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RESEARCH REPORT

I remembered the chorm! Word learning abilities of children with and without phonological impairment

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Abstract

Background: Children with phonological impairment present with pattern-based errors in their speech production. While some children have difficulties with speech perception and/or the establishment of robust underlying phonological representations, the nature of phonological impairment in children is still not well understood. Given that phonological and lexical development are closely linked, one way to better understand the nature of the problem in phonological impairment is to examine word learning abilities in children.

Aims: To examine word learning and its relationship with speech perception, speech production and vocabulary knowledge in children aged 4–5 years. There were two variables of interest: speech production abilities ranging from phonological impairment to typical speech; and vocabulary abilities ranging from typical to above average ('lexically precocious').

Methods & Procedures: Participants were 49 Australian-English-speaking children aged 48–69 months. Children were each taught four novel non-words (out of a selection of eight) through stories, and word learning was assessed at 1 week post-initial exposure. Word learning was assessed using two measures: confrontation naming and story retell naming. Data were analysed by group using independent-samples *t*-tests and Mann–Whitney *U*-tests, and continuously using multiple linear regression.

Outcomes & Results: There was no significant difference in word learning ability of children with and without phonological impairment, but regardless of speech group, children with above average vocabulary had significantly better word learning abilities than children with average vocabulary. In multiple linear regression, vocabulary was the only significant predictor of variance in word learning ability.

Conclusions & Implications: Children with phonological impairment can be lexically precocious and learn new words like their peers without phonological impairment. Contrary to expectations, vocabulary knowledge rather than expressive phonological ability explained variance in measures of word learning. These findings question an assumption that children with phonological impairment have underspecified phonological representations. They also highlight the heterogeneity among children with phonological impairment and the need to better understand the nature of their difficulty learning the phonological system of the ambient language.

KEYWORDS
children, phonological impairment, speech perception, speech production, word learning, vocabulary

WHAT THIS PAPER ADDS

What is already known on the subject

- There is limited research examining the word learning abilities of children with phonological impairment. Most previous research focuses on word properties such as phonotactic probability and neighbourhood density. Within the existing literature there are different reports and conclusions regarding the word learning abilities of children with phonological impairment and whether their word learning differs from that of children with typically developing speech.

What this study adds to existing knowledge

- This study found that vocabulary was the strongest predictor of word learning across children with and without phonological impairment. There was no significant difference in word learning ability between children with and without phonological impairment. However, children with lexically precocious vocabulary abilities were significantly better at word learning than children with average vocabulary abilities.

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

- Findings from this study support the importance of assessing and considering measures of word learning—including vocabulary—when working with children with phonological impairment. This study indicates that it is possible to use stories coupled with measures of confrontation naming and story retell to gain deeper insight into children's word learning abilities.

INTRODUCTION

Children have an incredible ability to learn new words, acquiring about 60,000 words by 18 years of age (McMurray et al., 2012). Although children appear to learn words and grow their vocabulary knowledge effortlessly, the task of word learning is complex. It involves multiple processes culminating in the establishment of underlying representations of words comprising phonological, lexical and semantic information (Hoover et al., 2010). The term *phonological* refers to the individual sounds that make up a word; *lexical* refers to the combined sound sequence of a word; and *semantic* refers to the meaning of a word (Hoover et al., 2010;

Storkel, 2004). Spoken word learning also draws on other abilities that develop during childhood, namely the ability to perceive and produce speech (Munson et al., 2011; Vihman, 2017).

In this paper, we examine the word learning abilities of children with typical speech development and children with the most common type of speech sound disorder (SSD)—phonological impairment (Broomfield & Dodd, 2004; Dodd et al., 2018). Phonological impairment manifests as pattern-based errors impacting one or more classes of phonemes, phonotactics and/or prosodic characteristics (Baker et al., 2020). Although difficulties with speech perception and the establishment of robust underlying phonological representations have been reported (e.g., Edwards et al., 1999; Rvachew & Brosseau-Lapré, 2018), the nature of phonological impairment is still not well understood. One area where there is a dearth of research is the word learning abilities of children with phonological impairment.

Word learning in children with phonological impairment

In contrast to the extensive body of research on word learning in children with developmental language disorder (DLD) (e.g., McGregor et al., 2022; Pomper et al., 2022), word learning in children with phonological impairment is understudied. When exposed to a new word, three processes occur: fast mapping, encoding and consolidation (Munro et al., 2012). Fast mapping refers to the process of recognising that a word is new, which prompts learning, as well as connecting a new word with its referent (Carey, 2010; Munro et al., 2012); encoding refers to the process of creating a new lexical representation of a word in memory following exposure to the word and the word-referent mapping; and consolidation refers to the process of strengthening the new representation, incorporating it into the lexicon, and building connections with existing representations (Munro et al., 2012). Phonological representations are considered important for fast mapping and triggering word learning, while lexical representations are thought to support encoding and consolidation of word learning (Hoover et al., 2010; Storkel et al., 2010). These processes and representations involved in word learning are thought to rely on children's abilities to perceive and produce speech as well as their existing vocabulary knowledge. In this paper, we focus on consolidation of word learning in children with phonological impairment because consolidation is important for stabilisation of words in long-term memory, and hence, building the lexicon (Munro et al., 2012).

The complex interaction between speech perception, speech production and vocabulary knowledge in children's word learning

Speech perception is a complex process involving many cognitive abilities, processes and acoustic properties (Nittrouer, 2002). There are different approaches to and theories explaining speech perception, but for the purposes of this study, we are considering speech perception in the context of the representation-based account of phonological impairment in children (e.g., Edwards et al., 1999; Munson et al., 2005; Sutherland & Gillon, 2005). The representation-based account emerged as an alternative to the cognitive–linguistic, rule-based understanding of phonological impairment (e.g., Fey, 1986; Grunwell, 1982; Ingram, 1976). The representation-based account focuses on the nature of underlying representations and how differences in the quality or detail of children's representations affect speech production and other related abilities including speech perception and word learning (Edwards et al., 1999; Munson et al., 2005; Pathi & Mondal, 2021; Rvachew, 1994; Sutherland & Gillon, 2005).

Speech perception and word learning are connected from infancy (e.g., Werker & Fennell, 2004; Werker & Yeung, 2005). As children learn more words and vocabulary knowledge grows, however, this relationship becomes more complex, with word learning and vocabulary knowledge influencing perception, and vice versa. As Samuelson and McMurray (2017: p. 7) highlight, 'as children acquire mappings between words and object mappings [...] this may actually help early auditory organization, by teaching them which sounds are meaningfully different'. Hearnshaw et al. (2023) and Edwards et al. (2002) found evidence for the influence of vocabulary on speech perception. Vocabulary size—a measure of word learning outcome—was a significant predictor of speech perception ability in children with and without SSDs. Vocabulary size also predicted more variance in speech perception than that predicted by speech production (Edwards et al., 2002; Hearnshaw et al., 2023).

The role of speech production (i.e., the ability to say words using the phonological system of the ambient language) in word learning is similarly complex. Young children learn words and speech sounds concurrently, while they are also learning the phonological, lexical, and semantic representations of new words (Storkel, 2004). Lexical and phonological development are considered to be inextricably linked—they have a bidirectional relationship with each ability influencing the other (Sosa, 2016; Stoel-Gammon, 2011; Storkel, 2004). Indeed, Benham and

Goffman (2020) demonstrated how the lexical–semantic and phonological systems are interconnected in word learning. They found that for children with DLD, adding lexical–semantic detail by linking new words with a referent led to improved organisation and stability of phonological forms (Benham & Goffman, 2020). Vihman et al. (2014: pp. 122–123) discussed three ways in which speech production and word learning are connected: that children use the ease of pronunciation of words to help select their first words (the 'articulatory filter'); that children generalise familiar patterns of production from words they know to help organise their phonology and increase their vocabulary, which, in turn can lead to reduced accuracy in word production ('systematisation and regression'); and that a child's productive knowledge of words can help them learn new word forms ('word-production experience facilitates new word learning').

