Received: 17 March 2016 | Accepted: 15 May 2017
DOI: 10.1111/desc.12588

PAPER

WILEY Developmental Science

Not all phonological awareness deficits are created equal: evidence from a comparison between children with Otitis Media and poor readers

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Funding information
Nuffield Foundation, Grant/Award Number: EDU/40250

Abstract

Children with reading difficulties and children with a history of repeated ear infections (Otitis Media, OM) are both thought to have phonological impairments, but for quite different reasons. This paper examines the profile of phonological and morphological awareness in poor readers and children with OM. Thirty-three poor readers were compared to individually matched chronological age and reading age controls. Their phonological awareness and morphological awareness skills were consistently at the level of reading age matched controls. Unexpectedly, a significant minority (25%) of the poor readers had some degree of undiagnosed mild or very mild hearing loss. Twenty-nine children with a history of OM and their matched controls completed the same battery of tasks. They showed relatively small delays in their literacy and showed no impairment in morphological awareness but had phonological awareness scores below the level of reading age matched controls. Further analysis suggested that this weakness in phonological awareness was carried by a specific weakness in segmenting and blending phonemes, with relatively good performance on phoneme manipulation tasks. Results suggest that children with OM show a circumscribed deficit in phoneme segmentation and blending, while poor readers show a broader metalinguistic impairment which is more closely associated with reading difficulties.

RESEARCH HIGHLIGHTS

- Children with a history of ear infections (OM) show a wide range of literacy outcomes, with mean literacy and phonological awareness scores below CA controls.
- Children with OM show selective impairments in phonological awareness tasks which involve segmenting and blending phonemes.
- Poor readers are impaired both on phonological and morphological metalinguistic tasks, highlighting that the deficits underlying poor reading cannot be explained in terms of difficulties in input phonology alone.
- Despite this, there was some evidence of similarities between the groups, with previously undetected mild hearing impairments shown by approximately 25% of the poor readers.

1 | INTRODUCTION

It is well established that phonological awareness is causally associated with reading (Hatcher, Hulme, & Ellis, 1994), and that children with reading difficulties normally show impairments in this area (Snowling & Carroll, 2011). Despite this, there is surprisingly little understanding of the nature of this phonological impairment. The phonological deficit theory of dyslexia classically argues that children have difficulties in both phonological awareness and phonological representation (Elbro, Borstrom, & Peterson, 1998; Snowling, 2000; Stanovich & Siegel, 1994). Conversely, Ramus, Marshall, Rosen, and van der Lely (2013) argue that individuals with reading difficulties but no language difficulties show impairments in accessing and processing phonological information, rather than in phonological representations themselves. It is an open question to what extent the phonological deficit in poor readers mirrors those phonological deficits with known aetiology, such as in children with permanent or transient hearing loss. A direct comparison of the language and literacy profile of these groups would allow us to understand the extent to which the phonological impairment in poor readers should be considered a metalinguistic impairment rather than a perceptual impairment.

OM (Otitis Media, middle ear infection) is amongst the most common of childhood infections—83% of children have at least one episode by 3 years old and 46% have multiple episodes (Teele, Klein, & Rosner, 1989). Acute cases can result in accumulation of fluid in the middle ear (OM with Effusion), causing temporary mild-moderate hearing loss (Winskel, 2006). In some cases, OM/OME can even result in permanent conductive hearing loss (Klein, 2000). Prevalence of OM reduces rapidly with age, with a peak in incidence at 6–18 months and few cases occur in non-otitis prone children after 3 years (Klein, 2000).

The period between 12 months and 3 years is, nonetheless, a crucial period for the formation of phonological representations. Some researchers argue that when children first begin to learn words, they store phonological information in terms of global word wholes rather than in terms of a series of phonemes (Ferguson & Farwell, 1975; Walley, 1993). As children learn more words and demands on their lexicon increase, they are thought to reconstruct their phonological representations, and they begin to represent words containing similar sounds in similar ways in the lexicon (Studdert-Kennedy, 1987). Over time, children come to implicitly understand that words are constructed from a finite set of sounds, which are similar across many different words, and governed by a language-specific set of rules (known as phonotactics). This knowledge, broadly measured by phonological processing tasks, is necessary to understand the alphabetic principle when children come to learn to read. Specifically, in order to learn to decode, children must understand that words are made up of a series of phonemes and that these phonemes are in some sense the same over different contexts (Byrne, 1998).

In order to form coherent phonetic categories, a child must be able to recognize phonemes across a variety of contexts. If a child has variable or restricted auditory input during this period, this may well limit their ability to construct these phonemic categories accurately. This in turn might make phonemic awareness tasks difficult, even after any hearing difficulties have resolved. Winskel (2006) argues that children with a history of OM show weaknesses in phonological awareness, semantic knowledge and reading in the school years, although their oral narrative ability is average. These weaknesses in phonological awareness and reading have been replicated elsewhere (Kindig & Richards, 2000; Nittrouer & Burton, 2005), although some studies have indicated that the effects are relatively small (Peters, Grievink, van Bon, & Schilder, 1994) or are only present in children with continuing infections in the school years (Shapiro, Hurry, Masterson, Wydell, & Doctor, 2009). In contrast, there is broad agreement of no significant long-term impairments in broader language skills such as vocabulary (Johnson, McCormick, & Baldwin, 2008; Roberts, Rosenfeld, & Zeisel, 2004).

Most children with reading difficulties have a phonological impairment of unknown aetiology, but in children with OM, we know that the cause of these difficulties is in the auditory input. If we find a different profile of phonological awareness difficulties in the two groups, we might conclude a different cause for the impairment, which would help us to understand more about the causes of reading difficulties. To date, there has been no previous direct comparison between these two groups.

There are, however, comparisons between children with dyslexia and other disorders, most commonly language impairment (Pennington & Bishop, 2009). Ramus and colleagues recently argued for a different type of phonological impairment in dyslexia and language impairment (Ramus et al., 2013). While children with language impairments showed difficulties on all of the phonological tasks, the children with only reading impairments showed relatively good performance on the phonological discrimination and production tasks, and weaker performance on the phonological awareness and short-term memory tasks. The authors argue that reading difficulties are specifically associated with difficulties in processing phonology, rather than in phonological representations themselves. This type of analysis, using a range of tasks with children with different profiles, is potentially useful for further clarifying the nature of the underlying phonological deficit in poor readers, and children with a history of OM make a useful contrast given the established phonological difficulties shown in this group.

