaches used to treat phonological difficulties and to investigate their effect on children and adolescents with speech and language difficulties. The study search process included a wide age range of participants and builds on previously published reviews in this area (Baker & McLeod, 2011; Law et al., 2004; Wren et al., 2018). It extends the investigation of intervention approaches by employing Wren et al.'s classification model and includes a statistical meta-analysis, which contributes to an understanding of effects from a range of interventions as well as the consistency of these effects across a broader age range of children with speech difficulties.

A total of 23 studies were identified as meeting study inclusion criteria, seven of which were included in our meta-analysis, which yielded nine individual effect sizes. In general, our findings indicated that different aspects of phonology were targeted, with a diverse range of intervention approaches used in studies. The categorization of the classification model for interventions showed that in most of the studies, a procedure combining a number of approaches to intervention (i.e., an approach that combined different activities and strategies) was used. None of the studies were categorised under environmental or production approach categories. In their review, Wren et al. (2018) found that the most frequently used approaches were either cognitive–linguistic or production approaches. A potential reason for the discrepancy in findings is that the categorization of studies was not straightforward. Many studies included different contexts and techniques, making it difficult to determine the specific approach being investigated. In addition, in contrast to the Wren review studies with participants with motorically-based disorders were excluded in the present review (i.e., participants with which production approaches are often used).

Based on the findings from our review and meta-analysis, interventions had generally positive effects on the dependent variable (i.e., speech production accuracy), and publication bias was minimal. Our results are consistent with previous evidence that interventions targeting phonology are effective (e.g., Baker & McLeod, 2011; Law et al., 2004; Wren et al., 2018). Although individual effect sizes were heterogeneous, no significant moderator variables were found. There was no relationship between effect size and participant (i.e., age of the participants, gender) or intervention characteristics (i.e., setting, practitioners involved, model of delivery, theoretical approach, level of service delivery and use of software). This may, in part, be due to an uneven number of effect sizes across comparison groups and inconsistent reporting of the pertinent participant and intervention characteristics. In a previous meta-analysis (Law et al., 2004) on expressive phonology outcomes, findings showed that effect sizes increased when parent-implemented interventions and interventions lasting less than 8 weeks were removed. In the current meta-analyses, no parent-implemented interventions were included. Nor were dosage effects examined, because they were the focus of two independent reviews of COST Action IS1406.

In summary, our review suggests that interventions tend to obtain improvements in children with phonological difficulties. However, the use of numerous techniques and procedures, insufficient data and a lack of study replication make it difficult to determine if any single intervention approach is more effective than another or more suited to specific groups of children with phonological difficulties.

Strengths and limitations of the review

The strengths of the current systematic review and meta-analysis are the wide age range of participants and the inclusion of group design studies alone. Although most of the included studies focused on pre-schoolers and children in middle childhood, school-age children and adolescents were also involved. While we know that phonological difficulties appear to be resolved for most children by the age of 8–9 years (Shriberg, 2010; Wren et al., 2012), they may sometimes persist into adolescence or even adulthood affecting 1%–2% of young adults (Flipsen, 2015). This places them at risk of poor academic achievement (Eadie et al., 2015; Lewis et al., 2015). Because the current review concentrated on group design studies, we were able to combine the numerical results of studies, and thus use a meta-analytic approach. Meta-analysis allowed us to statistically combine the results of studies and produce a more precise estimate of the effect of interventions. However, systematic reviews on single-case designs are also needed to provide a rich and in-depth understanding of intervention effects.

