

RESEARCH ARTICLE

Speech sound skills, language comprehension, and early reading development in poor readers

Line Walquist-Sørli¹ , Monica Melby-Lervåg^{1,2}, Oddgeir Friborg³ and Trude Nergård-Nilssen¹

¹Department of Education, UiT The Arctic University of Norway, Tromsø, Norway; ²Department of Special Needs Education, University of Oslo, Oslo, Norway and ³Faculty of Health Sciences, Department of Psychology, UiT The Arctic University of Norway, Tromsø, Norway

Corresponding author: Line Walquist-Sørli; Email: line.w.sorli@uit.no

(Received 28 March 2025; revised 06 September 2025; accepted 12 September 2025)

Abstract

This retrospective study investigates two questions: (a) whether speech sound difficulties, reported by parents looking back on their children's early speech sound skills and concurrently at ages 7–8, can predict language comprehension and early reading challenges in children identified as poor readers and (b) whether there is a relationship between the type of speech errors and language comprehension and early reading skills in these children. Two hundred twenty-eight children identified as poor readers were assessed on reading and language comprehension. The findings revealed that children whose parents reported early speech sound difficulties, and those with speech sound difficulties at ages 7–8, had significantly poorer language comprehension compared to children without a history of speech sound difficulties. This difference in language comprehension skills persisted after controlling for phoneme awareness. Additionally, both delayed and disordered speech errors significantly predicted difficulties in language comprehension compared to children without speech sound difficulties.

Keywords: speech sound difficulties; language comprehension; early reading

Abstract (Norwegian)

Denne studien undersøker (a) om språklydsvansker, rapportert av foreldre både retrospektivt fra tidlig barndom og ved 7–8 års alder, kan forutsi betydelige utfordringer i språk- og leseferdigheter hos barn identifisert som svake lesere, og (b) om det finnes en sammenheng mellom type språklydsfeil og språk- og leseferdigheter hos disse barna. Barna ($n = 228$) ble testet i lesing og språkferdigheter ved 7–8 års alder, og resultatene viste signifikant lavere språkferdigheter hos barn med tidlige språklydsvansker og de med språklydsvansker ved 7–8 år, sammenlignet med barn uten språklydsvansker. Gruppeforskjellene i språkferdighetene var fortsatt til stede etter fonembevissthet ble kontrollert for. Både forsinkede og atypiske språklydsmønstre predikerte vansker i språk, selv etter fonembevissthet ble kontrollert for.

1. Speech sound skills, language, and early reading development in poor readers

Research has found that many parents worry when their preschool children struggle to pronounce sounds in words correctly (de Simoni *et al.*, 2019; McAllister *et al.*, 2011). This is perhaps why speech sound difficulties is one of the main reasons for referral to educational psychology clinics and speech and language therapy (Eadie *et al.*, 2015). A prior meta-analysis investigating group differences in language comprehension and reading between children with and without speech sound difficulties found that these difficulties can be a risk marker for challenges in language comprehension and reading (Walquist-Sørli *et al.*, 2024). Furthermore, the meta-analysis revealed a moderate longitudinal relationship between early speech sound skills and reading-related skills, such as decoding, in school-age children (Walquist-Sørli *et al.*, 2024).

However, little is known about how parent-reported speech sound skills in preschool children identified as poor readers predict language comprehension and the severity of reading problems. Additionally, it is unclear when speech sound difficulties for these children persist into school age and whether the specific nature of their speech errors significantly predicts language comprehension and literacy development. Therefore, this study aims to determine whether parent-reported speech sound difficulties, both concurrent and retrospective, can identify children at higher risk for severe language comprehension and reading problems. Such findings underscore the importance of considering parental concerns in assessing preschool children's language development. As a retrospective study, this paper sheds light on the long-term impact of early speech sound difficulties, offering a distinct perspective on the progression of language comprehension and early reading skills.

1.1. Characteristics of speech sound difficulties

Speech sound difficulties encompass a broad range of challenges related to speech perception, speech sound discrimination, and speech production. They are considered an umbrella term for a heterogeneous group of children, depending on the underlying mechanisms of the disorder (Dodd, 2014). In this study, we use the term “speech sound difficulties” rather than “speech sound disorders” because of the inclusion criteria (through parental questionnaires) and a formal diagnosis of SSD was not required. Children with speech sound difficulties differ in “severity, etiology, type of errors made, consistency, chance of spontaneous resolution, profile of associated abilities, and response to therapy” (Dodd *et al.*, 2024, p. 7). The *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* defines speech sound disorders (SSD) as persistent unintelligible speech that interferes with social participation, occupational performance, or academic achievement, manifesting in early childhood and not attributable to another medical or neurological condition (American Psychological Association, 2013).

For some children, the cause of speech sound difficulties can be explained by, for example, cleft palate, genetic conditions such as Down syndrome, hearing loss, or cerebral palsy. However, most children struggling with pronouncing speech sounds correctly have phonological speech sound difficulties, where the cause is unknown (Williams *et al.*, 2010). The meta-analysis of Walquist-Sørli *et al.* (2024) comparing children with and without speech sound difficulties in language comprehension and reading skills demonstrated that most studies in the field consist of children with unknown causes of speech sound difficulties.

1.2. Speech sound difficulties: possible mechanisms behind language comprehension and reading problems in children

A number of studies have shown that those with speech sound difficulties have a higher risk of language comprehension and reading difficulties than peers without such problems, both concurrently and longitudinally (Burgoyne et al., 2019; Hayiou-Thomas et al., 2017; Nathan et al., 2004; Walquist-Sørli et al., 2024). The meta-analysis mentioned earlier (Walquist-Sørli et al., 2024) found moderate concurrent group differences in language comprehension skills ($g = 0.60$, number of studies, $k = 37$) and reading skills ($g = 0.58$, $k = 17$). However, importantly, there was also a longitudinal relationship in which children with preschool speech sound difficulties showed moderate to large group differences in language comprehension ($g = 0.85$, $k = 6$) and reading skills ($g = 0.50$, $k = 8$) when they were, on average, 11 years old. Still, there was a large variation in the magnitude of the relationship between the studies (I^2 between 63% and 98%). Concurrently, phonological awareness was a particularly important moderator in explaining this variation. Longitudinally, there were not enough studies to perform moderator analyses.

1.2.1. Speech sound difficulties and language comprehension difficulties

Reading is the product of decoding and linguistic comprehension (Gough & Tunmer, 1986). According to the simple view of reading, a reading model, some children may decode a text well but have limited comprehension due to language comprehension difficulties (Snowling & Hulme, 2021). Language comprehension refers to the capacity to understand and produce utterances, including vocabulary, listening comprehension, syntax, and morphology (Lervåg et al., 2018). These aspects of language comprehension are highly correlated and are usually well accounted for by a single latent variable (Bornstein et al., 2016). Research on children diagnosed with developmental disorders indicates that nearly 50% of children with developmental language difficulties also exhibit comorbid speech sound difficulties (Snowling & Hulme, 2012). Additionally, a community-based study identified that 40.8% of children with speech sound difficulties also present with co-occurring language difficulties (Eadie et al., 2015). A correlational study of typically developing children aged five years (Burgoyne et al., 2019; $n = 569$) found that speech sound difficulties at school entry are associated with poorer language comprehension skills. In addition, these differences between the children with and without speech sound difficulties in language comprehension at age five remained evident six months later.

As for the mechanisms behind the relationship, it has been suggested that pronouncing words provides a particularly strong learning experience in contrast to just being exposed to those words (Hopman & MacDonald, 2018). Thus, having speech sound difficulties might lead to missing out on this learning experience since these children might be more reluctant to speak and might not get the same learning experience because they do not pronounce the words correctly. There is some evidence for this explanation. In one study ($n = 125$), the participants, undergraduates, were randomly divided into two groups when they were learning a new language. One group was trained in using production and expressive language, while the other group was trained using receptive language (Hopman & MacDonald, 2018). The results showed that the group receiving expressive production training outperformed the group receiving receptive language training in both vocabulary and grammar, even after controlling for individual differences in vocabulary learning (Hopman & MacDonald, 2018). Another study, by (XXX et al.,

in press), looking into the relationship between early speech sound skills, early language comprehension skills, and the development of different aspects of language in a group of typical development children ($n = 215$) using bi-factor structural equation modeling (SEM) found that speech sound skills at ages four to five predicted the development of expressive language skills in school age (ages 7 to 9). In addition, the components shared between early speech sound skills and language comprehension predicted the development of receptive language and reading comprehension.

1.2.2. *Speech sound difficulties and reading difficulties*

Numerous studies have found an association between speech sound difficulties and reading difficulties (Bishop & Adams, 1990; Hayiou-Thomas *et al.*, 2017; Nathan *et al.*, 2004; Peterson *et al.*, 2009; Raitano *et al.*, 2004; Walquist-Sørli *et al.*, 2024). Typically, phonological awareness refers to the mental representation of the phonological structure of language, including the manipulation of speech sounds and rhymes (Bishop & Snowling, 2004; Snowling & Hulme, 2021). Children with speech sound difficulties often exhibit deficits in phonological skills, like phonological awareness and phonological memory (simultaneously store and process verbal information) (e.g., Rvachew & Grawburg, 2006; Waring *et al.*, 2017), although not all children show similar deficits in these areas (Roepke *et al.*, 2020). Phonological awareness is foundational to both language comprehension and decoding skills (Hjetland *et al.*, 2019; Snowling & Hulme, 2021).