The work of Ramus et al. (2013) is unfortunately limited in terms of the control group comparisons that can be made. The control group were not matched either in terms of chronological age or cognitive abilities to the impaired groups. We felt that it was important to have both chronological age and reading ability matched controls for each of our impaired samples. No previous research has compared children with OM with reading age matched controls. This is a standard comparison used in the dyslexia literature to assess whether children with dyslexia show unusual patterns of strengths and weaknesses given their reading experience (Bradley & Bryant, 1978; Joanisse, Manis, Keating, & Seidenberg, 2000). Typically, though not universally, studies show that children with dyslexia have phonological awareness abilities below their reading age matched controls, indicating a specific weakness in this area (Melby-Lervåg, Lyster, & Hulme, 2012). The reasoning with children with OM is slightly different, given that they have not been selected on the basis of having reading difficulties but rather on the basis of possible phonological input difficulties. If children with OM show delayed reading, and phonological awareness scores in line with their reading age matched controls, we would conclude that their reading is progressing as would be expected given their impairments in phonological awareness. If they show phonological awareness below the level of their reading age matched controls, we could conclude that they have underlying phonological difficulties, but that for some reason they have been able to overcome these difficulties. This may be because they have additional compensatory skills, or because their phonological deficit is of a different nature to that shown by children with reading difficulties.

An interesting contrast to phonological awareness is morphological awareness. A morpheme is a single unit that carries meaning. For example, the word “boys” has two morphemes, the root morpheme “boy” and the plural “s”. Morphological awareness is therefore an individual's awareness of the internal structure of words in relation to morphemes. Morphological knowledge is useful in reading and spelling since many words that are phonetically irregular are in fact morphologically determined (Treiman, 1993). For example, the word "sign" has a "g" in it because it is from the same root morpheme as the word "signal". It is well established that morphological awareness can predict progress in reading and spelling independently from phoneme awareness (Siegel, 2008) and that training in morphological awareness can improve literacy outcomes (Bowers, Kirby, & Deacon, 2010; Goodwin & Ahn, 2013). However, it is also known that there is a close association between phonological awareness and morphological awareness (Casalis, Colé, & Sodo, 2004; Cunningham & Carroll, 2015).

Many studies have demonstrated weaknesses in morphological awareness in children and adults with reading difficulties in comparison to chronological age controls. The picture with reading age matched controls is somewhat more complex, with the reading age controls outperforming the poor readers on the more "formal" or metalinguistic tasks and more variable findings in tasks that involve implicit use of morphology or morphological awareness (Breadmore & Carroll, 2016a, 2016b; Casalis et al., 2004). Despite the relative deficit in poor readers, research has demonstrated that morphological awareness can help to compensate for phonological difficulties in terms of literacy outcomes (Elbro & Arnbak, 1996; Law, Wouters, & Ghesquière, 2015; Tsesmeli & Seymour, 2009).

While there are good theoretical reasons to expect that children with OM may have difficulties with phonological awareness, it is less clear whether morphological awareness would be impaired. On the one hand, the association between phonological awareness and morphological awareness could mean that morphological awareness is also affected. On the other hand, evidence that semantic skills are relatively unaffected might indicate preserved morphological awareness. Only a few studies have examined oral morphological awareness in this group. For example, Teele et al. (1989) found that OM in the first 3 years of life correlated with impairments in grammatical morphology at age 7. However, Luotonen et al. (1996) found that despite relatively poor reading comprehension, children with a history of OM did not have deficits in morphological processing at 9 years old. It is therefore an open question whether children with OM will show morphological awareness impairments.

An increasingly popular approach to testing, particularly for children with difficulties, is to use dynamic assessment (Spector, 1992). In this approach, a child is asked to solve a relatively complex task (e.g., phoneme deletion within a nonword) and then given a series of increasingly explicit prompts to help them produce the correct answer. The dependent variable is the total number of prompts each child needed. Dynamic phonological awareness tasks tend to be highly sensitive and reliable (Cunningham & Carroll, 2011, 2015), as well as being good predictors of literacy development (Bridges & Catts, 2011; Spector, 1992). This is likely to be because the graduated series of prompts give information about how much teaching or support a child would need to progress. There is also evidence that dynamic tests of morphological awareness are good predictors of literacy (Larsen & Nippold, 2007; Wolter, Barger, Pike, Atwood, & Martin, 2011). On this basis, dynamic measures of phoneme awareness and morphological awareness were included in this study.

This study therefore compares the literacy, language, morphological and phonological awareness of poor readers and children with a history of OM. On the basis of past research, we anticipate that both impaired groups will show particular weaknesses in phonological tasks. We further predict that both groups will show literacy impairments, although the poor readers will be more severely impaired, having been selected on this basis. In other words, we anticipate that the children with OM will have been able to compensate to some extent for their phonological awareness difficulties. We anticipate that poor readers will show additional weaknesses in morphological awareness that are not shared by the OM group, indicating a more general metalinguistic impairment.

2 | METHOD

2.1 | Participants

A total of 195 participating children were recruited from 20 schools across the West Midlands Region, UK. Children were recruited through mainstream schools: when a school agreed to take part, we sent consent letters and background questionnaires to all parents of children in years 3–5 to recruit the impaired and CA controls, and to younger year groups to recruit RA controls. Children were excluded from any group if they achieved a non-verbal IQ below the 10th percentile, or if they were diagnosed with a pervasive developmental disorder. Parents completed a background questionnaire detailing their child's hearing and history of ear infections.

2.1.1 | Hearing screen

Pure tone hearing thresholds were not measured at the time of testing, but were measured 18 months later at follow up. An Amplivox 116 screening audiometer with Audiocups was used to conduct pure-tone air conduction audiometry without masking in accordance with the Recommended Procedure by the British Society of Audiology (2011). Hearing loss in each ear was classified as very mild (15–24 dBs loss), mild (25–34 dBs loss) or moderate (35–50 dBs loss). A "very mild" hearing loss would not normally be regarded as clinically significant. The patterns of parent responses and hearing profiles of the children are shown in Table 1. Eleven of the 119 control children tested showed a very mild unilateral hearing loss, and two showed a very mild bilateral hearing loss. None showed clinically significant hearing loss. The patterns of hearing loss shown in the clinical groups are described below.