Regarding vocabulary, as children's vocabularies expand they are better able to use their knowledge of words to learn more new words (Borovsky et al., 2016). For example, Crain-Thoreson and Dale (1992) found that children who were lexically precocious at age 20 months were still lexically precocious at age 4;6.

Why might children with phonological impairment have difficulties with word learning and what does the evidence say?

Drawing on the representation-based account of phonological and lexical acquisition, knowledge of sounds and words are mapped onto and stored in underlying representations which are then accessed to produce words (Edwards et al., 1999; Munson et al., 2005). Children with phonological impairment are thought to have poorer quality underlying phonological representations of words (e.g., Edwards et al., 1999; Sutherland & Gillon, 2005). It follows then that they may be at risk for difficulties with other abilities that have been linked to phonological representations, such as word learning and vocabulary (Anthony et al., 2010; Hoover et al., 2010; Storkel, 2004).

Across the extant literature on word learning abilities of children aged 3–6 years with and without phonological impairment, the focus has primarily been on the effects of lexical properties on word learning; particularly phonotactic probability (PP) and neighbourhood density (ND). For example, in a study examining the potential effects of high and low PP on non-word learning, Storkel (2004) discovered that children with phonological impairment had more difficulty learning words with high PP compared with low PP, while children with typically developing speech better learned words with high PP. Storkel (2004) concluded that children with phonological impairment had more difficulty forming lexical representations when learning new words. In a later study, Storkel et al. (2010) assessed word learning expressively via a naming task and receptively via a picture pointing task, and reported that children with phonological impairment differed from children with typically developing speech in their encoding and/or consolidation of real words. As part of a twice weekly 11-week vocabulary intervention study, McDowell and Carroll (2012) explored both the overall number of real words learned and the effects of lexical properties on word learning in children with typically developing speech and children with speech sound inaccuracies. Using an expressive definition task, McDowell and Carroll (2012) found no significant difference in the overall number of words learned by the two groups of children. However, they did find that children with typically developing speech better learned words with high PP and low ND, while children with speech sound inaccuracies better learned words with low PP and high ND (McDowell & Carroll, 2012). It was unclear what proportion of the children in their sample with speech sound inaccuracies had a phonological impairment. Collectively, these findings are difficult to reconcile, as types of words (real versus non-words), opportunities and time for exposure, and assessment tasks (e.g., pointing, naming, defining) have varied. What is apparent, is that children with phonological impairment do not seem to learn words in exactly the same way as their peers without phonological impairment.

Alongside the focus on PP and ND, other researchers have examined word learning by assessing the overall vocabulary size of children with SSDs—including phonological impairment. A range of vocabulary abilities have been reported. From children with concomitant SSDs and language impairment including below-average vocabulary ability (e.g., Eadie et al., 2015; Macrae & Tyler, 2014), to children with SSDs and age-appropriate vocabulary (Munson et al., 2011), through to children with SSDs with above average vocabulary abilities (e.g., Benway et al., 2021; Brosseau-Lapré & Schumaker, 2020; Edwards et al., 2002). Children with above average vocabulary abilities may also be described as 'lexically precocious'. In other research, 2-year-old children have been described as lexically precocious when they present with an expressive vocabulary score either above the 90th percentile (e.g., Kehoe et al., 2015; Kehoe et al., 2018), or at or above the 85th percentile (Smith et al., 2006). Hearnshaw et al. (2023) described 4–5-year-old children as lexically precocious if they scored at or above the 85th percentile on standardised measures of receptive and expressive vocabulary.

Word learning in lexically precocious children with phonological impairment

Children with phonological impairment who are lexically precocious present an apparent conundrum. On the one hand, the presence of their phonological impairment suggests they may have poor-quality underlying representations, and thus potential difficulties with word learning. On the other hand, their above average vocabulary suggests they may have robust underlying representations and that word learning may be a strength. Nevertheless, 'potential redundancies across the system of inputs and processes that support vocabulary development can provide a means by which an individual's relative strengths compensate for weaknesses' (Samuelson, 2021: p. 120).

Findings from Hearnshaw et al. (2023) provide evidence of such compensations, whereby children with precocious vocabulary abilities had better speech perception performance than children with average vocabulary abilities—regardless of whether they presented with SSDs or typically developing speech. Hearnshaw et al. (2023) used a broad definition of SSD, including children with phonological impairment and/or articulation impairment within their SSD cohort. Given that the nature of the problem underlying these two types of SSD is thought to differ (e.g., Dodd et al., 2018), there is a need to further examine these relationships in children with phonological impairment only. If lexically precocious children (i.e., strength in vocabulary) both with and without phonological impairment (i.e., either strength or difficulty in learning the phonological system of the ambient language) have better speech perception abilities than children with average vocabulary, will lexically precocious children both with and without phonological impairment also be better word learners? It is also possible that heterogeneity in vocabulary knowledge of children with phonological impairment may explain previous inconsistent results in word learning research (e.g., McDowell & Carroll, 2012; Storkel, 2004; Storkel et al., 2010). It may be that some but not all children with phonological impairment have difficulties with word learning. However, we do not yet know how to identify these children. By examining the word learning abilities of children with phonological impairment and lexically precocious vocabulary, we may gain richer insight into the process of word learning, as well as the underlying nature of phonological impairment. To our knowledge, such a study has not been done.

Aim and hypotheses

The aim of this study was to examine the word learning abilities of children with and without phonological impairment and to explore the relationship between their ability to learn words and their speech perception, speech production, and vocabulary knowledge. By doing so, we hoped to gain insight into the underlying nature of phonological impairment. Using a complementary analysis approach (Perry & Kucker, 2019), we analysed word learning abilities in two ways—by group based on speech production and vocabulary ability, and then by considering speech production, vocabulary, and speech perception abilities, each along a continuum. Considering that word learning is a dynamic process that evolves with time (Jackson et al., 2019; Samuelson, 2021), and that the ability to learn words can be measured in various ways (Jackson et al., 2019), we also included two different measures of word learning—confrontation naming and story retell naming, both involving target non-words, 1 week after initial exposure. We chose to look at naming as we were interested in an everyday, measurable, functional use of words and because it is a widely used measure in both research (e.g., Jackson et al., 2019) and clinical practice. We chose story retell naming based on Vlach (2019) who suggested that children may better remember words in the context in which they were learned. We chose to examine naming at 1 week post-initial exposure because we were interested in consolidation of learning, rather than just initial fast mapping and encoding of word learning.

Our research questions were as follows:

1. Is there a significant difference in word learning ability—measured as (a) confrontation naming after 1 week; and (b) naming during story retell after 1 week—between children aged 4–5 years grouped according to (i) speech production ability and (ii) vocabulary ability?

Hypothesis: We hypothesised that (i) children with typically developing speech would learn words better than children with phonological impairment; and (ii) children with above average vocabularies would learn words better than children with average vocabularies.

2. Do speech perception, speech production, and vocabulary abilities predict variance in word learning ability in children—measured as (a) confrontation naming after 1 week; and (b) naming during story retell after 1 week?

Hypothesis: We hypothesised that speech perception, speech production, and vocabulary would all predict variance in word learning ability, however vocabulary would be the strongest predictor.

METHOD

Participants

A total of 67 participants aged 48–69 months (36 male, 31 female) were recruited for this study from Canberra, Australian Capital Territory (ACT), Australia and the surrounding region via advertisements shared on parenting group social media sites and in private speech pathology clinics. Children in this study completed multiple experimental tasks, with other results reported elsewhere (e.g., Hearnshaw et al., 2023). Children's gender is reported as determined by parents/caregivers circling their child's gender—male/female—on a demographic questionnaire. All children in this study spoke Australian–English and presented with normal hearing—passing a pure tone audiometric hearing screening at 30 dB for 500, 1000, 2000 and 4000 Hz—and age-appropriate oral structures and functions (based on Robbins & Klee, 1987). Children were excluded if they presented with childhood apraxia of speech, childhood dysarthria, an identified cause for their speech difficulty including cleft palate or hearing loss, and/or a diagnosed developmental delay or autism. Children were also excluded if they presented with articulation impairment only (i.e., phonetic errors of distortion) given our focus on phonological impairment (see Hearnshaw et al., 2023 for further details regarding the articulation impairment diagnostic procedures).