The relationship between phonological awareness and speech sound difficulties, as the link between language comprehension and reading problems, is strong. Several studies have concluded that children with a history of speech sound difficulties should be routinely screened for phonological awareness skills in order to provide early reading interventions (Burgoyne *et al.*, 2019; Walquist-Sørli *et al.*, 2024). Phonological awareness is a key moderator in the relationship between speech sound skills, language comprehension, and literacy, as demonstrated in the meta-analysis (Walquist-Sørli *et al.*, 2024). Still, research indicates that phonological awareness does not necessarily account for the entire relationship between speech sound skills and language comprehension (XXX *et al.*, *in press*). The study by XXX *et al.* (*in press*) found that speech sound skills at ages four to five predicted the development of expressive language skills at ages 7 to 9, even after accounting for phonological awareness. Based on the findings, the study suggests a plausible causal relationship where speech sound skills can influence language comprehension development.

A study by Tambyraja *et al.* (2020) investigated co-occurring reading difficulties in children with speech sound disorders who received school-based speech therapy ($n = 120$). It examined the extent to which phonological processing and speech production abilities were associated with an increased likelihood of reading risk. Descriptive results indicated that approximately 25% of children with speech sound difficulties had concurrent deficits in word decoding, and these decoding difficulties were likely to persist throughout the academic year (Tambyraja *et al.*, 2020). The study also revealed that phonological awareness and speech production ability were important indicators of subsequent reading problems, after accounting for children's age, language comprehension skills, and socioeconomic status (Tambyraja *et al.*, 2020).

Regarding the mechanisms behind this, it has been suggested that the relationship between speech sound skills, phonology, and reading can be explained by the segmentation theory (e.g., Boada & Pennington, 2006). This theory proposes that speech

processing is the foundation of phonological skills and word-reading ability. According to this theory, the increasing segmentation of speech sounds during speech development leads to more detailed phonological representations. This, in turn, leads to the development of phonological awareness and vocabulary growth. In line with this theory, difficulties with speech segmentation can impact phonological awareness, which can lead to difficulties in language comprehension and reading skills (Boada & Pennington, 2006). Another theory, output phonology theory (Hulme & Snowling, 1992), argues that deficits in speech production, output phonology, can lead to decoding (reading) and spelling (writing) problems. This theory posits that difficulties in producing speech sounds may disrupt the development of phonological representations, which are critical for decoding and spelling. Further development of this theory suggests that the relationship between speech sound difficulties and reading is mediated by phonological awareness (Brosseau-Lapr  & Roepke, 2019; Burgoyne et al., 2019). However, there is also evidence indicating that speech perception contributes to this issue (Benway et al., 2021), and impaired speech production might also reflect speech perception processes (input phonology).

Although speech sound difficulties are acknowledged as a risk factor for language comprehension and reading problems, not all children who struggle with pronouncing speech sounds correctly develop difficulties in these areas (Hayiou-Thomas et al., 2017; Lewis et al., 2000). Research has tested several possible moderators and risk factors for poor reading outcomes in children with speech sound difficulties, including low phonological skills, the persistence of speech sound difficulties into school age, and the characteristics of the speech errors made (e.g., Burgoyne et al., 2019; Hayiou-Thomas et al., 2017; Peterson et al., 2009).

1.3. Persistence of speech sound difficulties in school-age

The critical age hypothesis, introduced by Bishop and Adams (1990), posits that speech sound difficulties become a risk factor for reading problems if they persist into the age when children are learning to read. Several studies have supported this theory (Hayiou-Thomas et al., 2017; Raitano et al., 2004). Nevertheless, other studies have found a weaker association between speech sound difficulties at school entry and reading skills, as the relationship was attributed to co-occurring language difficulties (Nathan et al., 2004; Peterson et al., 2009). The longitudinal study by Nathan et al. (2004) found that children with co-occurring speech and language difficulties, rather than those with isolated speech sound difficulties, experienced problems in early literacy development. However, the study reported that children with isolated speech sound difficulties were not exempt from literacy challenges, particularly if their speech sound difficulties persisted into the school-age years. Thus, it is important to assess whether the persistence of speech sound difficulties in school-age children who are poor readers increases the likelihood of severe language comprehension and early decoding problems, as these skills form the foundation for developing reading comprehension (Gough & Tunmer, 1986; Hjetland et al., 2019).

1.4. The nature of speech errors as a possible risk factor

Categorizations of types of speech errors have been highlighted as an important factor for constructing speech interventions specifically adapted to the difficulty type in children (Dodd, 2014). There are different ways to classify and generate subgroups of speech sound

difficulties (Dodd, 2014; Stringer *et al.*, 2024; Waring & Knight, 2013). In a review of evidence concerning the classification of subgroups of SSD, three common groups were identified across three specific pediatric SSD classification systems: an articulation-based subgroup, a phonological subgroup, and a motor planning/programming group (Waring & Knight, 2013). Phonological-based speech sound difficulties is a cognitive-linguistic difficulty (McLeod & Masso, 2019) and is the most frequent subtype (Dodd *et al.*, 2018). Some children with phonological speech sound difficulties exhibit delayed developmental error patterns that persist beyond the expected developmental age, while others display an atypical error pattern characterized by disordered speech errors (Dodd, 2014; Dodd *et al.*, 2024; McLeod & Masso, 2019).

It should be noted, however, that further research is needed on the nature of the differences between subgroups (Waring & Knight, 2013). Although there are some studies on validating subgroups (Ttofari Eecen *et al.*, 2019), no study we know of has used latent profile analysis between subgroups for validation. Several standardized assessments of SSD differentiate phonological speech errors between delayed errors (e.g., prevocalic voicing, cluster reduction, and substitution of velar by alveolar sounds) and disordered/atypical errors (e.g., initial consonant deletion and backing of alveolars) (Dodd, 2014; Dodd *et al.*, 2002; McIntosh & Dodd, 2008; Sandø-Frank & Bjerkan, 2023). Since this is a convention in the field, we have also used this categorization here, despite the lack of validation studies of these categorizations.

When analyzing studies that provide different categorizations of speech sound difficulties and examine their association with language comprehension and reading outcomes, the number of studies is limited. However, previous studies have found that children with a history of disordered speech often exhibit more literacy difficulties at school age compared with those who have delayed speech errors or no speech sound difficulties (Leitão & Fletcher, 2004). A longitudinal study tracking children with early speech sound difficulties until they were eight years old found that children with disordered speech errors had poorer word reading skills than children with speech errors classified as delayed (Hayiou-Thomas *et al.*, 2017). Another longitudinal study found that atypical errors at 4 years predicted reduced speech, phonological awareness, and literacy skills at age 8 (Preston *et al.*, 2013).

Regarding explanations for why individuals with disordered speech errors experience more reading problems, the theory is that they have greater difficulties with phonological awareness skills (Dodd *et al.*, 2024; Leitão & Fletcher, 2004). Studies comparing children with speech errors classified as delayed and disordered speech have found that children with disordered speech errors have more difficulties with phonological awareness than those with delayed speech errors (Holm *et al.*, 2008; Leitão *et al.*, 1997).

1.5. The present study

We know that early speech sound difficulties of unknown origin can be a risk marker for difficulties in language comprehension and reading skills, both concurrently and longitudinally, and this relation is highly moderated by phonological awareness (Walquist-Sørli *et al.*, 2024). However, the relationship between speech sound skills in a sample of children with reading difficulties and the development of language comprehension and early reading remains unclear. Moreover, to the best of our knowledge, no studies have investigated whether parental reports of speech sound skills, both retrospective and concurrent, serve as a significant predictor of language comprehension and early reading

skills. Additionally, it has not been explored whether parental reports of speech sound difficulties can identify children with language comprehension difficulties alongside reading difficulties, or those with particularly severe reading difficulties within a sample of children identified as poor readers. Moreover, the relationship between the type of reported speech error and the risk of language comprehension and early reading difficulties in these children remains unclear. If parental-reported speech sound skills play a significant role in predicting the development of language comprehension and early reading skills, this study has two important implications. First, it provides crucial information for the early identification of at-risk children. Second, it underscores the importance of taking parental concerns seriously when determining which children should be referred to educational psychology clinics for the comprehensive screening of language and early reading skills.

The hypotheses of this study are as follows:

1. There is a retrospective relationship between children whose parents recall speech sound difficulties at ages 4–5 and language comprehension and reading outcomes at ages 7–8 within a group identified as poor readers. This relationship remains significant even after controlling for phoneme awareness skills.
2. Speech sound difficulties persisting into ages 7–8 predict subsequent reading and language comprehension outcomes in children identified as poor readers, with the relationship remaining significant after controlling for phoneme awareness skills and early speech sound skills.
3. At ages 7–8, disordered speech errors significantly predict language comprehension and reading compared to delayed speech errors or the absence of reported speech errors.

2. Method

2.1. Participants

The present study is a substudy of a larger reading intervention, a randomized controlled trial known as UiT-ReadWell, carried out in Northern Norway. The children were recruited through schools across three different municipalities, and the criterion for participation was scoring at or below the 20th percentile in one or more subtests of the national reading test in the first or second grade. Parents of these children were invited to complete a retrospective survey about their children's speech sound status before starting school (ages 4–5) and their current speech status. A total of 228 parents responded to the survey. Among these, 21.5% of parents expressed concern about their children's language development during the preschool years, and 16.2% reported that kindergarten teachers shared similar concerns regarding their children's speech or language development. When comparing our sample with a sample of typical developmental Norwegian children aged 7 (Hjetland et al., 2019) in decoding, it confirmed that our sample of children were poor readers (nonword A [TOWRE; Torgesen et al., 1999] Cohen's $d = -1.09$ and nonword B Cohen's $d = -1.13$). As part of the main project, all children underwent comprehensive testing of their language comprehension and reading skills before beginning the intervention at ages 7 (second grade) and 8 (third grade). Children in Norway begin formal reading instruction in the first grade, at the age of 6. This study utilizes these pretest data. The main study excluded children who had issues with hearing or vision, as well as those with more pervasive developmental disorders, such as autism spectrum

disorder. The parents gave informed consent for their children's participation and had the option to withdraw their consent at any time.