2.2 | Clinical groups

2.2.1 | Children with OM

The OM group consisted of 29 (7 female) children whose parents reported more than seven ear infections before the age of 3, or a

TABLE 1 Background characteristics of the two impaired groups

	Poor reader (*n* = 36 for parent report & *n* = 32 for hearing screen)	OM (*n* = 29 for parent report & *n* = 25 for hearing screen)	Combined control group (n = 130 for parent report & n = 119 for hearing screen)
Report of >7 ear infections	0/36	23/29	0/130
Diagnosis of OM	0/36	19/29	0/130
Grommets fitted	0/36	15/29	0/130
Diagnosis of dyslexia	7/36	0/29	0/130
Any parent/child report of hearing issues	3/36 (excluded from further analyses)	11/29	0/130
Very mild unilateral hearing loss (15–24 dBs)	4/32	5/25	11/119
Very mild bilateral hearing loss (15–24 dBs)	0/32	2/25	2/119
Mild unilateral hearing loss (25–35 dBs)	1/32	0/25	0/119
Bilateral hearing loss (Mild/very mild)*	4/32	5/25	0/119

*child has a hearing loss of >25 dBs in the worse ear and a hearing loss of >15 dBs in the other ear.

medical diagnosis of Glue Ear or Otitis Media. Thirteen children fulfilled both criteria, six reported clinical diagnosis and 10 reported more than seven infections. Fifteen children within this group were also reported to have had tympanostomy tubes (grommets) fitted, and 11 were reported by parents to have ongoing hearing loss. Measurement of hearing thresholds at follow-up confirmed that eight of the children thought to have ongoing hearing loss still showed a hearing impairment, and four further children in the OM group showed some hearing loss. It is important to highlight, however, that hearing in this group is likely to be variable over time, so it cannot be assumed that this measurement reflects long-term stability in hearing patterns or is a metric of the severity of OM.

The children with OM had a mean chronological age of 9;2 years (range 8;0–10;9) and a mean reading age of 9;2 years (5;10–12;3). Each child with a history of OM was individually pairwise matched to two typically developing children, one matched by reading age and one by chronological age. These typically developing children were monolingual English speakers with no known literacy, language or hearing impairments. They had standardized scores between 90 and 120 on BAS3 Word Reading A. The 29 (16 female) OM-RA matched typically developing children had a mean reading age of 9;3 years (range 5;7–12;3) and a mean chronological age of 8;8 years (6;0–11;6). The 29 (8 female) OM-CA matched typically developing children had a mean chronological age of 9;2 years (range 7;9–10;7) and a mean reading age of 10;5 (8;9–12;9). The OM group were matched to the OM-CA group on chronological age ($t(56) = 0.18$, $p = .86$), but differed significantly on reading age ($t(56) = 15.79$, $p = .001$). While the OM group showed reading ages in line with their chronological age, they were significantly lower than typically developing controls in the same classrooms. Conversely, they were matched in reading age to the OM-RA group ($t(56) = 0.20$, $p = .85$) and differed significantly in chronological age ($t(56) = 2.35$, $p = .02$).

2.2.2 | Poor readers

The poor reader group consisted of 36 (16 male) children with a standard score below 90 on British Ability Scale 3 (BAS3; Elliott & Smith, 2011) Word Reading Form A. Seven of these children had a formal diagnosis of dyslexia, and two further children were under investigation for dyslexia. None of these 36 children were reported to have had more than seven ear infections before the age of 3, to have a diagnosis of Glue Ear, to have had a tympanostomy tube or clinically recognized hearing loss. Thirty-two of these children had their pure tone hearing thresholds tested at follow-up. Nine of these poor readers (25% of the sample) showed some degree of hearing loss, with four showing significant bilateral hearing loss.

On close examination, parents had expressed concerns about the hearing of two of these poor readers. One child was reported by her parent to "struggle to hear at times" but had not been tested, and a second child was reported to be "under investigation" for hearing loss. When their pure tone hearing thresholds were tested at follow-up, one showed mild unilateral hearing loss and one showed bilateral hearing loss. A third child self-reported having had "lots of ear infections", although his parent did not report this. He was also found to have mild bilateral hearing loss at follow-up. These three children are excluded from further analyses. A further two children in the poor reader group showed mild hearing loss and another four showed very mild hearing loss (between 15 and 25 dBs). These six children are included in the analyses, as there was no parent or child reporting of hearing loss. This resulted in a sample of 33 poor readers.

The poor readers had a mean reading age of 7;3 (range 5;7– 8;9 years) on the BAS3 word reading (Elliott & Smith, 2011) and a mean chronological age of 9;1 years (range 7;5–10;9). They were individually pairwise matched to reading age and chronological age matched controls in the same way as with the OM group.

The 33 (12 male) reading age (RA-PR) matched typically developing children had a mean reading age of 7;5 years (range 5;10–8;9 years) and a mean chronological age of 7;4 years (range 5;4–9;3 years). The 33 (16 male) chronological age (CA-PR) matched typically developing children had a mean chronological age of 9;1 years (range 7;8–10;10 years) and a mean reading age of 10;6 years (8;9–12;9 years). The poor reader group were matched to the CA-PR group on chronological age ($t(64) = 0.01$, $p = .99$), but differed significantly on reading age ($t(64) = 13.80$, $p < .001$). Conversely, they were matched in reading age to the RA-PR group ($t(64) = -0.66$, $p = .51$) and differed significantly in chronological age ($t(64) = 6.85$, $p < .001$).

The poor reader and OM groups did not differ in chronological age ($t(60) = 0.52$, $p = .61$), but differed in reading age, with the poor reader group being more severely impaired ($t(60) = 5.57$, $p < .001$).

2.3 | Measures

2.3.1 | Nonverbal reasoning

Nonverbal reasoning was measured using the BAS3 Matrices (Elliott & Smith, 2011), where children are shown a pattern with a piece missing and are asked to select the correct piece to complete the pattern. The task was administered in line with guidance in the instruction manual, except that all children, even those under 7 years old, began at item 19.

2.3.2 | Short-term memory and working memory

Verbal and nonverbal working memory skills were assessed using the Short Form of the Automated Working Memory Assessment (AWMA; Alloway, 2007). All measures were presented using a laptop computer, and standardized scores were calculated online. Verbal short-term memory was measured by Digit Recall, a task in which children had to repeat a series of lists of numbers. Verbal working memory was measured using Listening Recall, a task in which children had to say whether the sentence was true or false and also remember the final word in the sentence across a sequence of sentences. Visuo-spatial short-term memory was measured by Dot Matrix, in which children had to remember and tap out a particular sequence of dots within a matrix, and visuo-spatial working memory was measured using Spatial Recall, in which children had to compare two shapes and say if they were the same or mirror images, then remember the location of a red dot across a sequence of these shape comparisons. However, the Spatial Recall task had an error in the computerized training items and all children found the task very difficult. Because of concerns about its reliability in our sample, results for this task are not reported further.