Results from 49 participants (24 male, 25 female) were included in our final analyses. A total of 18 children were excluded due to: presenting with articulation impairment only ($n = 12$), only completing one of the two required assessment sessions ($n = 3$), not passing the hearing screening in either session ($n = 2$) and non-compliance across multiple tasks ($n = 1$). For the purposes of this study, a sample size of 49 is similar to the sample sizes of 50 and 54 participants in McDowell and Carroll (2012) and Storkel et al. (2010), respectively.

Socio-economic status (SES) was measured using (i) mother's highest education level and (ii) residential postcode. Participants' mothers had a mean and median highest education level of a completed bachelor's degree. The range was completion of Year 10 (11 years of formal schooling) through to completion of a postgraduate qualification. The Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD; Australian Bureau of Statistics, 2018) was used to measures SES by residential postcode, based on data collected in the 2016 Australian census. The most disadvantaged areas are indicated by a decile of 1, while the most advantaged areas are indicated by a decile of 10. Comparing with postcodes across the whole of Australia, the mean decile score was 9.4, the median was 10, and the range was 8–10. This means the sample came from a high SES background, which we will address in the discussion section.

For research question one, participants were grouped based on speech production ability. There were 18 children (8 male, 10 female) in the phonological impairment group and 31 children (16 male, 15 female) in the typically developing (TD) group. Children in the phonological impairment group presented with age-inappropriate phonological error patterns—specifically, within the Diagnostic Evaluation of Articulation and Phonology (DEAP)–Phonology Assessment (Dodd et al., 2002), they used at least one age-inappropriate phonological pattern-based error (as per Appendix D from the DEAP Manual; Dodd et al., 2002) on at least five opportunities. Children in the TD speech group presented with no phonological pattern-based errors not appropriate for their age (as per Appendix D from the DEAP Manual; Dodd et al., 2002). For research question two, participants were not divided into groups, and instead, their speech production abilities were analysed continuously. DEAP–Phonology Assessment (Dodd et al., 2002) raw scores ranged from 38 to 141 (total = 141, average = 117).

For research question one, participants were also grouped based on vocabulary ability. There were 21 children in the lexically precocious group. They all scored at or above the 85th percentile on both the Peabody Picture Vocabulary Test–4 (PPVT-4; Dunn & Dunn, 2007) and the Expressive One Word Picture Vocabulary Test–4 (EOWPVT-4; Martin & Brownell, 2011). Within the lexically precocious group, six participants presented with phonological impairments and 15 presented with typically developing speech. A receptive and expressive vocabulary cut-off at or above the 85th percentile was selected because: (a) scores are greater than 1 SD (standard deviation) above the mean and are labelled 'moderately high' to 'extremely high' scores based on the PPVT-4 test form (Dunn & Dunn, 2007); and (b) Smith et al. (2006) used an expressive vocabulary cut-off of the 85th percentile in their study of lexically precocious 2-year-olds. For research question two, participants were not divided into groups, and instead their vocabulary abilities were analysed continuously. PPVT-4 (Dunn & Dunn, 2007) raw scores ranged from 54 to 135 (average = 97). EOWPVT-4 (Martin & Brownell, 2011) raw scores ranged from 37 to 102 (average = 75). See Table 1 for participant characteristics.

TABLE 1 Participant characteristics.

	PI[a] group		TD[b] group	
	***M* (range)[c]**	**SD[d]**	***M* (range)[c]**	**SD[d]**
Age (months)	55.06 (48–69)	5.65	57.58 (48–68)	5.50
DEAP[e] (PCC[f])	70.05 (27–87.2)	15.21	91.03 (80.9–100)	5.25
PPVT-4[g] (raw score)	93.00 (54–135)	22.46	99.90 (64–134)	17.30
PPVT-4[g] (standard score)	113.83 (87–139)	14.18	116.29 (92–141)	12.43
EOWPVT-4[h] (raw score)	71.89 (37–102)	16.61	77.52 (53–96)	11.19
EOWPVT-4[h] (standard score)	117.11 (85–146)	14.77	120.23 (86–140)	13.43
SES[i] (mother's highest education level)	Bachelor's degree (vocational training—postgraduate qualification)	High school not completed: 0 Completion of high school: 0 Vocational training: 4 Bachelor's degree: 11 Postgraduate qualification: 3	Bachelor's degree (high school—postgraduate qualification)	High school not completed: 1 Completion of high school: 2 Vocational training: 7 Bachelor's degree: 16 Postgraduate qualification: 5

Note: [a]Phonological impairment; [b]typically developing; [c]mean; [d]standard deviation; [e]*Diagnostic Evaluation of Articulation and Phonology–Phonology Assessment*; [f]percentage of consonants correct; [g]*Peabody Picture Vocabulary Test–4;* [h]*Expressive One Word Picture Vocabulary Test–4;* [i]socio-economic status.

Procedure

The first author visited each participant in their homes for two testing sessions that took place 1 week apart. Session length ranged from 60 to 120 min. This research project was approved by the University of Sydney Research Ethics Committee (HREC; project number 2017/887). Parents/caregivers provided written consent for children to participate in this study. Standardised tests were used to assess children's speech production (DEAP–Phonology Assessment; Dodd et al., 2002), receptive vocabulary (PPVT-4; Dunn & Dunn, 2007) and expressive vocabulary (EOWPVT-4; Martin & Brownell, 2011) abilities. Children also completed novel experimental word learning and speech perception tasks. Sessions were audio and video recorded with parent/caregiver written consent. Figure 1 shows the structure and content of sessions 1 and 2.

Novel experimental word learning task

Word learning was assessed using an experimental computer-based word learning task. Novel non-words were presented via stories.

Target words

Eight target non-words were selected across four different word-initial phonemes—/k, ʧ, ɹ, ʃ/. These word-initial phonemes are the same as those targeted in a novel speech perception assessment (described in the *Experimental Australian-English Speech Perception Task* section). Non-words were used to control for the possible confounding effects of individual differences in real-word knowledge across participants. To ensure variety and balance across target non-words, for each initial phoneme we selected one target non-word with high PP and ND—chet (/ʧɛt/), shoak (/ʃoʊk/), reen (/ɹin/), kirn (/kɜn/)—and one target non-word with low PP and ND—chorm (/ʧɔm/), shoub (/ʃoʊb/), rirp (/ɹɜp/), koof (/kuf/). The consonant–vowel–consonant nonsense words child corpus spreadsheet supplemental material from Storkel (2013) was used to identify non-words and their PP and ND.

Stories

Each pair of non-words with the same initial phoneme was assigned to one of four pictures; two animals—tapir and stoat—and two fruit—horned melon (kiwano) and rambutan. These animals and fruit were selected as they were considered likely to be unfamiliar to the children participating in the study. These non-words were introduced in novel pre-recorded stories presented via computer. Listening to stories is a familiar and often engaging activity for children, and presenting new words via stories mirrors real-life where children are incidentally exposed to new words when listening to stories (Justice et al., 2005). One non-word was included in each story. Each story contained 170 words, including: 10 presentations of the target non-word; eight presentations of words that rhymed with the target non-word (four presentations of two different words; for example, rhyming words for *chorm* were 'storm' and 'warm', rhyming words for *reen* were