2.2. Measures

2.2.1. Speech sounds

The status of speech sounds was determined using a parent questionnaire, which was available online and divided into two parts. The questionnaire consisted of 36 items, with half focusing on the children's speech sound skills at ages 4–5 (retrospective) and the other half addressing their current speech sound status (See [S2](#) in [supplementary materials](#)). As for the validation of the questionnaire, the items were developed using prior research of subgroups of speech sound difficulties (Hayiou-Thomas *et al.*, 2017; Leitão & Fletcher, 2004), information from Differential Diagnostic Assessment for Speech Sound Disorders in Norwegian Children – Diffkas, normed on 407 Norwegian children (Sandø-Frank & Bjerkan, 2023) and items that addresses speech and speech sound skills from the Children's Communication Checklist (CCC-2) (Bishop, 2003), normed on 731 Norwegian children (Helland & Heimann, 2007). The reliability was $\alpha = 0.93$. The questions assessed the intelligibility of the child's speech and whether the child experienced difficulties with substitution and omission processes. Children were classified as having a history of speech sound difficulties if they had problems pronouncing one or more speech sounds into words according to the questionnaire. Ninety-six children (42.1%) were reported to have parent-reported speech sound difficulties at ages 4–5. The second part of the questionnaire was used to check for persistent difficulties with speech sounds at ages 7–8. Fifty children (20.9%) were reported to have persistent speech sound difficulties at this age. The groups of children with speech sound difficulties, both at ages 4–5 and 7–8, included children with both delayed and disordered speech sound errors. Furthermore, to answer the third research question, the 50 children with reported persistent speech sound difficulties (ages 7–8) were divided into two subgroups due to a Norwegian differential classification system of SSD (Diffkas) (Sandø-Frank & Bjerkan, 2023): delayed speech errors (one or more typical, but delayed, speech errors) ($n = 34$) and disordered speech errors (one or more atypical speech errors in their speech) ($n = 16$). Using parental questionnaires is considered an effective method for accurately representing a child's current developmental status (Ebert, 2017; Libertus *et al.*, 2015). This approach has also been employed to assess speech intelligibility in children (Jin *et al.*, 2020). Additionally, research has found that parent reports have good sensitivity and specificity in identifying children with speech and language difficulties (McAllister *et al.*, 2011; McLeod & Harrison, 2009).

At ages 7–8, children completed various measures that assessed different aspects of language comprehension and reading skills as part of a broader evaluation. The children were assessed at school by trained research assistants during the first semester in second or third grade, and the session lasted approximately one hour. The analyses in our study are based on unstandardized raw scores from the measures described below. The reliability score of each measure is reported in [Table 1](#).

2.2.2. Phoneme awareness

Phoneme awareness was measured using the “Change Sound” subtest from the Dyslexia Marker Test (Dysmate) (Nergård-Nilssen, 2024), a digital test standardized for Norwegian children. This subtest evaluates phoneme awareness and phonological processing

Table 1. Descriptive statistics

Variable	<i>N</i>	<i>M</i>	<i>SD</i>	<i>Item</i>	<i>Min</i>	<i>Max</i>	<i>Rel.α</i>
Parental questionnaire	228	44.21	13.45	34	34	34	0.93
CELF-4 grammatical structure	227	24.96	5.90	39	7	38	0.79
CELF-4 sentence repetition	228	21.76	7.06	18	0	45	0.83
WIAT expressive	227	2.78	1.77	15	0	9	0.91
WIAT word	227	10.31	2.67	16	2	16	0.89
WIAT sentence	227	6.31	1.61	10	1	10	0.59
WIAT focus word	220	16.85	7.43	26	0	26	0.91
DYSMATE word-chain	224	1.48	1.36	28	0	7	0.60
DYSMATE change sound	220	9.02	4.22	21	0	19	0.76

speed by asking the candidate to replace a specific sound in one word with another, thereby creating a new word. For example, the child might be instructed to replace the /b/ sound in the Norwegian word “bil” (car) with the /p/ sound, resulting in “pil” (arrow). The child has 10 seconds to select the correct answer. The test consists of 21 items and is discontinued after 5 consecutive wrong answers.

2.2.3. Language comprehension

Sentence repetition. This is a subtest from the Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF-4) (Semel et al., 2003). In “Sentence Repetition,” the child listens to a sentence read aloud and is then required to repeat the sentence accurately without altering its morphology. Each sentence progressively increases in length and complexity, with a total of 18 sentences. The scoring for each sentence is as follows: 3 points for no errors, 2 points for one error, 1 point for two to three errors, and 0 points for more than three errors. The test is terminated after four consecutive 0-point scores. The CELF-4 is normed on a sample of 600 Scandinavian children.

Grammatical structures. This is another subtest of CELF-4 (Semel et al., 2003). In “Grammatical Structures,” the child is presented with one or more pictures, and the test leader might say, “Here is a teddy bear,” while pointing to the picture of a teddy bear. Subsequently, the test leader points to the picture of two teddy bears and begins the sentence with, “Here are two...” The child is then expected to complete the sentence by saying, “Two teddy bears.” This subtest is designed to assess the child’s ability to a) use regular and irregular plurals, various tenses, and comparative forms, b) employ possessive pronouns, and c) understand receptive negations and the expression “neither/nor.” The test comprises 39 items, and the child is required to attempt all the items.

Expressive vocabulary. This is a component of the “Listening Comprehension” subtest from the Wechsler Individual Achievement Test, Fourth Edition (WIAT-4) (Wechsler, 2020). In this test, the child is presented with a single picture accompanied by a sentence that describes the picture. The child must identify a word that has the same meaning as the one depicted in the picture. Each correct answer is scored as 1 point, while an incorrect answer receives 0 points. The test comprises 15 items, and the administration is terminated after six consecutive incorrect responses.

Receptive vocabulary word. This is a component of the “Listening Comprehension” subtest from the WIAT-4 (Wechsler, 2020). In this test, the child is shown four pictures and presented with a single word. The child is expected to point to a picture that corresponds to the word. Each correct answer is scored as 1 point, while an incorrect answer receives 0 points. The test includes 16 items and is terminated after six consecutive incorrect responses.

Sentence comprehension. This is another component of the “Listening Comprehension” subtest from the WIAT-4 (Wechsler, 2020). In this part, the child is presented with a sentence and must identify the correct picture (from a set of four) that best represents the sentence. This test consists of 10 items, and the scoring and termination procedures are the same as those used for “Receptive Vocabulary.”

2.2.4. Early reading

Word chain. This measure is part of the Dysmate (Nergård-Nilssen, 2024) and serves as a silent reading assessment that measures rapid word recognition and orthographic knowledge. In this task, the child is asked to insert spaces between words that are written together in a continuous chain. Each chain comprises four random words. The child has four minutes to solve as many word chains as possible. One point is awarded for each correct answer (maximum 36 points).

Focus word. This is a measure from WIAT-4 (Wechsler, 2020). In “Focus Word,” the child reads a sentence aloud, and the test leader scores the highlighted focus words as either correct or incorrect, awarding one point for each correct focus word. There are 25 items, and each correct word is rewarded with one point (maximum 25 points). The child is required to attempt all the sentences.

3. Statistical analyses

All analyses were conducted using the SEM software Mplus version 8.9 (Muthén & Muthén, 2016). We first examined the measurement model fit using confirmatory factor analyses (CFA) of the latent variables representing the language comprehension and reading variables at ages 7–8 to decide which model should go into the full SEM. We considered three possible measurement models: 1) a simple uni-dimensional model accounting for all language comprehension and reading indicators, 2) a correlated two-factor model specifying a language comprehension and an early reading latent variable accounting for their respective indicators, and 3) a correlated three-factor model being the same as the second model, except splitting the first factor (language comprehension) into two further latent variables representing receptive and expressive language skills.

The full structural model specified the direct effects of early and current speech sound difficulties on the best-fitting measurement model representing the latent variables of language comprehension and early reading abilities. The speech sound variable was a dichotomous variable (0 = no speech sound difficulties or 1 = speech sound difficulties) registered at two time points: ages 4–5 and 7–8. These two variables were estimated as continuous to retain model fit indices (e.g., Root Mean Square Error of Approximation [RMSEA] and Comparative Fit Index [CFI]) since estimating them as categorical only provides information criteria (e.g., Akaike Information Criterion [AIC] or Bayesian Information Criterion [BIC]) as fit indices. Since the improvement in BIC was negligible (3.28) by estimating them as beta log-odds, the continuous parameters were preferred

(their odds ratios are nevertheless provided in [Figures 2–5](#) for interpretation purposes). The full SEM provides regression coefficients standardized for the outcome only, thus yielding a standardized mean group difference (equivalent to a Cohen's *d*) for the difference between children with and without speech sound difficulties. A Cohen's *d* of 0.2, 0.5, and 0.8 indicates a small, medium, and large effect size, respectively (Cohen, 2013).

Phoneme awareness was added for covariate adjustment. Since we only had access to a single observed sum score, we estimated its latent variance by multiplying the presumed latent error variance (1-reliability) with the observed sum score variance. Finally, we estimated two indirect (mediation) effects of early speech sound skills on the latent language comprehension and early reading variables going through the current level of speech sound skills. In addition, the size of the mediation effect was calculated by dividing the indirect effect by the total effect. Bias-corrected bootstrap 95% confidence intervals (CIs) are presented for all coefficients based on 2,000 bootstrap re-samplings.