2.3.3 | Semantic language tasks

The children's word level semantic abilities were tested using multiple measures. The British Picture Vocabulary Scale III (Dunn, Dunn, & NFER, 2009) was used to assess receptive vocabulary. In this task the children are shown four pictures and asked to point to the one that represents a spoken word. The task was administered in line with the guidance in the instruction manual. Expressive vocabulary was measured using the BAS3 Word Definitions task (Elliott & Smith, 2011), in which the child has to explain the meaning of a given word. Semantic knowledge was assessed using the Clinical Evaluation of Language Fundamentals IV (CELF; Semel, Wiig, & Secord, 2006) Word Classes task, in which a child has to select which two out of a group of four "go together" in terms of their semantic category or function. The task was administered as in the manual. A single "semantic language" factor score which contained common variance between the tasks was created from these three measures using principal component analysis. This accounted for 77% of the total variance.

2.3.4 | Literacy

Single word reading skills were assessed using the British Ability Scales III (BAS3; Elliott & Smith, 2011) Word Reading (Form A). Children were presented with a list of words of graded difficulty and were asked to read them aloud, with no time constraints. Testing was discontinued when a participant made 8 errors in a set of 10 words. This measure was used to define the groups as described above. Each item was given 1 point if it was read correctly and 0 points if an error was made. Maximum possible raw score was 90. The task was administered in line with the instruction manual.

The York Assessment of Reading for Comprehension (Snowling et al., 2011) was used to test text reading accuracy and comprehension. The task was administered in line with the instruction manual. Children were asked to read two short passages aloud and then answer questions about the passages to demonstrate comprehension. The number of errors made while reading aloud was used to calculate text reading accuracy, and the number of items correct on the comprehension questions was used to calculate reading comprehension. Time taken to read each passage was recorded to provide a measure of reading rate. Because children complete different passages dependent on their age and reading ability, ability scores are analysed rather than raw scores.

Spelling skill was measured with the BAS3 Spelling task (Elliott & Smith, 2011), a word spelling to dictation task with words of graded difficulty. The task was administered in line with the instruction manual. Testing was discontinued when a participant made 8 errors in a set of 10 words, and the maximum possible raw score is 75.

2.3.5 | Standardized morphological and phonological awareness

The CELF Word Structures task was used as a measure of morphological awareness. This is a picture-based sentence completion task, in which the experimenter asks the child to complete a sentence. For example, one item shows a picture of one horse and then a group of horses, and the accompanying sentence is "Here is one horse. Here are lots of _." The child is expected to say "horses". Each item involved a morphological change to a word. Maximum score is 30.

Phonological awareness was measured with the Phonological Awareness test from the CELF. This consists of 17 sections with five items each. The sections cover syllable, rhyme and phoneme awareness and identification, segmenting and blending and manipulation tasks. Maximum score is 85.

Subsections of phonological awareness

As described above, the CELF phonological awareness task included 17 subsections, each with five items. Five of these subsections concerned syllables (syllable tapping, syllable blending and initial, medial and final syllable deletion). Two concerned rhyme (rhyme identification and rhyme production) and one concerned words (word clapping). The remaining nine subsections concerned phoneme awareness. Three concerned phoneme identification (initial, medial and final sound), two concerned segmenting and blending, and four concerned phoneme manipulation (initial, medial and final phoneme substitution and phoneme deletion). Thus, scores for phoneme identification (maximum 15), segmenting and blending (maximum 10) and phoneme manipulation (maximum 20) were created. In order to allow direct comparisons between these subsections, percentage correct was calculated for each.

2.3.6 | Dynamic phonological awareness

The task used was a nonsense word phoneme deletion tasks based on Cunningham & Carroll (2015), following their procedure for providing prompts to elicit correct responses. The dynamic tasks were always carried out by the same experimenter (the second author) to maintain consistency of delivery. A full list of nonword stimuli is provided in Appendix 1, with their sources, and a flow chart of the procedure is provided in Appendix 2 (online Supplementary Materials).

Before beginning the task, participants were given the following instructions:

> *"We're going to play a word game. I'm going to say a nonsense word and I'd like you to take away one of the sounds. First, we'll practice with some real words (provide corrective feedback). (1) Say cup, now say cup without the /k/. (2) Say meet, now say meet without the /t/. (3) Say tiger, now say tiger without the /g/.*
>
> *Now we're going to do the main task. Don't worry if you don't get the answer first time round, as I will help you. Remember, we are working with the sounds in words, not looking at how they are spelled. Sometimes, the number of sounds does not correspond exactly with the number of letters in the spelling of the word. For example, the 'ee' in tree is spelled with two letters, but is one sound. Also, the 'x' in 'fixed' is spelled with one letter, but has two sounds, 'k' and 's'."*

Each item was presented orally within the following sentence frame "Say … now say … without the …." If the child gave the correct response on their first attempt, this was marked as correct with 0 prompts. If the child's first response was incorrect, the experimenter worked through the flow-chart illustrated in Appendix 2 giving increasingly explicit prompts until the child produced the correct response. Such responses were marked as incorrect, and the number corresponding to the prompt that elicited the correct response was recorded. The task duration was variable and dependent on the number of prompts required for each item, but typically took around 15 minutes. Testing was discontinued if a child reached the maximum number of prompts on three items in succession. The score derived was based on the total number of prompts needed. There were 17 items, giving a maximum total prompt score of 170. Sample specific reliability was good ($\alpha = .92$).

2.3.7 | Dynamic morphological awareness

Again, this task was based on the task used by Cunningham and Carroll (2015), using the same pattern of prompts. A full list of the items and prompts used is available in Appendix 3 (online Supplementary Materials). Participants manipulated the nonword to produce a novel target nonword. Each item involved a different morphological transformation increasing in difficulty, including eight inflections and six derivations.

Before beginning the task, participants were told, "Now we're going to play another word game with some more made up words. This time we're going to be changing the words in order to change their meaning. Again, don't worry if you don't get the right answer, just try your best."

For the first 10 items, pictures accompanied the sentence (the original pictures from Berko, 1958). For each item, participants were shown the picture while the experimenter read the item, pointing at the picture as appropriate. Two scores were produced for each item—one indicating whether the initial response was correct or incorrect and another indicating the number of prompts required to elicit a correct response.

If the child gave the correct response on their first attempt this was marked as correct with 0 prompts. If the child's first response was incorrect, the experimenter provided prompt 1 and then repeated the item. The experimenter continued through the prompts until the child produced the correct response. Such responses were marked as incorrect, and the number corresponding to the prompt that elicited the correct response was recorded.

As with the DPA, the task was always administered by the second author to maintain consistency. The task duration was dependent on the number of prompts required for each item, but typically took around 15 minutes. Testing was discontinued if a child reached the maximum number of prompts on three items in succession. The score derived from this measure was total prompts needed. Maximum total prompt score is 84. Sample specific reliability was good (total prompts: $\alpha = .87$).