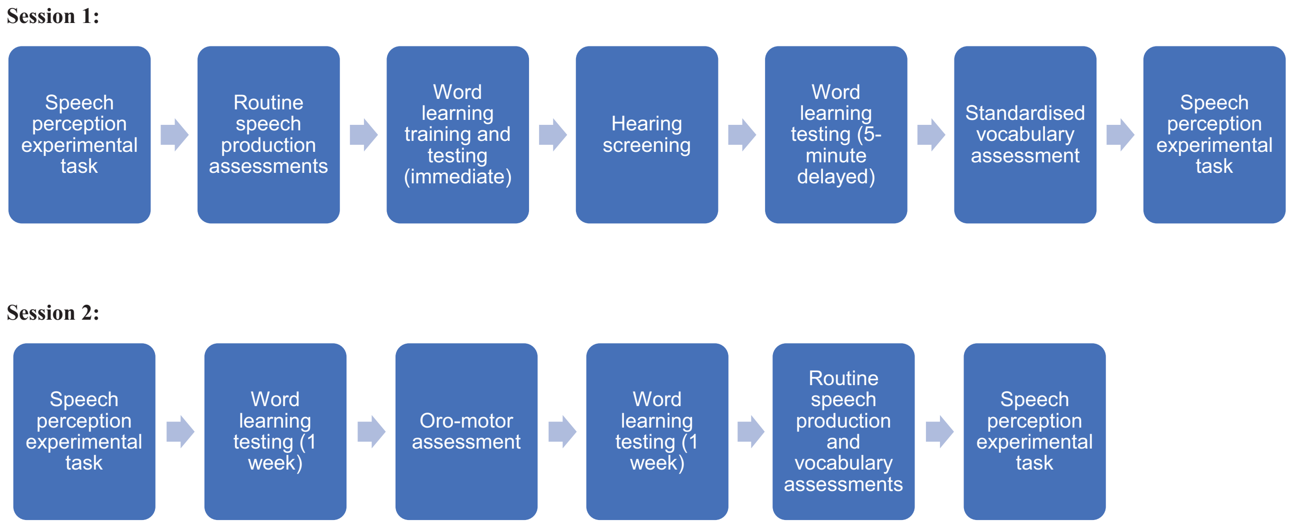

FIGURE 1 Structure and content of sessions 1 and 2. [Colour figure can be viewed at wileyonlinelibrary.com]

'green' and 'seen'); seven adjectives; and no words with the same initial phoneme as the target word. Rhyming words have been found to support word learning (e.g., Read, 2014; Read et al., 2014). Stories were created using Microsoft® PowerPoint. Photos and text were placed on 10 slides. A female adult Australian-English speaker (the first author) recorded the audio for each story. The story scripts are included in Supplement 1 and example visual stimuli are included in Supplement 2 online. Stories were then converted to a video file for presentation to participants. In the video file all four stories were presented consecutively in the one file.

Word learning task procedure

During training, participants were introduced to the four novel referents (two animals and two fruit) by listening to the four pre-recorded stories presented on a computer. The selection of target non-words and order of story presentation were randomised for each participant, so each participant was introduced to one non-word for each initial phoneme—one animal with high PP and ND, one animal with low PP and ND, one fruit with high PP and ND, and one fruit with low PP and ND. For example, one participant may have been allocated 'chet, shoub, reen, koof', while another was allocated 'rirp, kirn, chorm, shoak'. During testing, participants completed two tasks to assess their word learning of the novel non-words—confrontation naming and story retell. At the end of session 1, the participants' parents/caregivers were provided with a digital copy of the four stories and a log sheet. Participants were instructed to watch the stories three times during the week between the two sessions and parents/caregivers were asked to note on the log sheet what days they watched the stories. The stories were not presented in session 2, but confrontation naming and story retell tasks were completed again.

Of the 49 participants, 46 were reported by parents/caregivers to have watched the stories three times between the two sessions as instructed. Parents/caregivers of three participants reported they had forgotten the homework and these children had not watched the stories between sessions. Additionally, for one of these participants who did not complete the homework, the second session was completed 1 week and 4 days following session 1 as the family rescheduled the session. For all other 48 participants, sessions 1 and 2 were completed 1 week apart.

Confrontation naming. At the end of each story presented during session 1, participants completed the immediate naming task where they were asked to name a picture of the novel animal or fruit that had just been presented in the story. One picture at a time was displayed on the laptop screen for the child to name. Children were instructed: 'Now, we're going to look at a picture from the story. What was this called in the story?' One point was given for each non-word named correctly spontaneously (out of a maximum of four points). Where children made speech production errors consistent with their production errors on the DEAP–Phonology Assessment (Dodd et al., 2002), these productions were counted as correct for the purpose of naming of the target non-word and were given one point. Naming was then tested again after a 5-minute delay during which the hearing screening was administered. Naming was tested again during the second session 1 week after the first session. The stories were not played during this session. For both 5-minute delayed and 1 week naming, the same scoring criteria were used as for the immediate naming task.

Story retell. Following a 5–10-minute gap after the confrontation naming task during sessions 1 and 2, participants were asked to retell each story. Children were instructed: 'We're going to look at the stories again. I want you to tell me what happened in the stories.' No names were provided. The researcher presented the pictures from each story in order with text and audio removed. On each screen of the story the participant was asked to tell the researcher what happened in the story. Only non-specific cues were provided, for example, 'Can you remember what happened in the story?', 'What happened next?'. The same scoring criteria were used as for the naming tasks, with 1 point given for each of the four target non-words named correctly within the story retell.

Experimental Australian-English speech perception task

An experimental computer-based Australian-English lexical and phonetic judgment task was used to assess participants' speech perception abilities. The tool is described in Hearnshaw et al. (2018, 2023) and was based on Rvachew's *Speech Assessment and Interactive Learning System (SAILS)* program (Rvachew, 2009).

Target words

Eight different words were assessed across four word-initial phonemes—/k, ʧ, ɹ, ʃ/ (the same onset phonemes for the novel non-words introduced in the word learning task). The target words were: 'cat, coat, chain, chin, rat, rope, sheet, shoe'. A total of 24 productions of each word were included; spoken by three male and three female adults and three male and three female children with accurate speech productions, and six male and six female children with speech errors—that is, 12 correct productions and 12 errored productions per target word. Errored productions included an error on the initial phoneme only. Each target word was presented across two modules of 12 words. In total, children listed to 192 speech samples across 16 modules. The first two authors had 100% agreement on the lexical and phonetic accuracy of each production.

Speech perception task procedure

Participants were seated before a laptop connected to a Psychological Software Tools Serial Response Box™ with two buttons: one showing a happy face and one showing a sad face. Two pictures were displayed on the laptop screen—one depicting the target word and the other depicting the target word covered by a red cross. The spatial location of the pictures on the screen corresponded to the position of the happy and sad face buttons on the Serial Response Box™. During each module, participants listened to three practice items (that were not included in the scoring), followed by 12 test items of a single target word, each spoken by a different speaker. Participants heard a production of a target word (e.g., 'cat'). They used lexical (i.e., target word containing relevant target phoneme) and phonetic (i.e., clear phonetic production of the target phoneme) judgment to decide whether each presentation was correct or incorrect. If the participant thought a presentation was correct (e.g., /kæt/), they pressed the happy face button. If the participant thought a presentation was incorrect (e.g., /tæt/), they pressed the sad face button. Children's response accuracy was recorded by E-prime® and listed against the codings allocated by the first two authors. The final outcome measure of speech perception used in the analyses was overall number of words classified accurately as 'correct' versus 'incorrect' out of a total of 192. Children received one point per target word they accurately classified as correct versus incorrect. A brief animated picture was displayed on the laptop screen at the end of each module. Participants and the examiner wore headphones throughout the speech perception task.

The 16 modules of the task—cat 1, cat 2, coat 1, coat 2, chain 1, chain 2, chin 1, chin 2, rat 1, rat 2, rope 1, rope 2, sheet 1, sheet 2, shoe 1, shoe 2—were presented across four blocks of four modules (one at the beginning and end of each session). This division of 192 trials into four blocks of 48 was necessary to support the attention and concentration of participants. The order of stimuli and modules was randomised for each participant. Each block contained one module per phoneme; four in total. There was no significant difference between speech perception performance in session 1 versus session 2 ($t[48] = 0.053$, $p = .958$) or at the beginning versus the end of each session (session 1: $t[48] = 0.674$, $p = .504$; session 2: $t[48] = 1.329$, $p = .190$).