All models were evaluated for model fit. A nonsignificant chi-square statistic is preferable, as it indicates a perfectly fitting model; however, since the chi-square index is associated with sample size (Bentler, 1990), and full SEM models include both measurement and structural coefficients that contribute to the deviance statistics, we also provide discrepancy and relative model fit criteria: RMSEA, Standardized Root Mean Square Residual (SRMR), CFI, and Tucker–Lewis Index (TLI). Model fit is normally considered good if CFI and TLI are greater than 0.95 and RMSEA is smaller or equal to 0.06 (Hu & Bentler, 1999). The size of the residual correlations may be considered, in addition, with SRMR being smaller than 0.08 as the minimum.

In a final analysis, we categorized children with persistent speech sound difficulties at ages 7–8 years into two groups: 1. Children with delayed speech errors (one or more typical but delayed phonological errors), 2. children with disordered speech (one or more atypical phonological errors). Additionally, a third group included children without reported speech sound errors at school age, where created. Three additional regression analyses were run for all group combinations to provide standardized mean group differences in language comprehension and early reading skills.

4. Results

The results are organized as 1) descriptive statistics for the included variables, 2) measurement model comparisons, 3) estimation of direct and indirect (mediation) effects between previous speech sound skills (predictor), current speech sound skills (mediator) and language comprehension and early reading (as outcomes), and 4) group comparison of language comprehension and early reading skills based on types of speech sound errors. The dataset and correlation matrices are available as [supplementary material](#).

4.1. Descriptive statistics

[Table 1](#) displays the descriptive statistics for all the included measures.

4.2. Confirmatory factor analyses

Three different measurement models (see the Method section) of the language comprehension and reading variables were examined with CFA. According to [Table 2](#),

Table 2. Language comprehension and early reading fit measures

Fit indices for the model			
Fit measure	1-factor	2-factor	3-factor
Chi-square.	37.63 (14) **	41.68(19)**	40.29(11)**
RMSEA	0.086	0.071	0.080
SRMR	0.052	0.044	0.043
CFI/TLI	.936/.904	.960/.935	.957/.918
BIC	7895.53	7892.25	7901.74

Notes: Significant chi-square values are flagged with * $p < .05$, ** $p < .01$, and *** $p < 0.001$.

a correlated two-factor model was preferable in terms of least model discrepancy and best relative fit.

Figure 1 shows that the two-factor model consisting of two latent factors, one for language comprehension and another for early reading that, displayed in Table 2, fitted the data best. The latent factor for language comprehension was measured with five variables: CELF-4 sentence repetition ($\lambda = 0.78$), CELF-4 grammatical structure ($\lambda = 0.77$), WIAT expressive word ($\lambda = 0.68$), WIAT receptive word ($\lambda = 0.48$), and WIAT receptive sentence ($\lambda = 0.45$). The latent reading factor was measured by two reading indicators: Dysmate word chain ($\lambda = 0.58$) and WIAT focus word ($\lambda = 0.56$). The factor correlation was 0.68.

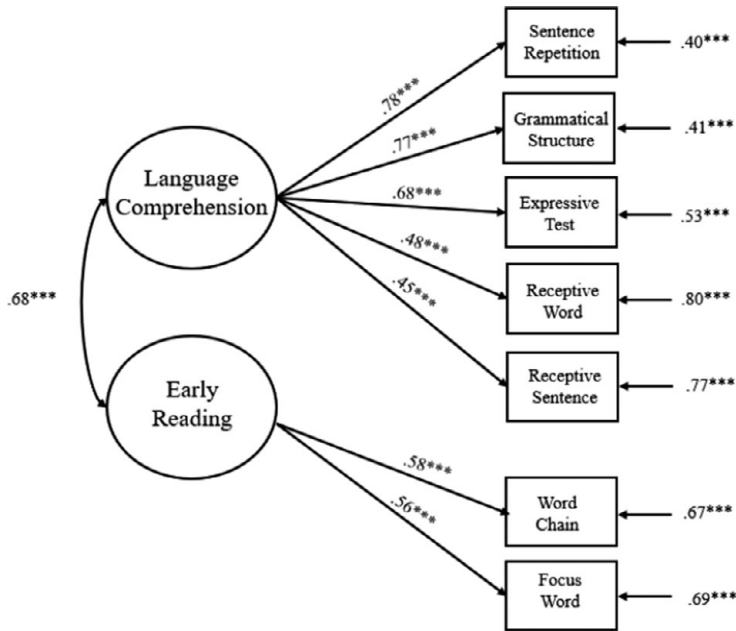


Figure 1. Two-factor model of the observed language comprehension and early reading variables.

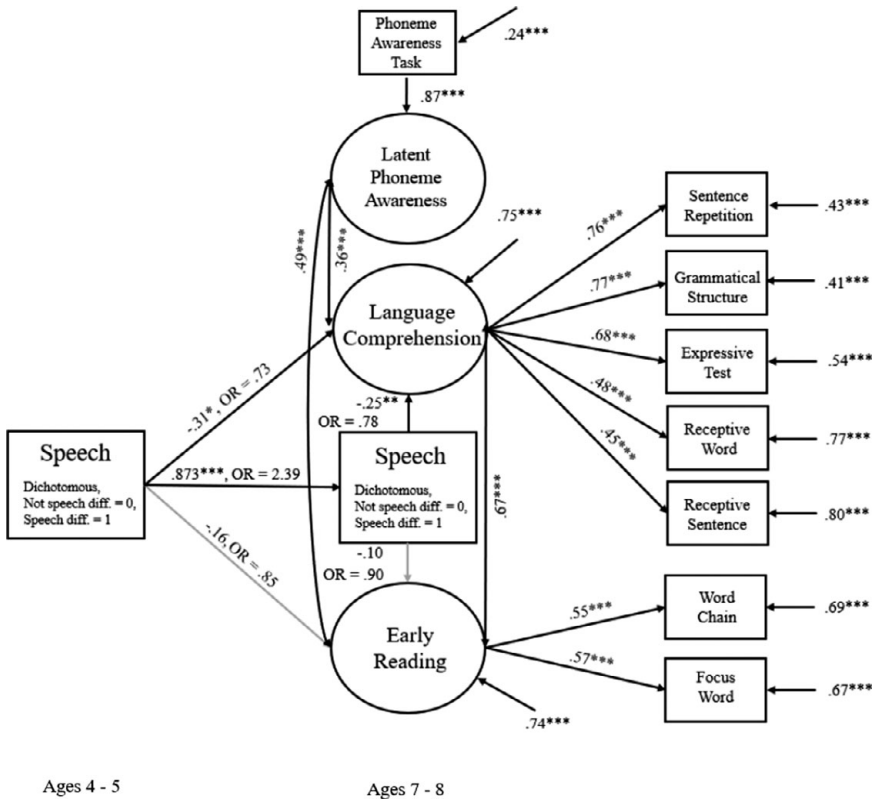


Figure 2. The full regression model in which language comprehension and early reading skills are regressed on early speech sound skills and current speech sound skills and phoneme awareness is incorporated as a covariate. Notes. Significant chi-square values are flagged with $*p < 0.05$, $**p < 0.01$, and $***p < 0.001$ OR = odds ratio.

4.3. Prediction of language comprehension and early reading skills at 7–8 years

Figure 2 displays a structural equation model adjusted for phoneme awareness that examines the statistical significance and size of the direct and indirect relation between early speech sound skills and the latent language comprehension and reading variables, with current speech sound skills as the indirect or intermediate path (model fit: $\chi^2_{df} = 54.53_{30}$, $p = 0.004$, RMSEA = 0.060, CFI = 0.948, TLI = 0.922, SRMR = 0.058). The presence of speech sound difficulties at 4–5 years of age predicted language comprehension skills three years later after controlling for phoneme awareness skills. The standardized β was -0.31 ($p < 0.05$, 95% CI $[-0.613, -0.006]$, odds ratio = 0.73). This mean group difference between the children with ($n = 96$) and without ($n = 138$) early speech sound difficulties was of a small to medium effect size, favoring those without speech sound difficulties. As for early reading skills, early speech sound difficulties were not statistically significant after controlling for phoneme awareness.

As Figure 2 shows, language comprehension skills at ages 7–8 were poorer if the child had concurrent speech sound difficulties ($n = 50$) compared to not having difficulties with speech ($n = 178$), even after controlling for early speech sound skills and phoneme awareness. The standardized β coefficient was -0.25 ($p < 0.01$, 95% CI $[-0.42, -0.09]$,

odds ratio 0.78), indicating that having concurrent speech sound difficulties implied worse language comprehension skills than not having concurrent speech sound difficulties. Thus, being in the speech sound difficulties group at ages 7–8 was associated with scoring 0.25 of a standard deviation unit under the mean in language comprehension. Again, this was not the case for early reading after controlling for phoneme awareness. Notably, phoneme awareness was a significant predictor of language comprehension and early reading skills.

4.3.1. Indirect (mediation) effects

We examined whether current speech sound difficulties might act as a mediator between early speech sound skills and current language comprehension and reading skills by estimating their two indirect effects or paths through current speech sound skills. The standardized indirect regression *beta* coefficient was -0.22 ($p < 0.004$, 95% CI $[-0.37, -0.07]$). Given the total effect on language comprehension (direct + indirect) of $\beta = -0.53$ ($p < 0.001$, 95% CI $[-0.80, -0.26]$), approximately 42% ($-0.22/-0.53$) of the total effect acted through the mediator. As for early reading, no indirect mediation effect was present since the total effects were not significant after controlling for phoneme awareness skills.