While the results of the current systematic review and meta-analysis clearly indicate that the overall effects of interventions targeting phonology outcomes were positive, there are several limitations to this review and meta-analysis. Although the 'grey' literature (e.g., dissertations and conference papers) may make various positive contributions to systematic reviews, we decided to restrict the scope of this review to published peer-reviewed literature. We took this decision because the grey literature may add a publication bias to the findings (Adams et al., 2017), and because we wanted to include the studies that were most likely to be of high quality by virtue of being published, thus enabling us to answer our research questions robustly. Because the current review was part of a larger piece of work (i.e., COST Action IS1406 focusing on interventions for children with difficulties learning their first language), the search terms common for all COST Action reviews with different foci were used. Thus, no SSD-related search terms were included. However, the authors ensured that the literature search also captured SSD-related studies by using hand searches and citation chaining to identify any potentially relevant studies. In addition, while the authors aimed to include literature published in languages other than English, there was no capacity in this review process to extract data from papers in languages other than English. Finally, some methodological limitations should be considered when interpreting the results of this meta-analysis. Five out of six studies had sample sizes of fewer than 25 participants. In addition to the small sample sizes, our meta-analysis included a total of only seven studies that reported nine effect sizes. The small number of studies led to a lack of variability in data and difficulty in detecting potential significant moderator variables. These limitations restrict the findings' generalisability.

Implications for practice

The present study highlights the need to systematically implement and replicate different intervention procedures to understand factors that will maximise positive outcomes and to grow the evidence base for best practice. Since the individual characteristics of the children (e.g., age, motivation, type, and severity of phonological disorder) may predict the response to an intervention, it is also important to study these characteristics to facilitate clinical decision making about which children are most suitable for certain kinds of intervention. In addition, more high-quality comparative studies are needed to verify the effectiveness of different intervention approaches targeting phonology and to guide clinical decision making. In the future, a thorough investigation of the ingredients of interventions will be needed to identify the active ingredients that are likely to lead to good outcomes.

The data-extraction process revealed that many studies reported incomplete data regarding participant characteristics, ingredients of intervention and fidelity measures used in the interventions, for example. This calls for common reporting guidelines for intervention research to enable data pooling and meta-analysis to examine the potential effects of moderating variables on intervention effectiveness, and to enable practitioners to consider the applicability of findings to clinical caseloads (see Frizelle et al., 2022).

CONCLUSIONS

Overall, the review and our meta-analysis summarise the intervention evidence from a substantial body of literature and indicate positive outcomes from a range of interventions with phonological outcomes in children and adolescents with speech and language difficulties. However, none of the potential moderator variables studied yielded a statistically significant influence on the effect size. Although no publication bias was detected, the conclusions must be considered in the context of the limitations of this meta-analysis and the limitations of the individual studies.

ACKNOWLEDGEMENTS

The systematic review was part of the work of the Cost Action IS1406 network entitled Enhancing Children's Oral Language Skills Across Europe and Beyond—A Collaboration Focusing on Interventions for Children with Difficulties Learning Their First Language. The network was supported by COST (European Cooperation in Science and Technology), funded by the European Union (Grant COST 106/14). This work was also supported in part by the Chilean national projects FONDECYT Regular 2019, Government of Chile, Chile [1190945], the Operational Program ERDF Andalusia 2014–2020, Government of Andalusia, Spain [US-1263096], the grant PID2020-115486GB-I00 funded by MCIN/AEI/ 10.13039/501100011033, and by the *Fundação para a Ciência e a Tecnologia* (FCT, Foundation for Science and Technology), grant UIDB/00214/2020.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data are available as Supplementary Material.

ORCID

Sari Kunnari https://orcid.org/0000-0001-5290-4851
Dina Caetano Alves https://orcid.org/0000-0002-7672-5898
Kakia Petinou https://orcid.org/0000-0001-6580-5190
Pauline Frizelle https://orcid.org/0000-0002-9715-3788
Carol-Anne Murphy https://orcid.org/0000-0002-9356-4045
Marja Laasonen https://orcid.org/0000-0002-4628-4251

REFERENCES

Adams, R.J., Smart, P. & Huff, A.S. (2017) Shades of grey: guidelines for working with the grey literature in systematic reviews for management and organizational studies. *International Journal of Management Reviews*, 19, 432–454. https://doi.org/10.1111/ijmr.12102

Allen, M. (2013) Intervention efficacy and intensity for children with speech sound disorder. *Journal of Speech, Language, and Hearing Research*, 56, 865–877. https://doi.org/10.1044/1092-4388(2012/11-0076)

Baker, E. & McLeod, S. (2011) Evidence-based practice for children with speech sound disorders: part 1 narrative review. *Language, Speech, and Hearing Services in Schools*, 42(2), 102–139. https://doi.org/10.1044/0161-1461(2010/09-0075)