3 | RESULTS

For each of the areas tested, three sets of comparisons were carried out. First, poor readers were compared to their CA and RA controls, with simple contrasts examining whether there were specific

TABLE 2 Mean IQ, memory and literacy scores for the six groups (standard deviations in parentheses)

Task	Poor reader	RA-PR	CA-PR	OM	RA-OM	CA-OM
Nonverbal IQ (T score)	45.70 (8.04)$_{a,b}$	53.24 (10.16)	55.33 (9.93)	45.24 (11.19)$_{b}$	49.00 (9.26)	52.41 (6.59)
Verbal STM	100.09 (16.99)	102.88 (15.98)	107.58 (12.49)	99.21 (17.06)	108.97 (15.51)	108.90 (11.56)
Verbal WM	94.39 (13.26)	99.97 (16.70)	102.94 (12.20)	95.83 (13.01)	99.90 (14.12)	102.52 (16.10)
Visuo-Spatial STM	96.94 (17.10)	98.55 (16.98)	101.09 (14.85)	99.38 (16.51)	97.41 (16.41)	105.52 (12.46)
BAS Word Reading Standard Scores	83.12 (6.54)	101.21 (8.26)	108.85 (5.68)	97.24 (11.07)	103.76 (6.82)	108.41 (7.05)
BAS Word Reading Raw Scores	46.24 (14.12)$_{b,c}$	48.55 (14.42)	74.39 (5.27)	63.93 (15.02)$_{b,c}$	64.59 (15.50)	74.31 (5.63)
BAS Spelling Standard Scores	84.42 (7.72)	100.94 (10.24)	106.09 (9.21)	97.66 (11.37)	102.04 (7.35)	108.93 (9.91)
BAS Spelling Raw Scores	25.24 (8.83)$_{b,c}$	25.67 (9.11)	44.67 (8.27)	38.14 (11.91)$_{b,c}$	37.04 (12.34)	47.55 (8.20)
YARC accuracy Standard Scores	87.85 (6.89)	105.73 (8.24)	110.03 (8.10)	100.48 (9.73)	107.83 (9.30)	108.97 (7.98)
YARC accuracy Ability Scores	42.45 (7.01)$_{b,c}$	44.73 (8.13)	59.58 (7.13)	53.24 (8.44)$_{b,c}$	53.83 (10.27)	59.21 (6.76)
YARC Comprehension Standard Scores	97.00 (9.34)	107.03 (8.07)	108.55 (9.05)	99.48 (8.88)	106.93 (11.95)	107.17 (11.51)
YARC Comprehension Ability Scores	52.93 (8.71)$_{b}$	50.63 (9.17)	61.79 (8.09)	55.76 (6.96)$_{b}$	56.76 (14.19)	51.96 (10.35)

Note. All measures are standard scores unless stated otherwise. Standard scores have a mean of 100 and a standard deviation of 15 in the general population. Subscripts indicate significant effects: 'a' indicates that the score of the impaired group is significantly lower than RA matched controls. 'b' indicates that the score of the impaired group is significantly lower than CA matched controls. 'c' indicates that the two impaired groups differ significantly.

differences between the poor readers and the two control groups. Second, children with OM were compared to their CA and RA controls, with the same simple contrasts. Finally, an ANOVA specifically comparing the poor readers and OM groups was carried out. Partial eta squared values (η^2) are presented as a measure of effect size. According to Cohen (1988), $\eta^2 = .01$ should be considered a small effect size, $\eta^2 = .06$ a medium effect size, and $\eta^2 = .14$ a large effect size.

3.1 | Nonverbal IQ and memory measures

All of the children were asked to complete some background language, cognitive processing and memory measures. Mean scores on these measures are shown in Table 2. In this table and throughout, standard scores are presented for ease of interpretation but raw scores are used for statistical analyses. For the comparisons with chronological age matched controls, results are the same whether raw scores or standard scores are used. However, for comparisons with reading age matched controls, raw scores are the appropriate basis for comparison, since the groups are of different ages.

An ANOVA comparing nonverbal IQ demonstrated a significant effect of group ($F(5, 180) = 6.31$, $p < .01$, $\eta^2 = .15$). This was further investigated by independent samples t-tests. The PR group showed lower nonverbal IQ than the RA-PR group ($t(64) = -3.45$, $p < .01$) and the CA-PR group ($t(64) = -4.33$, $p < .01$), but in line with the OM group ($t(60) = 0.19$, $p = 0.85$). The OM group showed nonverbal IQ in line with the RA-OM group ($t(56) = -1.39$, $p = 0.17$) and below the CA-OM group ($t(56) = -2.98$, $p < .01$). Because of these differences in nonverbal IQ, it is included as a covariate throughout.

A mixed ANOVA with group as a between-subjects variable and memory task as a within-subjects variable was carried out to examine short-term memory effects. As only age-standardized scores were available for the AWMA, it did not make sense to include the RA controls, who were of different ages. There was no significant effect of group ($F(3, 119) = 2.20$, $p = .09$, $\eta^2 = .05$), no significant effect of task ($F(3, 358) = 2.39$, $p = .09$, $\eta^2 = .01$) and no interaction between the two ($F(6, 238) = 0.60$, $p = .73$, $\eta^2 = .02$). There was, however, a small but significant effect of nonverbal IQ ($F(1, 119) = 5.04$, $p = .03$, $\eta^2 = .04$).

3.2 | Semantic language

Performance of the groups on the semantic language measure is presented in Table 2. Poor readers performed significantly better than their RA-PR controls on semantic language ($F(1, 63) = 10.63$, $p < .01$, $\eta^2 = .14$), and in line with their CA-PR controls ($F(1, 63) = 3.19$, $p = .08$, $\eta^2 = .05$). Nonverbal IQ was a significant covariate in both cases (RA comparison: $F(1, 63) = 9.04$, $p < .01$, $\eta^2 = .13$; CA comparison: ($F(1, 63) = 11.45$, $p < .01$, $\eta^2 = .15$).

The OM group did not differ from the RA-OM group or the CA-OM group on semantic language (RA comparison: $F(1, 55) = 0.04$, $p = .85$, $\eta^2 < .01$; CA comparison: ($F(1, 55) = 3.45$, $p = .07$, $\eta^2 = .06$), and nonverbal IQ was not a significant covariate in either case (RA comparison: $F(1, 55) = 0.04$, $p = .85$, $\eta^2 < .01$; CA comparison: $F(1, 55) = 2.93$, $p = .09$, $\eta^2 = .05$). Direct comparison between the poor readers and the OM group showed no significant difference between the groups ($F(1, 62) = 2.17$, $p = .15$, $\eta^2 = .29$), although there was a significant effect of nonverbal IQ ($F(1, 62) = 5.28$, $p = .03$, $\eta^2 = .08$).