4.4. The nature of speech errors as predictor of language comprehension and early reading

The full SEM models of delayed speech errors ($n = 34$) compared with children without speech sound difficulties ($n = 178$) as predictor of language comprehension showed a standardized *beta* coefficient of -0.57 ($p < 0.01$, 95% CI $[-0.90, -0.23]$, odds ratio 0.57) after controlling for phoneme awareness (Figure 3), which is a medium-sized effect indicating that children with delayed speech sound difficulties did worse than those without persistent speech errors. For early reading, there was no significant difference. When examining for group differences between children with disordered speech errors ($n = 16$) and children without speech sound difficulties ($n = 178$), the mean group difference was large ($\beta = 1.44$, $p < 0.001$, 95% CI $[-1.93, -0.94]$, odds ratio 0.24), but the relationship between speech sound status and reading was not significant after phoneme awareness was accounted for (Figure 4). In other words, being in the disordered speech error group is associated with being 1.44, a standard deviation unit under the mean in language comprehension concurrently. When comparing children with delayed speech errors ($n = 34$) and disordered speech errors ($n = 16$), the regression analyses of language comprehension exposed a large group difference ($\beta = 0.79$, $p < 0.01$, 95% CI $[-1.38, -0.21]$, odds ratio 0.45) in favor of children with delayed speech errors (Figure 5).

5. Discussion

This study focused on two key points: (a) whether parent-reported speech sound difficulties, both retrospectively from early childhood and concurrently at ages 7–8, can predict significant language comprehension and reading challenges in children identified as poor readers and (b) whether the nature of speech errors is related to the language comprehension and reading skills of these children. The results reveal key insights into the relationship among speech sound skills, language comprehension, and early reading skills in children identified as poor readers. First, parent-reported speech

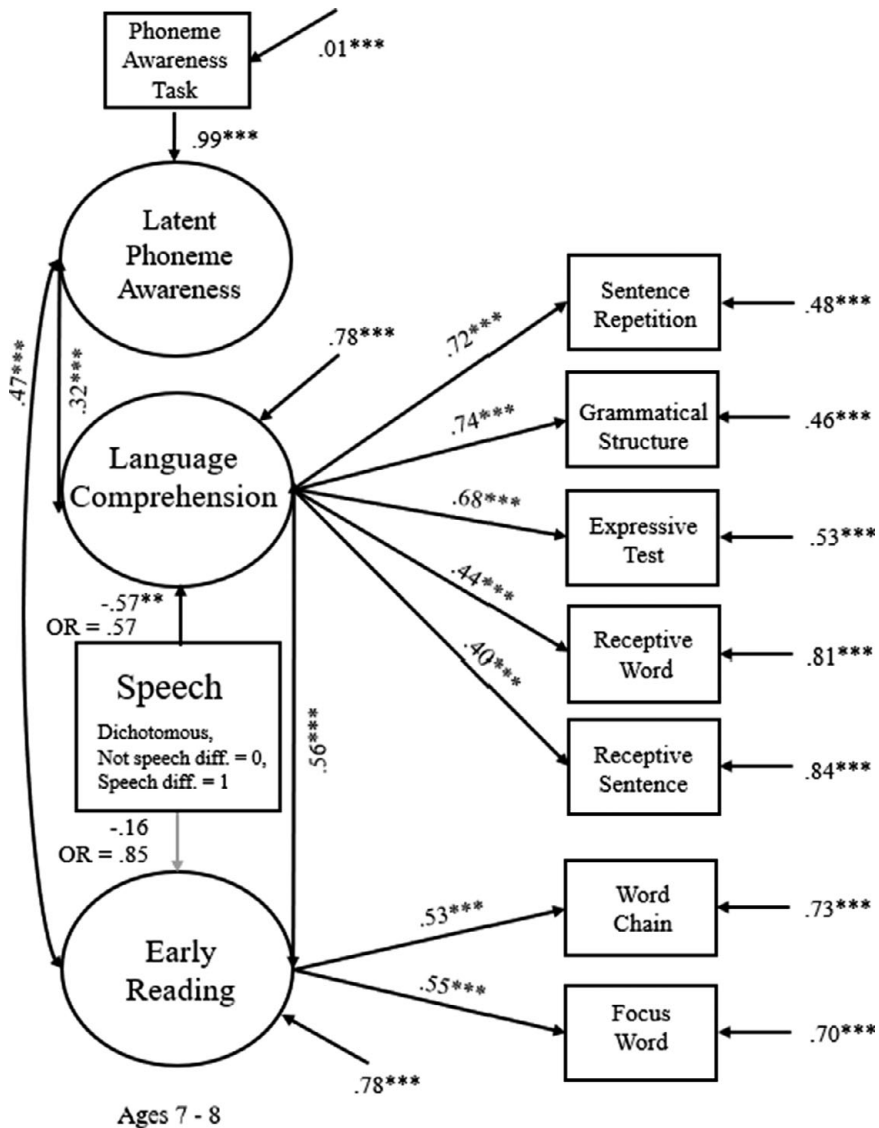


Figure 3. The full SEM in which language comprehension and early reading skills are regressed on children with delayed speech errors compared with children without speech errors. Phoneme awareness is incorporated as a covariate.

Notes. Significant chi-square values are flagged with * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$, OR = odds ratio.

sound difficulties during preschool is a significant predictor of language comprehension difficulties, even when phoneme awareness is taken into account. Second, children with persistent speech sound difficulties in the early school years have significantly poorer language comprehension, after controlling for early speech sound skills and phoneme awareness, than those without persistent difficulties. Third, our findings suggest that phoneme awareness skills account for the relationship between early speech sound

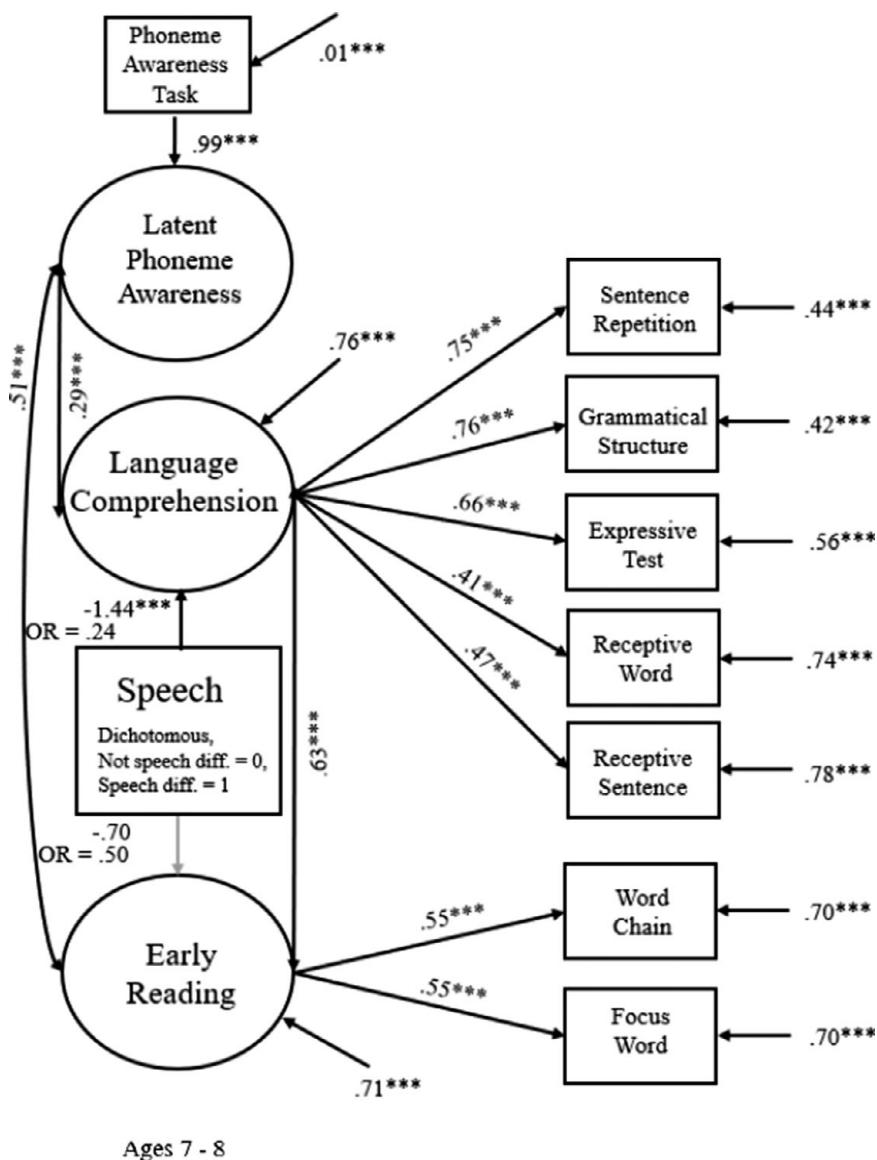


Figure 4. The full SEM in which language comprehension and early reading skills are regressed on children with disordered speech errors compared with children without speech errors. Phoneme awareness is incorporated as a covariate.

Notes. Significant chi-square values are flagged with * $p < .05$, ** $p < .01$, and *** $p < 0.001$, OR = odds ratio.

difficulties and early reading skills. Lastly, children with disordered speech errors have significantly poorer language comprehension skills compared to those without speech errors or those with delayed speech errors. Additionally, there is a significant difference in language comprehension between children with delayed speech errors and those without persistent speech errors at ages 7–8.