Reliability

The first author performed the initial transcriptions and then re-transcribed a randomly selected 10% of the DEAP–Phonology Assessment (Dodd et al., 2002) to check intra-rater reliability. Point-by-point intra-rater reliability was 98.1% based on 1100 points. To check inter-rater reliability, the second author transcribed the same randomly selected 10% of the DEAP–Phonology Assessment (Dodd et al., 2002). Point-by-point inter-rater reliability was 95.8% based on 1100 points. Calculation of Cohen's κ showed there was substantial agreement between the two authors' transcriptions, $\kappa = .721$, $p < .001$.

Data analysis

Data were analysed by group using independent-samples t-tests and Mann–Whitney U-tests, and continuously using multiple linear regression. The dependent variables were two measures of word learning ability: (a) confrontation naming at 1 week; and (b) story retell naming at 1 week. For each dependent variable, children's scores ranged from 0 (no words correctly recalled) to 4 (all words correctly recalled). A p-value less than .05 was considered statistically significant. Effect sizes were calculated using Cohen's d and Pearson's R^2. A d-value of .25 represents a small effect, .55 a medium effect and .95 a large effect (Gaeta & Brydges, 2020). An R^2-value of .06 represents a small effect, .16 a medium effect and .42 a large effect (based on Gaeta & Brydges, 2020). Data were analysed using R (R Core Team, 2022; version 4.1.2) in Rstudio (R Studio Team, 2022; version 2021.09.0). Data manipulation and plotting were completed using the tidyr (Wickham & Girlich, 2022; version 1.2.0) and ggplot2 (Wickham, 2016; version 3.3.5) packages.

RESULTS

Speech production, vocabulary and word learning: By-group analyses

Speech production

Confrontation naming at 1 week

Figure 2a shows a violin plot displaying performance on the confrontation naming task at 1 week for the phonological impairment and TD groups. Given that the residual errors from the speech production data were not normally distributed, a Mann–Whitney U-test was used and showed no significant difference in word learning performance between groups, $W = 349.5$, $p = .122$, $d = .427$ (small effect). The median number of target non-words named correctly was similar for children in the phonological impairment (median = 0, SD = 1.127) and TD (median = 1, SD = 1.290) groups.

Story retell naming at 1 week

Figure 2b shows a violin plot displaying performance on the story retell naming task at 1 week for the phonological impairment and TD groups. A Mann–Whitney U-test (residual errors of the data not normally distributed) showed no significant difference in word learning performance between groups, $W = 340$, $p = .199$, $d = .368$ (small effect). The median number of target non-words named correctly when retelling the stories was similar for children in the phonological impairment (median = 1.5, SD = 1.505) and TD (median = 2, SD = 1.253) groups.

Vocabulary

Confrontation naming at 1 week

Figure 3a shows a violin plot displaying performance on the confrontation naming task at 1 week for the average vocabulary and precocious vocabulary groups. An independent-samples t-test showed a significant difference in word learning performance between groups, $t(47) = -3.865$, $p < .001$, 95% CI = [−1.864, −0.588], $d = 1.066$ (large effect). The mean number of target non-words named correctly was lower for children in the average vocabulary group (mean = 0.536, SD = 0.744) than in the precocious vocabulary group (mean = 1.762, SD = 1.446).

Story retell naming at 1 week

Figure 3b shows a violin plot displaying overall performance on the story retell naming task at 1 week for the average vocabulary and precocious vocabulary groups. An independent-samples t-test showed a significant difference in word learning performance between groups, $t(47) = -3.422$, $p = .001$, 95% CI = [−1.928, −0.501], $d = .996$ (medium effect). The mean number of target non-words named correctly when retelling the stories was lower for children in the average vocabulary group (mean = 1.643, SD = 1.283) than in the precocious vocabulary group (mean = 2.857, SD = 1.153).

Speech production, vocabulary, speech perception and word learning: Continuous analyses

Speech production, vocabulary, and speech perception

Confrontation naming at 1 week

A multiple linear regression analysis was run to examine the influences of speech production accuracy (DEAP–Phonology Assessment raw score), vocabulary (mean z-score calculated from PPVT-4 and EOWPVT-4 raw scores), and speech perception (total number correct on the speech perception task) on word learning performance (confrontation naming at 1 week). Correlations between the four predictor measures are presented in Supplement 3 online, along with histograms, quantile–quantile (qq) plots, and Shapiro–Wilk tests showing normality of the residual errors for each multiple regression model, as well as the distribution of the four predictor measures. This regression model included additive terms with no interactions. Due to the presence of multicollinearity between receptive and expressive vocabulary ($r = .800$, $p < .001$), a single composite vocabulary score was calculated averaging across PPVT-4 and

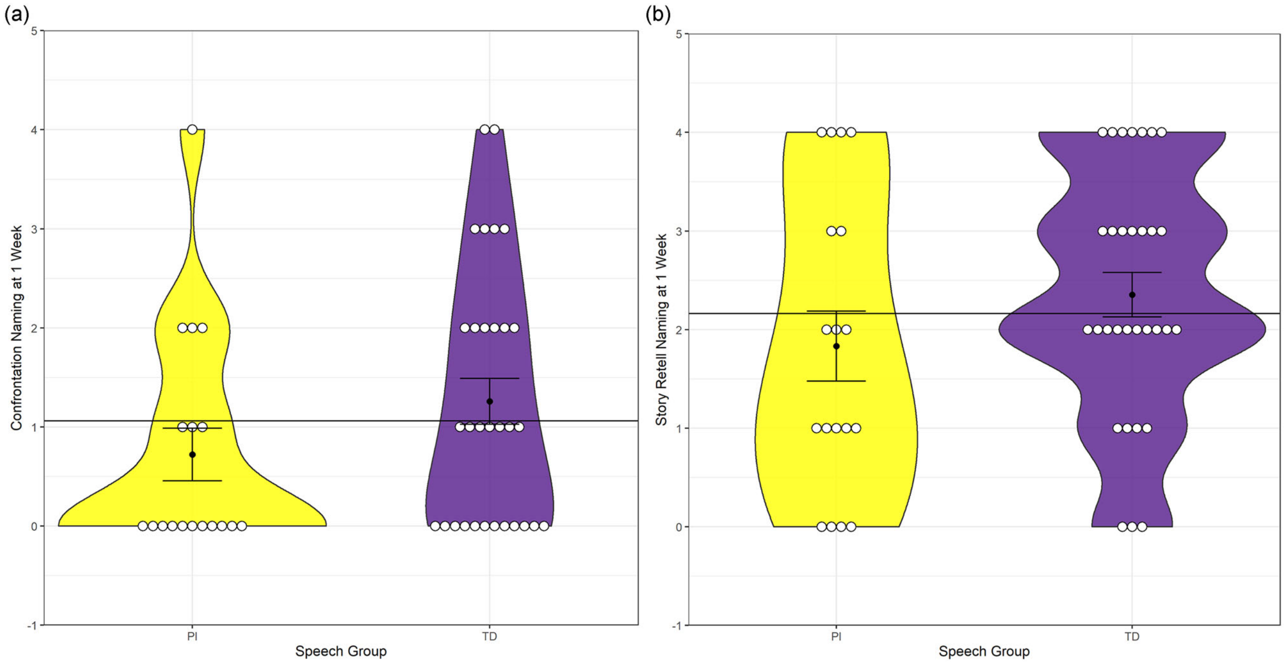

FIGURE 2 Violin plots displaying word learning performance for the phonological impairment (PI) and typically developing (TD) groups: (a) confrontation naming at 1 week; and (b) story retell naming at 1 week. [Colour figure can be viewed at wileyonlinelibrary.com]