Ballard, K.J., Wambaugh, J.L., Duffy, J.R., Layfield, C., Maas, E., Mauszycki, S. & McNeil, M.R. (2015) Treatment for acquired apraxia of speech: a systematic review of intervention research between 2004 and 2012. *American Journal of Speech-Language Pathology*, 24, 316–337. https://doi.org/10.1044/2015_AJSLP-14-0118

Bishop, D.V.M. (2017) Why is it so hard to reach agreement on terminology? The case of developmental language disorder (DLD). *International Journal of Language & Communication Disorders*, 52(6), 671–680. https://doi.org/10.1111/14606984.12335

Bishop, D.V.M., Snowling, M.J., Thompson, P.A., Greenhalgh, T., & the CATALISE-2 consortium (2017) Phase 2 of CATALISE: a multinational and multidisciplinary Delphi consensus study of problems with language development: terminology. *Journal of Child Psychology and Psychiatry*, 58, 1068–1080. https://doi.org/10.1111/jcpp.12721

Borenstein, M. (2019) *Common mistakes in meta-analysis and how to avoid them*. Englewood: Biostat.

Borenstein, M., Hedges, L.V., Higgins, J.P.T. & Rothstein, H.R. (2009) *Introduction to meta-analysis*. Chichester: Wiley.

Broomfield, J. & Dodd, B. (2004) Children with speech and language disability: caseload characteristics. *International journal of language & communication disorders*, 39, 303–324. https://doi.org/10.1080/13682820310001625589

Cabbage, K.L. & DeVeney, S.L. (2020) Treatment approach considerations for children with speech sound disorders in school-based settings. *Topics in Language & Communication Disorders*, 40(4), 312–325. https://doi.org/10.1097/TLD.0000000000000229

Catt, M., Neeley, R.A. & Lovins, S. (2011) The real (relevant, exciting, applicable lessons) project: thematic language intervention. *Education*, 131(3), 587–599.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*, 2nd edition, Hillsdale: Lawrence Earlbaum Associates.

Crowe, K., Cuervo, S., Guiberson, M. & Washington, K.N. (2021) A systematic review of interventions for multilingual preschoolers with speech and language difficulties. *Journal of Speech, Language, and Hearing Research*, 64, 4413–4438. https://doi.org/10.1044/2021_JSLHR-21-00073

Dodd, B. (2014) Differential diagnosis of pediatric speech sound disorder. *Current Developmental Disorders Reports*, 1, 189–196. https://doi.org/10.1007/s40474-014-0017-3

Dodd, B., Crosbie, S., Mcintosh, B., Holm, A., Harvey, C., Liddy, M., Fontyne, K., Pinchin, B. & Rigby, H. (2008) The impact of selecting different contrasts in phonological therapy. *International Journal of Speech–Language Pathology*, 10, 334–345. https://doi.org/10.1080/14417040701732590

Eadie, P., Morgan, A., Ukoumunne, O.C., Ttofari Eecen, K., Wake, M. & Reilly, S. (2015) Speech sound disorder at 4 years: prevalence, comorbidities, and predictors in a community cohort of children. *Developmental Medicine and Child Neurology*, 57, 578–584. https://doi.org/10.1111/dmcn.12635

Ebbels, S.H., Wright, L., Brockbank, S., Godfrey, C., Harris, C., Leniston, H., Neary, K., Nicoll, H., Nicoll, L., Scott, J. & Marić, N. (2017) Effectiveness of 1:1 speech and language therapy for older children with (developmental) language disorder. *International Journal of Language and Communication Disorders*, 52(4), 528–539. https://doi.org/10.1111/1460-6984.12297

Fabiano-Smith, L., & Hoffman, K. (2018) Diagnostic accuracy of traditional measures of phonological ability for bilingual preschoolers and kindergarteners. *Language, Speech, and Hearing Services in Schools*, 49(1), 121–134. https://doi.org/10.1044/2017_LSHSS-17-0043