3.3 | Literacy measures

Performance of the groups in the literacy measures is presented in Table 2. As expected, given the selection criteria, there was no difference between poor readers and their RA-PR controls on Spelling ($F(1, 63) = 0.35$, $p = .55$, $\eta^2 = .01$) or Reading Accuracy ($F(1, 63) = 0.07$, $p = .80$, $\eta^2 < .01$), although the difference approached significance on Reading Comprehension ($F(1, 63) = 3.83$, $p = .06$, $\eta^2 = .06$). Nonverbal IQ was a small but significant covariate for all three measures (Spelling: $F(1, 63) = 4.03$, $p = .05$, $\eta^2 = .06$; Reading Accuracy: $F(1, 63) = 5.45$, $p = .02$, $\eta^2 = .08$; Reading Comprehension: $F(1, 63) = 6.11$, $p = .02$, $\eta^2 = .09$), indicating that individuals with higher IQs tended to perform better, regardless of group.

The poor readers performed less well than their CA-PR controls on all three literacy measures: Spelling ($F(1, 63) = 57.29$, $p < .01$, $\eta^2 = .48$); Reading Accuracy ($F(1, 63) = 65.27$, $p < .01$, $\eta^2 = .51$); and Reading Comprehension ($F(1, 63) = 6.28$, $p = .02$, $\eta^2 = .09$), as would be expected. Nonverbal IQ was a significant covariate for Reading Comprehension ($F(1, 63) = 10.09$, $p < .01$, $\eta^2 = .14$), but not for Spelling ($F(1, 63) = 1.43$, $p = .24$, $\eta^2 = .02$) or Reading Accuracy ($F(1, 63) = 1.67$, $p = .20$, $\eta^2 = .03$).

Again as expected, the OM group showed very similar literacy scores to their RA-OM controls: Spelling ($F(1, 54) = 0.45$, $p = .51$, $\eta^2 = .01$); Reading Accuracy ($F(1, 55) = 0.03$, $p = .87$, $\eta^2 < .01$); Reading Comprehension ($F(1, 55) = 0.01$, $p = .91$, $\eta^2 < .01$). Nonverbal IQ was not a significant covariate for Spelling ($F(1, 54) = 2.86$, $p = .10$, $\eta^2 = .05$), or for Reading Comprehension ($F(1, 55) = 1.52$, $p = .22$, $\eta^2 = .03$), but it was a significant predictor of text reading accuracy ($F(1, 55) = 4.81$, $p = .03$, $\eta^2 = .08$).

The OM group showed slightly poorer literacy scores than their CA-OM controls: Spelling ($F(1, 55) = 6.64$, $p = .01$, $\eta^2 = .11$); Reading Accuracy ($F(1, 55) = 3.71$, $p = .06$, $\eta^2 = .06$); Reading Comprehension ($F(1, 55) = 4.59$, $p = .04$, $\eta^2 = .08$). Nonverbal IQ was not a significant covariate for Reading Comprehension ($F(1, 55) = 0.08$, $p = .78$, $\eta^2 < .01$), but it was a significant predictor of for Spelling ($F(1, 54) = 4.48$, $p = .04$, $\eta^2 = .08$) and text reading accuracy ($F(1, 55) = 7.09$, $p = .01$, $\eta^2 = .11$).

Direct comparison between the poor readers and the OM group showed poorer literacy skills for the poor readers, with the exception of reading comprehension (Word Reading: $F(1, 59) = 23.77$, $p < .001$, $\eta^2 = .29$; Spelling: $F(1, 59) = 24.82$, $p < .001$, $\eta^2 = .30$; YARC accuracy: $F(1, 59) = 31.91$, $p < .001$, $\eta^2 = .35$; YARC comprehension: $F(1, 59) = 2.12$, $p = .15$, $\eta^2 = .04$). Nonverbal IQ did not account for significant variance (Word Reading: $F(1, 59) = 2.56$, $p = .12$, $\eta^2 = .04$; Spelling: $F(1, 59) = 2.57$, $p = .12$, $\eta^2 = .04$; YARC accuracy: $F(1, 59) = 3.40$, $p = .07$, $\eta^2 = .06$; YARC comprehension: $F(1, 59) = 2.86$, $p = .10$, $\eta^2 = .05$).

3.4 | Static and dynamic morphological awareness

Table 3 shows the morphological awareness scores of the different subgroups. Poor readers did not differ from their RA-PR controls on morphological awareness (CELF word structures: $F(1, 63) = 0.62$, $p = .43$, $\eta^2 = .01$; DMA: $F(1, 63) = 0.01$, $p = .94$, $\eta^2 < .01$). Nonverbal IQ was a significant covariate only on the DMA measure: Word Structures ($F(1, 63) = 1.09$, $p = .30$, $\eta^2 = .02$); DMA ($F(1, 63) = 5.40$, $p = .02$, $\eta^2 = .08$).

In the comparisons between poor readers and CA-PR controls, controls marginally outperformed the poor readers on the static morphological awareness task, CELF Word Structures ($F(1, 63) = 4.25$, $p = .04$, $\eta^2 = .06$) and DMA task ($F(1, 63) = 3.38$, $p = .07$, $\eta^2 = .05$). Nonverbal IQ was a significant covariate on both measures (Word Structures: $F(1, 63) = 6.10$, $p = .02$, $\eta^2 = .09$; DMA: $F(1, 63) = 6.63$, $p = .01$, $\eta^2 = .10$).

There were no group differences between the children with OM and their CA-OM controls on either morphological awareness task (CELF word structures: $F(1, 55) = 0.04$, $p = .85$, $\eta^2 < .01$; DMA: $F(1, 55) = 1.14$, $p = .29$, $\eta^2 = .02$). Nonverbal IQ was not a significant covariate: Word Structures ($F(1, 55) = 0.33$, $p = .57$, $\eta^2 = .01$); total prompts DMA ($F(1, 55) = 1.74$, $p = .19$, $\eta^2 = .03$).