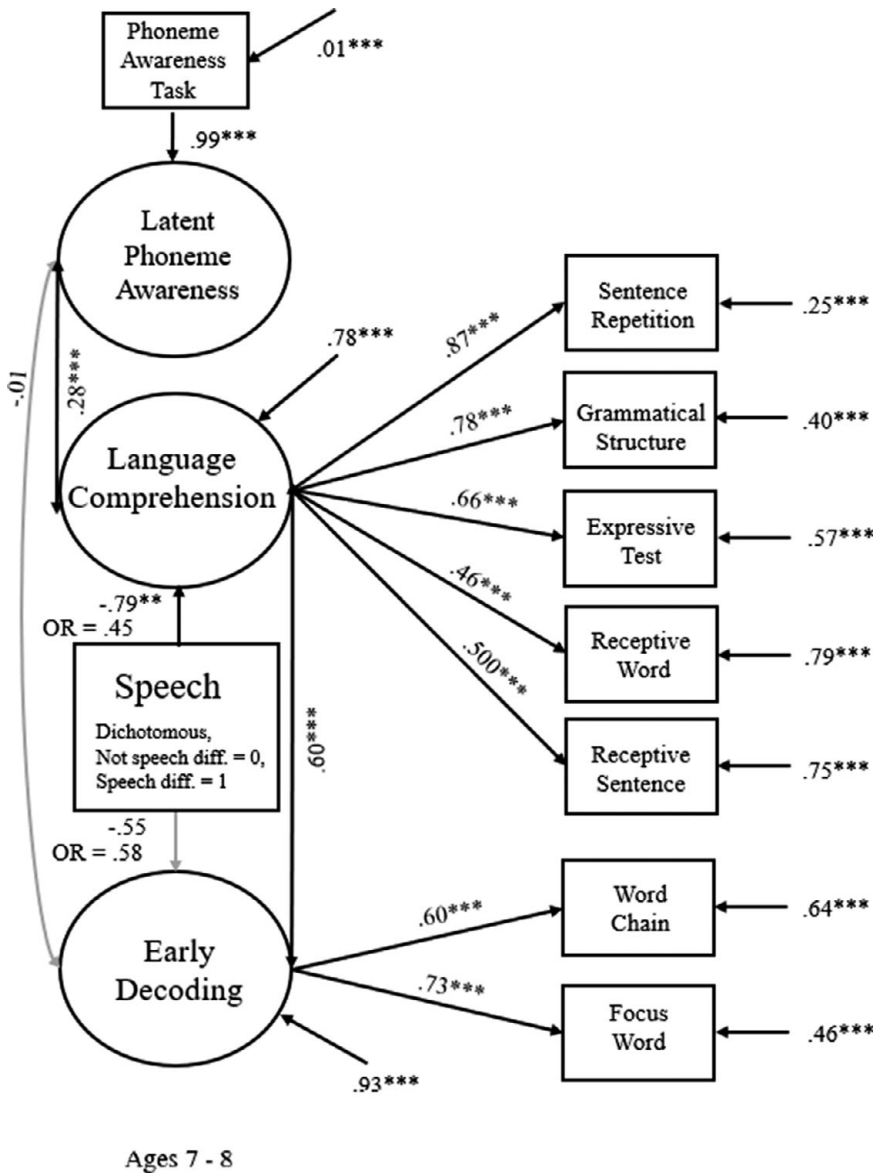


Figure 5. The full SEM in which language comprehension and early reading skills are regressed on children with disordered speech errors compared with children with delayed speech errors. Phoneme awareness is incorporated as a covariate.

Notes. Significant chi-square values are flagged with * $p < .05$, ** $p < .01$, and *** $p < .001$, OR = odds ratio.

5.1. Speech sound skills and their impact on language comprehension and early reading

Our findings align with previous studies showing that speech sound difficulties in preschool age are a risk factor for developing language comprehension and reading

problems (Hayiou-Thomas *et al.*, 2017; Nathan *et al.*, 2004; Walquist-Sørli *et al.*, 2024). The full SEM examining the statistical significance and size of the direct and indirect effects revealed that speech sound difficulties at ages 4–5 are significant predictor of language comprehension skills in school age, even after controlling for phoneme awareness. Our findings are consistent with the findings of Burgoyne *et al.* (2019) that speech sound difficulties are associated with poorer language comprehension skills.

Our findings partly align with the theory of Hopman and MacDonald (2018), which posits that pronouncing words provides a stronger learning experience than just hearing words and that children with speech sound difficulties might be more reluctant to speak and therefore do not get the same learning experience. However, our study did not find a significant effect of speech sound difficulties on early reading. One possible reason for this is that our sample includes only children who have already been identified as poor readers. In contrast, previous studies (Bishop & Adams, 1990; Hayiou-Thomas *et al.*, 2017; Nathan *et al.*, 2004; Peterson *et al.*, 2009; Raitano *et al.*, 2004; Walquist-Sørli *et al.*, 2024) have included broader samples with varying reading abilities, where speech sound skills have been shown to predict reading outcomes. In our sample, both groups – those with and without speech sound difficulties – already exhibit poor reading skills. For significant group differences to emerge, the speech sound difficulties group would need to demonstrate substantially more severe reading problems than the group without speech sound difficulties, which was not observed in our data.

Our findings suggest that phoneme awareness skills account for the relationship between early speech sound difficulties and early reading skills. This supports previous research suggesting that the link between speech sound skills and reading is mediated by phonological awareness (Burgoyne *et al.*, 2019; Walquist-Sørli *et al.*, 2024). Our findings support the segmentation theory and the output phonology theory. Segmentation theory posits that speech processing underpins phonological skills and word reading ability, with increased segmentation during speech development leading to more detailed phonological representations and enhancing phonological awareness and vocabulary growth (Boada & Pennington, 2006). Difficulties in speech segmentation can thus impact phonological awareness, leading to challenges in language and literacy skills. Output phonology theory argues that deficits in speech production can lead to reading and spelling problems, with issues in phonological representations causing speech sound difficulties and related phonological awareness problems (Hulme & Snowling, 1992). Our findings align with both theories by highlighting the role of phonological awareness in linking speech sound skills to reading outcomes. While our models do not establish causality, they are consistent with output phonology theory, which posits that speech sound difficulties may stem from problems with the quality of phonological representations (Brosseau-Lapr   & Roepke, 2019; Burgoyne *et al.*, 2019; Hulme & Snowling, 1992).

In addition, the meta-analysis by Walquist-Sørli *et al.* (2024) found that phonological awareness skills were significant and strong moderators for early language comprehension and reading skills. These findings indicate that children with speech sound difficulties with more severe problems in phonological awareness skills also have more severe language comprehension and reading problems. Our findings indicate that phoneme awareness is a significant predictor of both language comprehension and early reading. These findings are also in line with the study by Tambyraja *et al.* (2020), who found that speech abilities together with phonological awareness were important indicators of reading problems.

Our study revealed that phoneme awareness skills explain some, but not all, of the problems children with speech sound difficulties exhibit in language comprehension

since speech sound difficulties remain significant predictor after adding phoneme awareness as a covariate. This aligns with the findings of the study using a bi-factor model of predicting expressive and receptive language skills, in addition to reading comprehension (XXX et al., *in press*). It was found that the unique factor of speech predicted growth in expressive language skills and the combined factor of speech and language comprehension predicted development of receptive language skills and reading comprehension after controlling for phonological awareness skills as a covariate.

5.2. Persistence of speech sound difficulties in school age

In line with the critical age hypothesis (Bishop & Adams, 1990), our findings suggest that speech sound difficulties are a risk factor for language comprehension and reading problems if they persist into the age when children are learning to read. Our analysis revealed that parent-reported persistent speech sound difficulties at ages 7–8 are significant predictor of difficulties in language comprehension, even when early speech sound skills and phoneme awareness are taken into consideration. These findings are consistent with several studies that found persistent speech sound difficulties at school entry are associated with poorer emergent literacy skills (Bishop & Adams, 1990; Hayiou-Thomas et al., 2017).

However, some studies that have examined the critical age hypothesis have found that the relation between persistent speech sound difficulties and literacy skills was no longer significant after language skills were controlled for (Nathan et al., 2004; Peterson et al., 2009). Although we have not controlled for language skills in our regression model for early reading, our results revealed that language comprehension skills are significantly predicted by speech sound skills, even after controlling for phoneme awareness. This indicates that persistent speech sound difficulties is a risk marker for severe concurrent language comprehension difficulties, underscoring the findings of Burgoyne et al. (2019), who found that speech sound difficulties at school entry are associated with poorer language comprehension skills, and this was still evident six months later.

In our model, we assessed the indirect effects of speech sound skills at ages 4–5 on language comprehension and early reading at ages 7–8, mediated by concurrent speech sound skills. The indirect effect on language comprehension was a $\beta = -0.22$, indicating a small negative indirect effect of early speech sound skills on later language comprehension through concurrent skills. The total direct effect was $\beta = -0.31$, suggesting a small to moderate negative direct effect of early speech sound skills on later language comprehension, independent of concurrent skills. The mediation rate was 0.42, which indicates that 42% of the effect from early speech sound difficulties was explained through current speech sound skills. In other words, when examining how early difficulties with speech sounds affect later development, 42% of this influence can be attributed to the speech sound skills the child has at the time of assessment. This suggests that there is a significant relationship between early speech sound difficulties and later language comprehension skills, even though not all children have persistent speech sound difficulties into school age. In addition, the mediation rate shows that language comprehension skills are a direct result of persistent speech sound difficulties at ages 7–8.