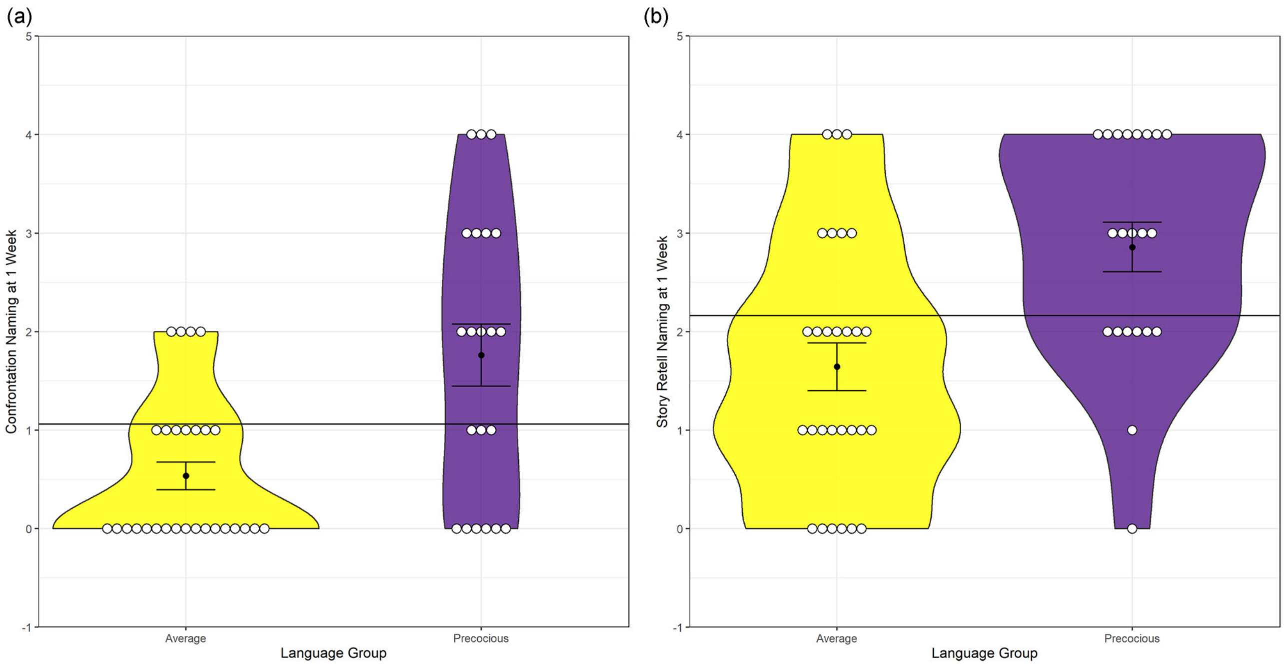

FIGURE 3 Violin plots displaying word learning performance for the average vocabulary and precocious vocabulary groups: (a) confrontation naming at 1 week; and (b) story retell naming at 1 week. [Colour figure can be viewed at wileyonlinelibrary.com]

EOWPVT-4 raw scores for each participant. Due to the PPVT-4 and EOWPVT-4 tests being scored on different scales, we also converted each measure to a *z*-score before averaging across receptive and expressive vocabulary. Vocabulary was the only uniquely significant predictor of word learning performance, accounting for 11.6% of unique variance, $t = 3.225$, $b = .605$, $p = .002$. That is, for every 1 SD increase in vocabulary, children's confrontation naming accuracy increased by .605. However, when combined, these three variables also contributed significantly to word learning and accounted for 28.3% of variance in confrontation naming at 1 week, $F(3, 45) = 5.918$, $p = .002$, $R^2 = .283$ (medium effect; see Table 2(a) for coefficients and confidence intervals).

TABLE 2 Coefficient tables for multiple linear regression of speech production accuracy (DEAP–phonology assessment raw score), vocabulary (vocabulary *z*-score), and speech perception (total number correct on the speech perception task) on word learning performance: (a) confrontation naming at 1 week; and (b) story retell naming at 1 week.

	Coefficients	Standard error	*t*-statistic	*p*-value	Lower 95%	Upper 95%
(a)						
(Intercept)	−.580	1.518	−.382	.704	−3.637	2.477
DEAP raw score	−.002	.009	−.168	.868	−0.020	0.017
Vocabulary *z*-score	.605	.187	3.225	.002	0.227	0.982
Speech perception score	.012	.010	1.206	.234	−0.008	0.033
(b)						
(Intercept)	.388	1.680	.231	.818	−2.996	3.772
DEAP raw score	.007	.010	.679	.501	−0.014	0.028
Vocabulary *z*-score	.594	.208	2.862	.006	0.176	1.012
Speech perception score	.006	.011	.569	.572	−0.016	0.029

Story retell naming at 1 week

A multiple linear regression analysis was run to examine the influences of speech production accuracy (DEAP–Phonology Assessment raw score), vocabulary (mean *z*-score calculated from PPVT-4 and EOWPVT-4 raw scores), and speech perception (total number correct on the speech perception task) on word learning performance (story retell naming at 1 week). This regression model included additive terms with no interactions. Again, vocabulary was the only significant predictor, accounting for 8.0% of unique variance, $t = 2.862$, $b = .594$, $p = .006$. That is, for every 1 SD increase in vocabulary, children's story retell naming accuracy increased by .594. These three variables combined once again contributed significantly to word learning and accounted for 25.9% of variance in story retell naming at 1 week, $F(3, 45) = 5.236$, $p = .003$, $R^2 = .259$ (medium effect; see Table 2(b) for coefficients and confidence intervals). While the main focus of our continuous analyses was the multiple linear regression with all variables of interest combined, results from simple linear regression analyses for each variable—speech production, vocabulary, speech perception—and each of the two measures of word learning—confrontation naming and story retell naming—are included in Supplement 4 online. Results from the simple linear regressions match the multiple linear regressions in that the strongest predictor of word learning was vocabulary knowledge.

Post-hoc observations regarding confrontation naming versus story retell naming

The mean number of target non-words named correctly was significantly higher in the story retell naming task at 1 week (mean = 2.163, SD = 1.359) than in the confrontation naming task at 1 week (mean = 1.061, SD = 1.248), $t(48) = 5.957$, $p < .001$, $d = .851$ (medium effect). There was also a moderate correlation between performance on the confrontation naming task at 1 week (mean = 1.061, SD = 1.248) and the story retell naming task at 1 week (mean = 2.163, SD = 1.359), $r = .510$, $p < .001$.

We looked more closely at the results for each of the two naming tasks. Out of a total of 49 participants, three (two with TD speech, one with phonological impairment; all three lexically precocious) named 4/4 target non-words correctly in the confrontation naming task at 1 week and 11 (seven with TD speech, four with phonological impairment; eight lexically precocious, three with average vocabulary) named 4/4 target non-words correctly in the story retell naming task at 1 week. All three participants who named 4/4 target non-words correctly in the confrontation naming task at 1 week also named 4/4 target non-words correctly in the story retell naming task at 1 week. The 11 participants who named 4/4 target non-words correctly in the story retell naming task at 1 week named between 0–4/4 target non-words correctly in the confrontation naming task at 1 week.

As per the *Word Learning Task Procedure* section, three children (one with TD speech, two with phonological impairment; one lexically precocious, two with average vocabulary) did not complete the homework between sessions 1 and 2. All three children who did not complete the homework named 0/4 target non-words correctly in the confrontation naming task at 1 week. However, so did 20 children (eleven with TD speech, nine with phonological impairment; five lexically precocious, fifteen with average vocabulary) who did complete the homework. Two of these three children (one with TD speech, one with phonological impairment; one lexically precocious, one with average vocabulary) also named 0/4 target non-words correctly in the story retell naming at 1 week task, as did five children (two with TD speech, three with phonological impairment; all with average vocabulary) who did complete the homework.

DISCUSSION

In this study, we investigated the word learning abilities of 4–5-year-old children with and without phonological impairment, with typical through to precocious vocabulary abilities. We also considered the relationship between word learning, speech perception, speech production, and vocabulary abilities. When analysed by group, there was no significant difference in word learning ability at 1 week between children with phonological impairment and children with typically developing speech. This was true across measurement contexts—when learning was measured via confrontation naming or story retell naming. Children with precocious vocabulary abilities were significantly better at word learning than children with average vocabulary abilities. When analysed continuously in multiple linear regression, vocabulary was the only significant predictor of word learning ability.