TABLE 3 Language measures in the six groups (standard deviations in parentheses)

Task	Poor reader	RA-PR	CA-PR	OM	RA-OM	CA-OM
BPVS (Standard Score)	89.94 (10.44)	99.92 (11.21)	101.86 (11.57)	90.24 (13.54)	98.83 (12.61)	101.10 (12.54)
Semantic Language Factor (full sample mean = 0, *SD* = 1)	−0.27 (1.03)$_a$	−0.76 (0.78)	0.57 (0.89)	0.01 (0.70)	0.04 (1.11)	0.55 (0.86)
CELF Word Structure (/30)	24.30 (4.74)$_b$	23.85 (4.07)	27.64 (2.58)	26.00 (3.51)	26.66 (3.39)	26.41 (3.70)
Total Prompts DMA (/84)	20.70 (17.64)$_c$	17.21 (8.55)	9.85 (6.07)	11.86 (7.68)$_c$	12.86 (11.87)	9.00 (5.22)
CELF4 phonological awareness (/85)	65.61 (9.82)$_{b,c}$	67.85 (7.49)	73.33 (4.11)	70.34 (7.85)$_{a,b,c}$	74.55 (6.59)	75.17 (4.68)
Total Prompts DPA (/170)	49.52 (40.43)$_{b,c}$	42.39 (37.20)	21.36 (16.61)	24.63 (28.13)$_c$	19.69 (19.67)	21.25 (15.51)

Subscripts indicate significant effects: 'a' indicates the score of the impaired group is significantly lower than RA matched controls. 'b' indicates the score of the impaired group is significantly lower than CA matched controls. 'c' indicates that the two impaired groups differ significantly.

There were also no group differences between the children with OM and their RA-OM controls on either morphological awareness task (CELF word structures: $F(1, 55) = 0.28$, $p = .60$, $\eta^2 < .01$; DMA: $F(1, 55) = 0.39$, $p = .54$, $\eta^2 = .01$). Nonverbal IQ was not a significant covariate: Word Structures ($F(1, 55) = 0.98$, $p = .33$, $\eta^2 = .02$); total prompts DMA ($F(1, 55) = 1.78$, $p = .19$, $\eta^2 = .03$).

A final set of comparisons between the two impaired groups (poor readers and children with OM) was carried out. The difference between groups did not reach significance in Word Structures ($F(1,59) = 2.65$, $p = .11$, $\eta^2 = .04$), but it did reach significance on the DMA ($F(1, 59) = 6.79$, $p = .01$, $\eta^2 < .10$), with the poor readers requiring more prompts. Nonverbal IQ was not a significant covariate in Word Structures ($F(1, 59) = 1.98$, $p = .17$, $\eta^2 = .03$), although it was in DMA ($F(1, 59) = 4.05$, $p = .05$, $\eta^2 = .06$).

3.5 | Static and dynamic phonological awareness

Phonological awareness measures are presented in Table 3. ANOVAs were carried out to examine differences between the poor reader and RA-PR control group on the static measure of phonological awareness (CELF phonological awareness). There was no significant effect of group: CELF PA ($F(1, 63) = 0.01$, $p = .92$, $\eta^2 < .01$);. Similarly, there was no main effect of group on the DPA score ($F(1, 63) = 0.19$, $p = .67$, $\eta^2 < .01$). Nonverbal IQ was a significant covariate in both analyses: CELF PA ($F(1, 63) = 8.46$, $p < .01$, $\eta^2 = .12$); Total correct ($F(1, 63) = 6.94$, $p = .01$, $\eta^2 = .10$); Total prompts ($F(1, 63) = 9.11$, $p < .01$, $\eta^2 = .13$).

The poor readers were significantly poorer than the CA-PR controls on the phonological awareness tasks (CELF PA: $F(1, 63) = 8.97$, $p < .01$, $\eta^2 = .13$; DPA: $F(1, 63) = 5.23$, $p = .03$, $\eta^2 = .08$). Nonverbal intelligence was a significant covariate on the DPA ($F(1, 63) = 5.03$, $p = .03$, $\eta^2 = .07$), but not on the CELF PA ($F(1, 63) = 2.20$, $p = .14$, $\eta^2 = .03$).

Next, ANOVAs were carried out to examine OM and RA control group differences on measures of phonological awareness. The OM group scored worse than RA-OM controls on CELF PA ($F(1, 55) = 4.15$, $p = .04$, $\eta^2 = .07$), but not on the DPA ($F(1, 55) = 0.19$, $p = .66$, $\eta^2 < .01$). Nonverbal IQ was not a significant covariate (CELF PA: $F(1, 55) = 0.47$, $p = .50$, $\eta^2 = .01$; DPA total prompts: $F(1, 55) = 1.37$, $p = .25$, $\eta^2 = .03$).

The OM group scored worse than CA-OM controls on CELF PA ($F(1, 55) = 4.91$, $p = .03$, $\eta^2 = .08$), but not on the DPA ($F(1, 52) = 0.01$, $p = .93$, $\eta^2 < .01$). Nonverbal IQ was not a significant covariate (CELF PA: $F(1, 55) = 1.41$, $p = .24$, $\eta^2 = .03$; DPA: $F(1, 52) = 0.84$, $p = .36$, $\eta^2 = .02$).

A final set of comparisons between the two impaired groups was carried out. The OM children consistently outperformed poor readers (CELF PA: $F(1, 59) = 4.50$, $p = .04$, $\eta^2 = .07$; DPA: $F(1, 59) = 9.02$, $p < .01$, $\eta^2 = .14$). Nonverbal IQ was a significant covariate on the DPA measures (correct: $F(1, 59) = 7.24$, $p = .01$, $\eta^2 = .11$; total prompts: $F(1, 59) = 4.85$, $p = .03$, $\eta^2 = .08$), but not the CELF PA ($F(1, 59) = 1.67$, $p = .20$, $\eta^2 = .03$).

3.6 | Subsections of phonological awareness

Performance on the standardized PA measure indicates that the children with OM are reading in advance of the level predicted by their PA, as we hypothesized. However, it is not clear why there are group differences on the CELF PA task but none on the dynamic PA task, despite a good correlation between the two ($r = .61$) and previous findings that dynamic tasks are more sensitive (Cunningham & Carroll, 2011). In order to investigate whether the two groups showed an unusual profile, performance on the different subsections of the CELF were examined. Percentage correct on each of the sections is shown in Figure 1 for the two impaired groups and their RA controls. Focusing on the comparison with RA controls allows us to investigate whether the phonological awareness profile is unusual for the level of literacy development.

A repeated measures ANOVA comparing poor readers with RA-PR controls showed a main effect of task ($F(2,126) = 13.72$, $p < .001$, $\eta^2 = .18$) but no main effect of group ($F(1, 58) = 1.27$, $p = .26$, $\eta^2 = .02$) and no interaction between group and task ($F(1, 126) = 0.10$, $p = .90$, $\eta^2 < .01$). For the poor readers, their profile of phonological awareness was in line with their literacy level.