Farquharson, K., Tambyraja, S. R., & Justice, L. M. (2020) Contributions to gain in speech sound production accuracy for children with speech sound disorders: Exploring child and therapy factors. *Language, Speech, and Hearing Services in Schools*, 51(2), 457–468. https://doi.org/10.1044/2019_LSHSS-19-00079

Fey, M.E., Finestack, L.H., Gajewski, B.J., Popescu, M. & Lewine, J.D. (2010) A preliminary evaluation of Fast ForWord-Language as an adjuvant treatment in language intervention. *Journal of Speech, Language, and Hearing Research*, 53(2), 430–449. https://doi.org/10.1044/1092-4388(2009/08-0225)

Flipsen, P. (2015) Emergence and prevalence of persistent and residual speech errors. *Seminars in Speech and Language*, 36, 217–223. https://doi.org/10.1055/s-0035-1562905

Frizelle, P., McKean, C., Eadie, P., Ebbels, S., Firicke, S., Justice, L.M., Kunnari, S., Leitão, S., Morgan, A.T., Munro, N., Murphy, C.A., Storkel, H.L. & Owen Van Horne, A. (2022) Editorial Perspective: maximising the benefits of intervention research for children and young people with developmental language disorder (DLD)—a call for international consensus on standards of reporting in intervention studies for children with and at risk for DLD. *Journal of Child Psychology and Psychiatry*,64, 474–479. https://doi.org/10.1111/jcpp.13694

Frizelle, P., Tolonen, A.-K., Tulip, J., Murphy, C.A., Saldana, D. & McKean, C. (2021a) The influence of quantitative intervention dosage on oral language outcomes for children with developmental language disorder: a systematic review and narrative synthesis. *Language, Speech, and Hearing Services in Schools*, 52(2), 738–754. https://doi.org/10.1044/2020_LSHSS-20-00058

Frizelle, P., Tolonen, A.-K., Tulip, J., Murphy, C.A., Saldana, D. & Mckean, C. (2021b) The impact of intervention dose form on oral language outcomes for children with developmental language disorder. *Journal of Speech, Language, and Hearing Research*, 64, 3253–3288. https://doi.org/10.1044/2021_JSLHR-20-00734

Gabel, R., Grogan-Johnson, S., Alvares, R., Bechstein, L. & Taylor, J. (2013) A field study of telepractice for school intervention using the ASHA NOMS K-12 database. *Communication Disorders Quarterly*, 35(1), 44–53. https://doi.org/10.1177/1525740113503035

Gierut, J.A., Morrisette, M.L. & Ziemer, S.M. (2010) Nonwords and generalization in children with phonological disorders. *American Journal of Speech-Language Pathology*, 19(2), 167–177. https://doi.org/10.1044/1058-0360(2009/09-0020)

Gordon, K. R., Storkel, H. L., Lowry, S. L., & Ohlmann, N. B. (2021) Word learning by preschool-age children with developmental language disorder: impaired encoding and robust consolidation during slow mapping. *Journal of Speech, Language, and Hearing Research*, 64(11), 4250–4270. https://doi.org/10.1044/2021_JSLHR-21-00046

Hegarty, N., Titterington, J. Mcleod, S. & Taggard, L. (2018) Intervention for children with phonological impairment: knowledge, practices and intervention intensity in the UK. *International Journal of Language and Communication Disorders*, 53, 995–1006. https://doi.org/10.1111/1460-6984.12416

Heikkilä, J., Lonka, E., Meronen, A., Tuovinen, S., Eronen, R., Leppänen, P.H., Richardson, U., Ahonen, T. & Tiippana, K. (2018) The effect of audiovisual speech training on the phonological skills of children with specific language impairment (SLI). *Child Language Teaching and Therapy*, 34(3), 269–287. https://doi.org/10.1177/0265659018793697

Higgins, J.P.T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M.J. & Welch, V.A., (2017) Cochrane Handbook for Systematic Reviews of Interventions version 5.2 (updated June 2017) Cochrane, 2017. Available from: https://www.training.cochrane.org/handbook [Assessed 4th October 2022].