No difference in word learning ability of children with and without phonological impairment: Why?

Our results did not show a significant difference in word learning performance (i.e., number of target non-words accurately named to their referent) between children in the phonological impairment and TD groups. This aligns with research by McDowell and Carroll (2012) who found no significant difference in the number of words learned by children with typically developing speech versus children with speech sound inaccuracies. However, the findings do not match our hypothesis or our understanding of the representation-based approach to phonological impairment. Why might this be the case?

First, although there was no group difference, this does not mean all children with phonological impairment have robust word learning abilities. Children with SSDs are heterogeneous and have differing strengths and needs across other abilities (e.g., Hearnshaw et al., 2019; Hearnshaw et al., 2023). Our research adds to previous literature showing that some children with phonological impairment—with average to above average vocabulary—appear to have similar word learning abilities to their typically developing peers (e.g., McDowell & Carroll, 2012). One important consideration is the proportion of children in the phonological impairment group in the current study who presented with lexically precocious vocabulary abilities (33%). When we consider the results from the continuous analysis this is noteworthy because vocabulary was such a strong predictor of word learning ability—so strong that speech production and speech perception both became non-significant predictors in the multiple linear regression. This aligns with research that has found that existing vocabulary abilities may be a stronger predictor of speech perception abilities more so than speech production abilities in children with and without SSDs (e.g., Edwards et al., 2002; Hearnshaw et al., 2023). Results from the current study extend this finding by showing that this is also true for word learning; including for children with phonological impairment where speech may be a presumed predictor. Perhaps for lexically precocious children, underlying phonological representations become more robust, simply because they have more experience in creating representations and building vocabulary knowledge. This does not, however, elucidate why these children have phonological impairment.

This idea that the ability to learn words is more intricately connected to vocabulary knowledge than the ability to perceive or produce speech offers a way forward in explaining the alignment with McDowell and Carroll (2012) as well as differences between other studies. Specifically, in the study by McDowell and Carroll (2012), the participants ranged in age from 5;2 to 6;6 years (approximately a year older than the children in the current study) and had vocabulary abilities within the normal range (albeit a mean PPVT standard score of 110 [TD group] and 105 [speech sound inaccuracies group]). They also received intervention targeting word learning in twice weekly 30-minute sessions for 11 weeks and found no difference in the overall number of words learned between the groups. In the current study, the children were aged 48–69 months and exposed to novel words in an experimental task (i.e., no teaching or feedback) and tested on a pre-post-interval of 1 week. Perhaps the 33% of children with phonological impairment in the current study who were lexically precocious were able to rapidly learn words within the week, like their TD peers, hence the similarity between findings. Storkel (2004) and Storkel et al. (2010) focused on which lexical properties facilitate word learning and reported a difference in types of words learned between their groups, however the participants with phonological impairment in Storkel (2004) had an average PPVT-3 standard score of 105, whereas the age- and vocabulary-matched TD group had a mean standard score of 112. Again, perhaps vocabulary abilities underlie the findings in word learning performance. These postulates aside, two other issues could inform our understanding of the results.

The word learning measures considered in our study were measures from 1 week post-initial exposure. Children were introduced to the novel non-words during session 1 and watched the stories three times in the week between sessions 1 and 2. However, the stories were not watched during session 2. This means memory was particularly important to performance on the word learning assessment tasks and may have impacted performance, as we were testing consolidation, rather than fast mapping or encoding. According to Vlach (2019: p. 160), 'there are significant memory constraints on word learning and language acquisition'. The role of memory in word learning of children with phonological impairment would be a valuable line of inquiry for future research, particularly given the extent of unexplained variance in the children's word learning performance.

The PP and ND characteristics of the target non-words in our study were controlled. Previous research has experimentally investigated these characteristics; reporting differences between groups of children with typical speech versus phonological impairment with regards to types of words learned (e.g., McDowell & Carroll, 2012; Storkel, 2004; Storkel et al., 2010). This difference in stimuli may therefore explain differences between findings from our study and previous research. Given that McDowell and Carroll (2012) studied both the number and types of words learned and did not find a difference between speech groups with regards to number, but did with regards to type, more research is needed. Specifically, it would be valuable to determine whether lexically precocious children with phonological impairment align with peers with typically developing speech both in terms of number and lexical characteristics of words learned in word learning tasks, or whether the difference in characteristics of words learned is retained. If the finding is the latter, this might contribute to greater insight about the nature of phonological impairment.

Vocabulary is significant and predicts variance in word learning ability

As hypothesised, there was a significant difference in word learning ability between children with above average versus average vocabulary abilities. Additionally, vocabulary was the strongest predictor of variance in word learning ability. These findings are not surprising when we consider the close connection between vocabulary and word learning—word learning is the process of adding words to vocabulary (Samuelson, 2021; Samuelson & McMurray, 2017; Storkel et al., 2010).

The significant role of vocabulary in both children with phonological impairment as well as children with typically developing speech prompts discussion regarding different profiles of strengths and needs in children. Children have differing experiences with and qualities of underlying abilities involved in word learning (Samuelson, 2021). For some children, difficulties with one or more abilities will lead to poorer word learning abilities. For other children, strengths in other abilities will be enough to overcome these difficulties so they present with robust word learning abilities (Samuelson, 2021). While children with phonological impairment presented with pattern-based speech production errors, lexically precocious children with phonological impairment also have a strength in vocabulary and word learning abilities. This adds to findings from Hearnshaw et al. (2023) and Rvachew and Brosseau-Lapré (2015) in suggesting that good word learning and high vocabulary abilities in children with phonological impairment may act as a protective factor for other abilities.

But what does contribute to a child being or becoming lexically precocious? We can consider linguistic and cognitive abilities such as speech perception, attention and memory, and capacity for learning. It is also important to acknowledge potential environmental contributions such as SES, parental education levels, school/childcare, joint book reading, and the quality and quantity of speech and language children have been exposed to.

Insights from complementary measures: Confrontation naming versus story retell

There were no notable differences in word learning results for each separate analysis when word learning was measured using confrontation naming versus story retell. However, children named significantly more target non-words correctly in the story retell compared with the confrontation naming task. Additionally, when examined descriptively, there were differences in performance across the two word learning tasks. Of the 49 participants, 31 named more target non-words correctly in the story retell naming task at 1 week than in the confrontation naming task at 1 week. Four participants named more target non-words correctly in the confrontation naming task, and 14 named the same number correctly in each task. As observed in the *Results* section, more participants named all four target non-words correctly in the story retell naming task at 1 week ($n = 11$), compared with the confrontation naming task at 1 week ($n = 3$). All children who named all four target non-words correctly in the confrontation naming task at 1 week also named all four target non-words correctly in the story retell naming task at 1 week, however this was not the same for the children who named all four target non-words correctly in the story retell naming task at 1 week.

Different measures of word learning vary in difficulty and can provide insight into a range of underlying abilities

(Adlof & Patten, 2017). Confrontation naming has been observed to be difficult—for example, floor effects were seen for the naming task in Adlof and Patten (2017). By contrast, while new words are often taught via stories (e.g., Hoover et al., 2010; Justice et al., 2005; Storkel et al., 2017), we are not aware of other studies that have also tested naming during a story retell task. According to Vlach (2019), children may better remember words in the context in which they were learned. This provides support for using story retell to test word learning of words taught via stories. Additionally, the story context has the potential to provide semantic cues and carrier phrases which may support word recall.