5.3. The nature of speech sound errors as risk markers

First, our analyses revealed that children with parent-reported persistent speech sound difficulties, classified as disordered speech, significantly predicted more problems in

language comprehension than children without speech sound difficulties. This might indicate that speech sound skills affects language comprehension development, with disordered speech errors having a higher risk of experiencing language comprehension difficulties than delayed speech errors. These findings align with the study using bi-factor SEM, which found that the unique factor of speech at age four predicted the development of expressive language skills in school-age children, even after controlling for phonological awareness skills (XXX *et al.*, *in press*). Another possible explanation is that phoneme awareness is difficult to measure in samples selected for poor reading skills due to the restriction of range and potential floor effects. Finally, children with disordered speech errors may have greater deficits in phonological awareness than those with delayed speech errors and, therefore, struggle more with language comprehension (Dodd *et al.*, 2024; Leitão & Fletcher, 2004). However, importantly, our analysis does not test for this hypothesis. The group difference between those with disordered speech and those without speech sound difficulties was not significant in early reading when controlling for phoneme awareness. This may indicate the notion that early reading skills are heavily dependent on phonological awareness skills (Snowling & Melby-Lervåg, 2016). Furthermore, these findings could also be related to the fact that the Norwegian language has a much more transparent orthography compared to English. Since word reading skills also measure reading accuracy, it is possible that word reading does not differentiate as clearly between children with delayed and disordered speech errors in Norwegian as it does in English. Second, delayed speech errors were a significant predictor of children with concurrent language comprehension difficulties compared to children without speech sound difficulties. When comparing children with delayed speech errors with children with disordered speech errors, having a disordered error pattern was predictive of language comprehension problems. In contrast to Hayiou-Thomas *et al.* (2017), who found that children with disordered speech errors had significantly poorer word reading skills than children with delayed speech errors, our analysis did not reveal a significant group difference in early reading skills. Thus, this may be because our sample consists solely of children already identified as poor readers, as discussed earlier.

5.4. Strengths and limitations

To the best of our knowledge, this is the only study that has examined whether parent-reported speech sound difficulties predict language comprehension and reading skills in a group of poor reading children. Our study has both strengths and limitations. A strength is that phoneme awareness skills are controlled for in all analyses. Despite individual variations, children who experience difficulties with speech sounds often exhibit deficits in phonological processing (Roepke *et al.*, 2020). This enables us to identify speech sound skills as a predictor of language comprehension and reading development beyond phoneme awareness. However, a limitation of our study is that children are identified as having speech sound difficulties through parental questionnaires, which include both retrospective and current speech sound status. The retrospective design may raise concerns about the ability to identify children with early speech sound difficulties. However, this part of the survey only classified children as having or not having speech sound difficulties. The current part of the survey classified children into subgroups, and research has found that parental reports can be an effective method for accurately representing a child's current developmental status (Feldman *et al.*, 2005; Libertus *et al.*, 2015). Testing children with persistent speech sound difficulties using a diagnostic

assessment of speech sound disorders could have enhanced the validity of the parental responses in our study. However, this was not feasible due to the time-consuming nature of the comprehensive language comprehension and reading assessments conducted with the children. Future longitudinal studies should broadly examine the relationship between early and persistent speech sound difficulties, phoneme awareness, language comprehension, and literacy skills in children identified as being at risk for reading disorders.

5.5. Conclusion and implications

Despite these limitations, this study enhances our understanding of the development of language comprehension and early reading in children with speech sound difficulties. Our findings suggest that parent-reported early speech sound difficulties are significant predictor of language comprehension skills at school age. This implies that speech sound difficulties may serve as a risk factor for language comprehension and literacy problems in school-aged children. This insight is crucial because speech sound skills are easy and cost-effective to screen. Our findings indicate that children with speech sound difficulties require further assessment of broader language comprehension skills and potential delays in reading development, including phonological abilities. In this way, evidence-based interventions for language comprehension and/or phoneme awareness training can be initiated.

Second, our findings suggest that assessing the type of speech error can serve as an indicator of potential academic challenges in language comprehension and reading at school, in addition to initiating appropriate speech interventions. These findings highlight the importance of a comprehensive speech sound assessment by a speech and language pathologist for children with speech sound difficulties.

Supplementary material. The supplementary material for this article can be found at <http://doi.org/10.1017/S0305000925100329>.

Data availability statement. Data and scripts are available at the following URL: https://osf.io/d7syz/?view_only=2965b3a95a664c3f99eb866197b919cc.

Acknowledgments. All necessary approvals, including ethics, are in place for the proposed research. All authors have approved the manuscript and its submission in its current form. They declare that there is no conflict of interest. All authors confirm that they agree to share the raw data, any digital study materials, and the analysis code, as appropriate. All authors confirm no use of AI during analyzing data or generating text or figures.

Financial support. This work was supported by the Research Council Norway through ReadWell (grant holder Trude Nergård-Nilssen, grant number 298981), Centre for Research in Special Needs Education and Inclusion (grant holder Monica Melby-Lervåg, grant number 327377), CREATE (grant holder Monica Melby-Lervåg, grant number 331640). This research was partly supported by the Research Council of Norway through its Centre of Excellence Scheme (grant holder Monica Melby-Lervåg, grant number 331640).

Competing interests. No authors have any competing interests.

References

- American Psychological Association.** (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). American Psychiatric Association.
- Bentler, P. M.** (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, **107**, 238–246. <https://doi.org/10.1037/0033-2909.107.2.238>.

- Benway, N. R., Garcia, K., Hitchcock, E., McAllister, T., Leece, M. C., Wang, Q., & Preston, J. L. (2021). Associations between speech perception, vocabulary, and phonological awareness skill in school-aged children with speech sound disorders. *Journal of Speech, Language, and Hearing Research*, **64**(2), 452–463. https://doi.org/10.1044/2020_JSLHR-20-00356.
- Bishop, D. V. M. (2003). *The children's communication checklist second edition (CCC-2)*. The Psychological Corporation.
- Bishop, D. V., & Adams, C. (1990). A prospective study of the relationship between specific language impairment, phonological disorders and reading retardation. *Journal of Child Psychology and Psychiatry*, **31**, 1027–1050. <https://doi.org/10.1111/j.1469-7610.1990.tb00844.x>.
- Bishop, D. V. M., & Snowling, M. J. (2004). Developmental dyslexia and specific language impairment: Same or different? *Psychological Bulletin*, **130**(6), 858–886. <https://doi.org/10.1037/0033-2909.130.6.858>.
- Boada, R., & Pennington, B. F. (2006). Deficient implicit phonological representations in children with dyslexia. *Journal of Experimental Child Psychology*, **95**, 153–193. <https://doi.org/10.1016/j.jecp.2006.04.003>.
- Bornstein, M. H., Hahn, C.-S., & Putnick, D. L. (2016). Long-term stability of core language skill in children with contrasting language skills. *Developmental Psychology*, **52**(5), 704–716. <https://doi.org/10.1037/dev0000111>.
- Brosseau-Lapr , F., & Roepke, E. (2019). Speech errors and phonological awareness in children ages 4 and 5 years with and without speech sound disorder. *Journal of Speech, Language, and Hearing Research*, **62**, 3276–3289. https://doi.org/10.1044/2019_JSLHR-S-17-0461.
- Burgoyne, K., Lervag, A., Malone, S., & Hulme, C. (2019). Speech difficulties at school entry are a significant risk factor for later reading difficulties. *Early Childhood Research Quarterly*, **49**, 40–48. <https://doi.org/10.1016/j.ecresq.2019.06.005>.
- Cohen, J. (2013). *Statistical power analysis for the behavioral sciences* (Rev. ed.). Academic Press.
- Dodd, B., Hua, Z., Crosbie, S., Holm, A., & Ozanne, A. (2002). *Diagnostic evaluation of articulation and phonology*. Pearson.
- Dodd, B., Reilly, S., Ttofari Eecen, K., & Morgan, A. T. (2018). Articulation or phonology? Evidence from longitudinal error data. *Clinical Linguistics & Phonetics*, **32**(11), 1027–1041. <https://doi.org/10.1080/02699206.2018.1488994>.
- Dodd, B. (2014). Differential diagnosis of pediatric speech sound disorder. *Current Developmental Disorders Reports*, **1**(3), 189–196. <https://doi.org/10.1007/s40474-014-0017-3>.
- Dodd, B., Holm, A., & Crosbie, S. (2024). Clinical phonology and phonological assessment. In Ball, M.J., M ller, N., & Spencer, E. (Eds.) *The handbook of clinical linguistics* (2nd Edn, pp. 453–467). John Wiley & Sons, Ltd. <http://doi.org/10.1002/9781119875949>
- 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 & Child Neurology*, **57**(6), 578–584. <https://doi.org/10.1111/dmcn.12635>.
- Ebert, K. D. (2017). Convergence between parent report and direct assessment of language and attention in culturally and linguistically diverse children. *PLoS One*, **12**(7). <https://doi.org/10.1371/journal.pone.0180598>.
- Feldman, H. M., Dale, P. S., Campbell, T. F., Colborn, D. K., Kurs-Lasky, M., Rockette, H. E., & Paradise, J. L. (2005). Concurrent and predictive validity of parent reports of child language at ages 2 and 3 years. *Child Development*, **76**(4), 856–868. <https://doi.org/10.1111/j.1467-8624.2005.00882.x>.
- Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *RASE: Remedial & Special Education*, **7**, 6–10. <https://doi.org/10.1177/074193258600700104>.
- Hayiou-Thomas, M. E., Carroll, J. M., Leavett, R., Hulme, C., & Snowling, M. J. (2017). When does speech sound disorder matter for literacy? The role of disordered speech errors, co-occurring language impairment and family risk of dyslexia. *Journal of Child Psychology and Psychiatry*, **58**(2), 197–205. <https://doi.org/10.1111/jcpp.12648>.
- Hjetland, H. N., Lerv g, A., Lyster, S.-A. H., Hagtvet, B. E., Hulme, C., & Melby-Lerv g, M. (2019). Pathways to reading comprehension: A longitudinal study from 4 to 9 years of age. *Journal of Educational Psychology*, **111**(5). <https://doi.org/10.1037/edu0000321>.
- Helland, W. A., & Heimann, M. (2007). Assessment of pragmatic language impairment in children referred to psychiatric services: A pilot study of the children's communication checklist in a Norwegian sample. *Logopedics Phoniatrics Vocology*, **32**, 22–30.