Jesus, L.M.T., Martinez, J., Santos, J., Hall, A. & Joffe, V. (2019) Comparing traditional and tablet-based intervention for children with speech sound disorders: a randomized controlled trial. *Journal of Speech, Language, and Hearing Research*, 62, 4045–4061. https://doi.org/10.1044/2019_JSLHR-S-18-0301

Joffe, V. & Pring, T. (2008) Children with phonological problems: a survey of clinical practice. *International Journal of Language and Communication Disorders*, 43, 154–164. https://doi.org/10.1080/13682820701660259

Kunnari, S., Laasonen, M., Alves, D., Petinou, K., Ozbič, M., Zajdó, K., Tolonen, A-K., Murphy, C. A., Saldana, D. (2017) Interventions for children with primary language impairment: a COST Action IS1406 systematic review of the evidence for interventions targeting phonology. *National Institute for Health and Care Research*. https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42017076075

Lancaster, G., Keusch, S., Levin, A., Pring, T. & Martin, S. (2010) Treating children with phonological problems: does an eclectic approach to therapy work? *International Journal of Language & Communication Disorders*, 45(2), 174–181. https://doi.org/10.3109/13682820902818888

Law, J., Garrett, Z. & Nye, C. (2004) The efficacy of treatment for children with developmental speech and language delay/disorder: a meta-analysis. *Journal of Speech, Language, and Hearing Research*, 47, 924–943. https://doi.org/10.1044/1092-4388(2004/069

Law, J., Lee, W., Roulstone, S., Wren, Y. & Zeng, B. (2012) *'What works': Interventions for children and young people with speech, language and communication needs*. Department for Education Research Report DFERR-247-BCRP10. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/556912/DFE-RR247-BCRP10.pdf [Assessed 4th October 2022].

Law, J., McKean, C. & Murphy, C.-A., & Thordardottir, E. (Eds.) (2019) *Managing children with developmental language disorder: theory and practice across Europe and beyond*. Abingdon: Routledge.

Law, J., Roulstone, S. & Lindsay, G. (2015) Integrating external evidence of intervention effectiveness with both practice and the parent perspective: development of 'What Works' for speech, language, and communication needs. *Developmental Medicine and Child Neurology*, 57, 223–228. https://doi.org/10.1111/dmcn.12630

Law, J., Rush, R., Schoon, I. & Parsons, S. (2009) Modelling developmental language difficulties from school entry into adulthood: literacy, mental health and employment outcomes. *Journal of Speech, Language and Hearing Research*, 52(6), 1401–1416. https://doi.org/10.1044/1092-4388(2009/08-0142)

Lee, A.S.Y. & Gibbon, F.E. (2015) Non-speech oral motor treatment for children with developmental speech sound disorders. *Cochrane Database of Systematic Reviews*, 3, Article No. CD009383. Available from: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD009383.pub2/pdf [Assessed 4th October 2022].

Lewis, B., Freebairn, L., Tag, J. & Taylor, H. (2015) Adolescent outcomes of children with early SSD with and without language impairment. *American Journal of Speech Language Pathology*, 24(2), 150–163. https://doi.org/10.1044/2014_AJSLP-14-0075

Lourenço, I., Rocha, J., Peixoto, V. & Lousada, M. (2020) Effects of the narrative intervention program for preschool Portuguese children. *Folia Phoniatrica et Logopaedica*, 72(3), 211–217. https://doi.org/10.1159/000496793

Lousada, M., Jesus, L.M.T., Capelas, S., Margaca, C., Simoes, D., Valente, A., Hall, A. & Joffe, V. (2013) Phonological and articulation treatment approaches in Portuguese children with speech and language impairments: a randomized controlled intervention study. *International Journal of Language and Communication Disorders*, 48, 172–187. https://doi.org/10.1111/j.1460-6984.2012.00191.x

McCauley, R.J., Strand, E., Lof, G.L., Schooling, T. & Frymark, T. (2009) Evidence-based systematic review: effects of nonspeech oral motor exercises on speech. *American Journal of Speech-Language Pathology*, 18(4), 343–360. https://doi.org/10.1044/1058-0360(2009/09-0006)