It was also interesting to observe different participants' awareness of the apparent self-cueing provided by the story retell task. For instance, Participant 32 presented with typically developing speech and lexically precocious vocabulary abilities. Her confrontation naming at 1 week score was 2/4, while her story retell naming at 1 week score was 3/4. During the story retell naming task in session 2, she had two instances of saying the correct target non-word without initially realising. First, when retelling the story for 'koof' (a type of fruit), Participant 32 did not use the correct name until the final (10th) slide where she said: 'Dad picked up the koofs. *I do remember!* [emphasis added]'. In her retell before this point, she had referred to it as 'fruit' or 'it'. Then, when retelling the story for 'chorm' (an animal), on the first slide, Participant 32 said: 'Um, um, I've got a pet chorm. *Chorm! I remembered the chorm!* [emphasis added]'. Participant 6 presented with a phonological impairment and average vocabulary abilities. Her confrontation naming at 1 week score was 0/4, while her story retell naming at 1 week score was 1/4. When retelling the story for 'rirp' (the other type of fruit), Participant 6 did not use the correct target non-word until the final (10th) slide: 'And then the girl said 'Oh, rirps are y-' *Oh, I just said rirp!* [emphasis added]'. Previously she also referred to it as 'fruit' or 'it'. It is possible that these children had incomplete or partial knowledge of these target non-words (as per Justice et al., 2005; McDowell & Carroll, 2012). That is, they were able to use the target non-word appropriately in a sentence (Justice et al., 2005) when additional semantic context was provided by the story, but were less successful naming the target when seeing a picture of the referent in isolation.

Two other possible examples of incomplete or partial knowledge of target non-words were observed. First, in participants who produced target non-words differently at different points of the story retell—for example, referring to the 'kirn' as a /tɜn/, a /θɜn/, and a /fɜn/. Second, in participants who produced target words with one phoneme incorrect (that was not one of their known speech errors)—for example, referring to the 'rirp' as a /dɜp/. More in-depth error analysis and evidence of partial knowledge is an important area for future research.

There are a few important considerations. First, the confrontation naming task in session 2 only provided one opportunity to name each target non-word. By contrast, the story retell task provided multiple opportunities across 10 story pages to use each target non-word. Second, each participant completed the word learning tasks in the same order—confrontation naming followed by story retell naming, with a 5-minute break in between. While the examiner did not name any of the target non-words or provide cueing or feedback about their performance during the confrontation naming task, it is possible that this task may have primed performance on the later story retell naming task.

Novel insights about word learning in children with phonological impairment: Theoretical implications

Findings from the current study have theoretical implications regarding the underlying nature of phonological impairment in children. When considering the representation-based account, children with phonological impairment have been hypothesised to present with poor quality underlying representations of words (e.g., Edwards et al., 1999; Sutherland & Gillon, 2005). However, in this study, some children with phonological impairment presented with an impressive ability to learn new words and, as a group, were not significantly poorer word learners than children with typically developing speech. What then could be the nature of the problem for these children?

One option is that the locus of the difficulty for lexically precocious children with phonological impairment may be in abstracting or revising well-established, highly practiced phonological rules rather than in establishing and using quality underlying representations (e.g., Waring et al., 2022). This idea echoes early accounts of the nature of the problem from the 1970s and 1980s (e.g., Grunwell, 1982; Ingram, 1976). Alternatively, for some children perhaps subtle articulation or motor difficulties involving tongue control underlie overt pattern-based errors (e.g., Gibbon & Wood, 2002). Further still, some children may have established phonemic contrasts, but the contrasts may be covert and not detected by adult listeners (e.g., McAllister Byun & Tessier, 2016). These ideas are speculative and would require more detailed instrumental assessment plus acoustic analysis of minimal pair words.

An alternate view that may be worthy of further inquiry is that of anti-representationalism (e.g., Ambridge, 2020; Knabe & Vlach, 2020). The anti-representationalist view posits that knowledge of words does not require stored abstractions. Instead, language knowledge involves only stored exemplars and processes such as memory, attention, and perception (Ambridge, 2020; Knabe & Vlach, 2020). These views also present language as processes that are dynamic and influenced by prior learning (Ambridge, 2020; Knabe & Vlach, 2020). Views from anti-representationalism have been considered in language, and more specifically, word learning research (Knabe & Vlach, 2020). There may also be a place for consideration of these views in the field of phonological impairment in children—especially given the potential advantages of these views in considering change, as well as the influences of context and prior learning. This is a different framework that may account for additional variance in word learning performance, and warrants further investigation. There have been paradigm shifts in the past regarding our understanding of the underlying nature of phonological impairment—from errors of articulation, to a linguistic account of pattern-based phonological errors (Fey, 1986), to a representation-based understanding (Edwards et al., 1999). Perhaps it is time for another paradigm shift to anti-representationalism to account for the additional insight we have into the heterogeneity among children with phonological impairment with average to precocious vocabulary abilities.

Novel insights about word learning in children with phonological impairment: Clinical implications

This study adds support to the need to consider vocabulary as well as other measures of word learning abilities in children with phonological impairment. But why should we study other word learning measures, rather than just considering vocabulary abilities? Clinically, there is a tendency for speech–language therapists (SLTs) to focus primarily on the speech production abilities of children presenting with speech concerns, and vocabulary has not been routinely included in assessment batteries for children with phonological impairment (McLeod & Baker, 2014). However, speech is used functionally in the context of words and language. As the lexicon and phonology develop together, each influencing the other, knowledge of word learning is relevant to speech development. Additionally, SLTs use words to assess and treat speech problems. This is especially relevant to phonological treatments such as 'minimal pairs' which rely on the distinction between different words to teach speech sounds (Baker, 2021). Research has also suggested that both lexical and phonological properties of words can influence treatment focusing on speech sounds, as well as how easily a new word is learned (e.g., Morrisette & Gierut, 2002; Storkel & Morrisette, 2002).

It would also be valuable to include dynamic assessments—both for understanding individual children's abilities and potential for learning, as well as for the purpose of planning optimal management. Researchers such as Cummings and Barlow (2011), Gierut and Morrisette (2010), and Gierut et al. (2010) have proposed that using novel or non-words may be valuable within intervention targeting speech production. Dynamic assessment of word learning could give insight into different children's abilities to cope with interventions that introduce and use novel words. For example, is this approach better suited to lexically precocious children with phonological impairment who are good word learners? This is also an area for future research.

Limitations and future directions

One limitation of this study is that most children in the phonological impairment group presented with a mild–moderate speech impairment. There were also no children with below average vocabulary. Future research could include children with severe through to mild phonological impairment, as well as below to above average vocabulary abilities. Additionally, participants came from high SES backgrounds; living in socially advantaged postcodes and in many cases with well-educated parents. This comes with advantages that may have influenced their word learning abilities; including the high number of lexically precocious children. While participants' families came from different racial and cultural backgrounds, participants also all spoke English as their first language. Hence, findings and conclusions from this study may not be generalisable to the broader Australian population—including children from lower SES backgrounds and children from multicultural, multilingual families. These findings need to be viewed in their sociolinguistic context—largely children from advantaged backgrounds in an advantaged city. Future research could examine lexical precocity and word learning abilities of children from a wider range of backgrounds—including different racial and cultural backgrounds and less socially advantaged families.

Vocabulary, speech perception and speech production combined accounted for 28.3% of variance in word learning when measured as confrontation naming at 1 week and 25.9% of variance in word learning when measured as story retell naming at 1 week. It would be valuable to conduct further research to explore what other variables and abilities, such as memory, are predictors of word learning ability in these children.

Future research could investigate the value of using stories to assess word learning abilities in children with phonological impairment. Our word learning task also only introduced and assessed four novel non-words. More insight may be gained from future research including more target words and a variety of measures of word learning. Finally, there is also a need for further experimental work and theoretical insights into the nature of children's underlying representations, and indeed, the very existence of abstract representations as a way of better understanding the nature of the problem.

CONCLUSIONS

Examining the word learning abilities of children has provided further insight into the underlying nature of phonological impairment, as well as the complex relationship between word learning, speech perception, speech production, and vocabulary abilities in children. There was no significant difference in word learning ability between children with and without phonological impairment, and vocabulary was the strongest predictor of variance in word learning ability. This research adds to the understanding of heterogeneity among children—specifically children with phonological impairment. It also raises questions about the representation-based approach to understanding phonological impairment in children. Our findings also point to a need for future research further exploring children's word learning abilities, as a way to advance our understanding of the nature of phonological impairment.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The datasets generated and analysed during the current study are not publicly available due to ethical restrictions.

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

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