- Holm, A., Farrier, F., & Dodd, B. (2008). Phonological awareness, reading accuracy and spelling ability of children with inconsistent phonological disorder. *International Journal of Language and Communication Disorders*, 43(3), 300–322. <https://doi.org/10.1080/13682820701445032>.
- Hopman, E. W. M., & MacDonald, M. C. (2018). Production practice during language learning improves comprehension. *Psychological Science*, 29(6), 961–971. <https://doi.org/10.1177/0956797618754486>.
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>.
- Hulme, C., & Snowling, M. (1992). Deficits in output phonology: An explanation of reading failure?. *Cognitive Neuropsychology*, 9(1), 47–72. <https://api.semanticscholar.org/CorpusID:141273218>
- Jin, F., Schjølberg, S., Eadie, P., Nes, R. B., & Røysamb, E. (2020). Preschool speech intelligibility and 8-year literacy: A moderated mediation analysis. *Journal of Speech, Language, and Hearing Research*, 63(10), 3380–3391. https://doi.org/10.1044/2020_JSLHR-19-00394.
- Lewis, B. A., Freebairn, L. A., & Taylor H. G. (2000). Follow-up of children with early expressive phonology disorders. *Journal of learning disabilities*, 33(5), 433–444. <https://doi.org/10.1177/002221940003300504>
- Libertus, M. E., Odic, D., Feigenson, L., & Halberda, J. (2015). A developmental vocabulary assessment for parents (DVAP): Validating parental report of vocabulary size in 2- to 7-year-old children. *Journal of Cognition and Development*, 16(3), 442–454. <https://doi.org/10.1080/15248372.2013.835312>.
- Leitão, S., & Fletcher, J. (2004). Literacy outcomes for students with speech impairment: Long-term follow-up. *International Journal of Language & Communication Disorders*, 39(2), 245–256. <https://doi.org/10.1080/13682820310001619478>.
- Leitão, S., Hogben, J., & Fletcher, J. (1997). Phonological processing skills in speech and language impaired children. *European Journal of Disorders of Communication*, 32(2), 91–111. <https://doi.org/10.1111/j.1460-6984.1997.tb01626.x>.
- Lervåg, A., Hulme, C., & Melby-Lervåg, M. (2018). Unpicking the developmental relationship between Oral language skills and Reading comprehension: It's simple, but complex. *Child Development*, 89(5), 1821–1838. <https://doi.org/10.1111/cdev.12861>.
- McAllister, L., McCormack, J., McLeod, S., & Harrison, L. J. (2011). Expectations and experiences of accessing and participating in services for childhood speech impairment. *International Journal of Speech Language Pathology*, 13(3), 251–267. <https://doi.org/10.3109/17549507.2011.535565>.
- McIntosh, B., & Dodd, B. J. (2008). Two-year-olds' phonological acquisition: Normative data. *International Journal of Speech-Language Pathology*, 10(6), 460–469. <https://doi.org/10.1080/17549500802149683>.
- McLeod, S., & Harrison, L. J. (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(5), 1213–1229. [https://doi.org/10.1044/1092-4388\(2009\)08-0085](https://doi.org/10.1044/1092-4388(2009)08-0085).
- McLeod, S., & Masso, S. (2019). Speech sound disorders in children. In J. Horst & J. von Koss Torkildsen (Eds.), *International handbook of language acquisition* (pp. 362–386). Routledge.
- Muthén, L. K., & Muthén, B. O. (1998–2016). *Mplus user's guide* (7th ed.). Author.
- Nathan, L., Stackhouse, J., Goulondris, N., & Snowling, M. J. (2004). The development of early literacy skills among children with speech difficulties: A test of the “critical age hypothesis”. *Journal of Speech, Language, and Hearing Research*, 47, 377–391. [https://doi.org/10.1044/1092-4388\(2004\)031](https://doi.org/10.1044/1092-4388(2004)031).
- Nergård-Nilssen, T. (2024). *Dysmate [håndbok og måleinstrument]*. Literate AS, Tromsø, Norge.
- Peterson, R., Pennington, B., Shriberg, L., & Boada, R. (2009). What influences literacy outcome in children with speech sound disorders? *Journal of Speech, Language, and Hearing Research*, 52, 1175–1188. [https://doi.org/10.1044/1092-4388\(2009\)08-0024](https://doi.org/10.1044/1092-4388(2009)08-0024).
- Preston, J., Hull, M., & Edwards, M.-L. (2013). Preschool speech error patterns predict articulation and phonological awareness outcomes in children with histories of speech sound disorders. *American Journal of Speech-Language Pathology*, 22, 173–184. [https://doi.org/10.1044/1058-0360\(2012\)12-0022](https://doi.org/10.1044/1058-0360(2012)12-0022).
- Raitano, N. A., Pennington, B. F., Tunick, R. A., Boada, R., & Shriberg, L. D. (2004). Pre-literacy skills of subgroups of children with speech-sound disorders. *Journal of Child Psychology and Psychiatry*, 45(4), 821–835. <https://doi.org/10.1111/j.1469-7610.2004.00275.x>.
- Rvachew, S., & Grawburg, M. (2006). Correlates of phonological awareness in preschoolers with speech sound disorders. *Journal of Speech, Language, and Hearing Research*, 49(1), 74–87. [https://doi.org/10.1044/1092-4388\(2006\)006](https://doi.org/10.1044/1092-4388(2006)006).

- Roepke, E., Bower, K. E., Miller, C. A., & Brosseau-Lapr , F. (2020). The speech “Bamana”: Using the syllable repetition task to identify underlying phonological deficits in children with speech and language impairments. *Journal of Speech, Language, and Hearing Research*, *63*, 2229–2244. https://doi.org/10.1044/2020_JSLHR-20-00027.
- Sand -Frank, A. M., & Bjerk , K. M. (2023). Differensialdiagnostisk kartlegging av spr klydsforstyrrelser (Diffkas) [Differential diagnostics assessment of speech sound disorders]. *Statped*.
- Semel, E., Wiig, E. H., & Secord, W. A. (2003). *Clinical evaluation of language fundamentals fourth edition* (CELF-4). The Psychological Corporation/A Harcourt Assessment Company.
- de Simoni, S. N., Leidow, I. C., Britz, D. L., Moraes, D. A. d. O., & Keske-Soares, M. (2019). Impact of the speech sound disorders: Family and child perception. *Revista CEFAC*, *21*(3). <https://doi.org/10.1590/1982-0216/201921310718>.
- Snowling, M. J., & Hulme, C. (2012). Interventions for children’s language and literacy difficulties. *International Journal of Language & Communication Disorders*, *47*(1), 27–34. <https://doi.org/10.1111/j.1460-6984.2011.00081.x>.
- Snowling, M. J., & Hulme, C. (2021). Annual research review: Reading disorders revisited – The critical importance of oral language. *Journal of Child Psychology and Psychiatry*, *62*(5), 635–653. <https://doi.org/10.1111/jcpp.13324>.
- Snowling, M. J., & Melby-Lerv , M. (2016). Oral language deficits in familial dyslexia: A meta-analysis and review. *Psychological Bulletin*, *142*(5), 498–545. <https://doi.org/10.1037/bul0000037>.
- Stringer, H., Cleland, J., Wren, Y., Rees, R., & Williams, P. (2024). Speech sound disorder or DLD (phonology)? Towards a consensus agreement on terminology. *International Journal of Language & Communication Disorders*, *59*(6), 2131–2145. <https://doi.org/10.1111/1460-6984.12989>.
- Tambyraja, S. R., Farquharson, K., & Justice, L. (2020). Reading risk in children with speech sound disorder: Prevalence, persistence, and predictors. *Journal of Speech, Language, and Hearing Research*, *63*(11), 3714–3726. https://doi.org/10.1044/2020_JSLHR-20-00108.
- Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (1999). *Test of word reading efficiency*. Pro-Ed.
- Ttofari Eecen, K., Eadie, P., Morgan, A. T., & Reilly, S. (2019). Validation of Dodd’s model for differential diagnosis of childhood speech sound disorders: A longitudinal community cohort study. *Developmental Medicine and Child Neurology*, *61*(6), 689–696. <https://doi.org/10.1111/dmcn.13993>.
- Walquist-S rli, L., Caglar-Ryeng, Furnes, B., Nerg rd-Nilssen, T., Donolato, E., & Melby-Lerv , M. (2024). Are speech sound difficulties risk factors for difficulties in language and reading skills? A systematic review and meta-analysis. *Journal of Speech, Language, and Hearing Research*, *68*(1), 1–14. https://doi.org/10.1044/2024_JSLHR-24-00170.
- Waring, R., Eadie, P., Rickard Liow, S., & Dodd, B. (2017). Do children with phonological delay have phonological short-term and phonological working memory deficits? *Child Language Teaching and Therapy*, *33*(1), 33–46. <https://doi.org/10.1177/0265659016654955>.
- 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>.
- Wechsler, D. (2020). *WIAT-4: Wechsler individual achievement test*. Pearson.
- Williams, A. L., McLeod, S., & McCauley, R. (2010). Introductions to intervention to speech sound disorders in children. In A. L. Williams, S. McLeod, & R. McCauley (Eds.), *Intervention for speech sound disorders in children* (pp. 1–26). Brookes Publishing.
- XXX, et al. (in press). *The influence of speech sound skills on language and literacy development: A longitudinal study from ages 4 to 9*.