McKean, C., Reilly, S., Bavin, E.L., Bretherton, L., Cini, E., Conway, L., Cook, F., Eadie, P., Prior, M., Wake, M. & Mensah, F. (2017) Language outcomes at 7 years: early predictors and Co-Occurring difficulties. *Pediatrics*, 139, e20161684. https://doi.org/10.1542/peds.2016-1684

McLeod, S. & Baker, L. (2014) Speech-language pathologists' practices regarding assessment, analysis, target selection, intervention, and service delivery for children with speech sound disorders. *Clinical Linguistics & Phonetics*, 28, 508–531. https://doi.org/10.3109/02699206.2014.926994

McLeod, S. & Baker, L. (2017) *Children's speech: an evidence-based approach to assessment and intervention*. Boston: Pearson.

McLeod, S., Davis, E., Rohr, K., McGill, N., Miller, K., Roberts, A., Thornton, S., Ahio, N. & Ivory, N. (2020) Waiting for speech-language pathology services: a randomised controlled trial comparing therapy, advice. and device. *International Journal of Speech-Language Pathology*, 22(3), 372–386. https://doi.org/10.1080/17549507.2020.1731600

McLeod, S. & Harrison, L. (2009) Epidemiology of speech and language impairment in a nationally representative sample of 4- to 5-year-old children. *Journal of Speech, Language and Hearing Research*, 52, 1213–1229. https://doi.org/10.1044/1092-4388(2009/08-0085)

Mecrow, C., Beckwith, J. & Klee, T. (2010) An exploratory trial of the effectiveness of an enhanced consultative approach to delivering speech and language intervention in schools. *International Journal of Language & Communication Disorders*, 45(3), 354–367. https://doi.org/10.3109/13682820903040268

Morgan, A.T., Murray, E. & Liégeois, F.J. (2018) Interventions for childhood apraxia of speech. *Cochrane Database of Systematic Reviews*, 5. Art. No.: CD006278. https://doi.org/10.1002/14651858.CD006278.pub3

Mullen, R. & Schooling, T. (2010) The national outcomes measurement system for pediatric speech-language pathology. *Language, Speech, and Hearing Services in Schools*, 41, 44–60. https://doi.org/10.1044/0161-1461(2009/08-0051)

Murphy, C.B., Peres, A.K., Zachi, E.C., Ventura, D.F., Pagan-Neves, L., Wertzner, H.F. & Schochat, E. (2015) Generalization of sensory auditory learning to top-down skills in a randomized controlled trial. *Journal of the American Academy of Audiology*, 26(1), 19–29. http://doi.org/10.3766/jaaa.26.1.3

Murray, E., McCabe, P. & Ballard, K.J. (2014) A systematic review of treatment outcomes for children with childhood apraxia of speech. *American Journal of Speech-Language Pathology*, 23(3), 486–504. http://doi.org/10.1044/2014_AJSLP-13-0035

Norbury, C.F., Gooch, D., Wray, C., Baird, G., Charman, T., Simonoff, E., Vamvakas, G. & Pickles, A. (2016) The impact of nonverbal ability on prevalence and clinical presentation of language disorder: evidence from a population study. *Journal of Child Psychology and Psychiatry*, 57, 1247–1257. https://doi.org/10.1111/jcpp.12573

Özcebe, E., Erbas, A.N., Tirank, S.B. & Gunduz, B. (2021) Turkish stimulability treatment program for children with speech sound disorders: a preliminary study. *Logopedics Phoniatrics Vocology*, 46(2), 63–69. https://doi.org/10.1080/14015439.2020.1740317

Page, M.J., Mckenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P. & Moher, D. (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *British Medical Journal*, 372, 71. https://doi.org/10.1136/bmj.n71

Rodgers, L., Botting, N., Cartwright, M., Harding, S., & Herman, R. (2023) Shared characteristics of intervention techniques for oral vocabulary and speech comprehensibility in preschool children with co-occurring features of developmental language disorder and a phonological speech sound disorder: protocol for a systematic review with narrative synthesis. *BMJ open*, 13(6), e071262.

Rodgers, L., Harding, S., Rees, R. & Clarke, M.T. (2022) Interventions for pre-school children with co-occurring phonological speech sound disorder and expressive language difficulties: a scoping review. *International Journal of Language and Communication Disorders*, 57, 700–716. https://doi.org/10.1111/1460-6984.12719

Rvachew, S. & Brosseau-Lapré, F. (2015) A randomized trial of twelve-week interventions for the treatment of developmental phonological disorder in Francophone children. *American Journal of Speech-Language Pathology*, 24, 637–658. https://doi.org/10.1044/2015_AJSLP-14-0056

Rvachew, S. & Brosseau-Lapré, F. (2018) *Developmental Phonological Disorders: Foundations of Clinical Practice*, 2nd edition, San Diego: Plural Publishing, Inc.

Shriberg, L.D. (2010) Childhood speech sound disorders: from post-behaviorism to the post genomic era. In: Paul , R. & Flipsen, P. (Eds.) *Speech sound disorders in children*. San Diego: Plural Pub, pp. 1–33.

Siemons-Lühring, D. I., Euler, H. A., Mathmann, P., Suchan, B., & Neumann, K. (2021) The effectiveness of an integrated treatment for functional speech sound disorders—A randomized controlled trial. *Children*, 8(12), 1190. https://doi.org/10.3390/children8121190

Stringer, H., Cleland, J., Wren, Y., Rees, R. & Williams, P. (2023) Speech sound disorder or DLD (phonology)? Towards a consensus agreement on terminology. *International Journal of Language & Communication Disorders*. https://doi.org/10.1111/1460-6984.12989

Sutherland, D. & Gillon, G.T. (2007) Development of phonological representations and phonological awareness in children with speech impairment. *International Journal of Language & Communication Disorders*, 42, 229–250. https://doi.org/10.1080/13682820600806672

Tomblin, J.B., Records, N.L., Buckwalter, P., Zhang, X., Smith, E. & O'brien, M. (1997) Prevalence of specific language impairment in kindergarten children. *Journal of Speech, Language, and Hearing Research*, 40, 1245–1260. https://doi.org/10.1044/jslhr.4006.1245

Tyler, A. A., Gillon, G., Macrae, T., & Johnson, R. L. (2011) Direct and indirect effects of stimulating phoneme awareness vs. other linguistic skills in preschoolers with co-occurring speech and language impairments. *Topics in Language Disorders*, 31(2), 128–144. https://doi.org/10.1097/TLD.0b013e318217d473

Tyler, A.A., Williams, M.J. & Lewis, K.E. (2006) Error consistency and the evaluation of treatment outcomes. *Clinical Linguistics & Phonetics*, 20(6), 411–422. https://doi.org/10.1080/02699200500097769

Waring, R. & Knight, R. (2013) How should children with speech sound disorders be classified? A review and critical evaluation of current classification systems. *International Journal of Language and Communication Disorders*, 48(1), 25–40. https://doi.org/10.1111/j.1460-6984.2012.00195.x

Wren, Y., Harding, S., Goldbart, J. & Roulstone, S. (2018) A systematic review and classification of interventions for speech-sound disorder in preschool children. *International Journal of Language and Communication Disorders*, 53, 446–467. https://doi.org/10.1111/1460-6984.12371

Wren, Y. & Roulstone, S. (2008) A comparison between computer and tabletop delivery of phonology therapy. *International Journal of Speech–Language Pathology*, 10(5), 346–363. https://doi.org/10.1080/17549500701873920

Wren, Y., Roulstone, S. & Miller, L.L. (2012) Distinguishing groups of children with persistent speech disorder: findings from a prospective population study. *Logopedics Phoniatrics Vocology*, 37(1), 1–10. https://doi.org/10.3109/14015439.2011.625973

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Kunnari, S., Sanduvete-Chaves, S., Chacon-Moscoso, S., Alves, D.C., Ozbič, M., Petinou, K. et al. (2024) Intervention studies with group design targeting expressive phonology for children with developmental speech and language disorder: A systematic review and meta-analysis. *International Journal of Language & Communication Disorders*, 1–20. https://doi.org/10.1111/1460-6984.13110