A repeated measures ANOVA comparing the OM group with RA-OM controls showed a main effect of task ($F(2, 112) = 17.06$, $p < .001$, $\eta^2 = .23$), a main effect of group ($F(1, 56) = 8.52$, $p = .01$, $\eta^2 = .13$) and a significant interaction between group and task ($F(1, 112) = 3.29$,

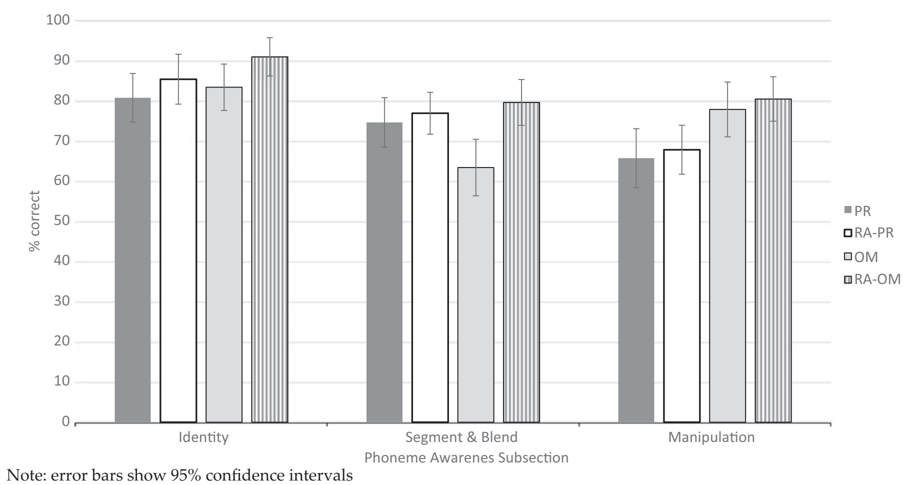

FIGURE 1 Performance on the phonological awareness subsections

p = .04, η^2 = .06). The interaction occurred because the difference between the two groups was larger on the segmenting and blending task (t(56) = −3.51, p = .001) than on the other two measures (phoneme ID: t(56) = −1.98, p = .05; phoneme manipulation: t(56) = −0.58, p = .57).

A direct comparison between the poor readers and OM children showed a main effect of task (F(2, 118) = 9.17, p < .001, η^2 = .14), an effect of nonverbal IQ (F(1, 61) = 10.68, p < .01, η^2 = .15), no main effect of group (F(1, 59) = 0.16, p = .69, η^2 < .01) and a significant interaction between group and task (F(2, 118) = 6.69, p = .002, η^2 = .10). The interaction occurred because while the two groups performed at a similar level on the phoneme ID task (t(59) = −0.84, p = .41), the OM children scored lower than the poor readers on segmenting and blending (t(59) = 2.37, p = .02) while the poor readers scored lower than the OM group on phoneme manipulation (t(59) = −2.36, p = .02). In other words, the children with OM show a specific deficit in segmenting and blending and relatively good phoneme manipulation skills.

4 | DISCUSSION

Overall, the results give clear indications of two different profiles of impairment. The poor readers achieve scores below those of their chronological age matched controls on literacy, semantic and morphological language skills, phonological skills and working memory. This remained true even after controlling for differences in nonverbal intelligence. The poor readers did not differ from the reading age matched controls for the most part, except in terms of showing slightly better semantic language skills.

The children with OM showed a more circumscribed pattern of impairments. Their literacy skills were below those of CA controls, and this was most clearly demonstrated in word reading and spelling. Their semantic language and morphological skills were average for their age. They had phonological awareness scores below CA and RA controls on the standardized measure, but did not differ from controls on the dynamic phoneme deletion measure. Closer investigation indicated that the children with OM showed a specific deficit on the segmenting and blending sections of the phonological awareness task, and showed significantly better phoneme manipulation skills than the poor readers. This provides an explanation for their lack of a deficit on the dynamic phoneme awareness task, which was a phoneme manipulation task.

This profile of weakness in segmenting and blending with additional weaknesses in spelling is further demonstrated in another paper based on this sample (Breadmore & Carroll, 2016a) focusing on use of morphology in nonword spelling. The children with OM showed fewer phonologically plausible spellings of nonsense words than their age matched controls, and the difference with reading age matched controls approached significance (p = .10). They showed good use of morphological strategies in spelling derivational suffixes, but impaired spelling of inflectional suffixes. We argue that this indicates subtle difficulties in processing perceptually demanding phonological information.

The poor readers, therefore, show a broad pattern of weaknesses on linguistic tasks, with particular impairments on the metalinguistic tasks investigating morphological and phonological awareness. They consistently required more prompts to successfully complete the dynamic morphological and phonological tasks. In contrast, children with OM show a circumscribed difficulty with phonological tasks that required segmenting and blending, and no difficulties in metalinguistic processing. These findings are in line with the recent proposal by Ramus et al. (2013) that children with dyslexia are impaired in metalinguistic processing, although the broader language deficits seen in this group would not be predicted from Ramus' theory. There are at least two possible explanations for these findings. First, it could be that within the group of poor readers, there are some children who would be better characterized as having a broader language impairment. There is a high level of overlap between these groups (McArthur, Hogben, Edwards, Heath, & Mengler, 2000). An alternative explanation is that these children have developed language weaknesses as a result of their limited reading experience due to their literacy difficulties (Stanovich, 1986; Snowling, Duff, Nash, & Hulme, 2015). These possibilities are not mutually exclusive and it is likely that both are at least partly true. It is important to note, however, that the difficulties shown by the poor readers cannot be dismissed as purely a consequence of a more generalized language impairment. Their semantic language skills were similar to the OM group, and they marginally outperformed their reading age matches on these measures.

In contrast to previous research, we did not demonstrate significant deficits in short-term memory for poor readers. It is perhaps worth noting that there was a significant difference between poor readers and CA-PRs (F(1, 64) = 7.25, p = .01, η^2 = .10) which dropped out of significance when nonverbal IQ was included as a covariate, suggesting an association between short-term memory and nonverbal reasoning in this sample.

We provide a contrast between children with OM and poor readers, but it is likely that there is overlap between these groups. In particular, results from our hearing screen indicate that both of these groups are at increased risk of hearing loss in comparison to typically developing controls, and that the rates of mild or moderate bilateral or unilateral hearing loss were very similar across the two groups. This is a striking finding when one considers that all of the poor readers were rated by their parents as having no significant history of ear or hearing problems. In addition to the six poor readers with hearing loss, there were a further three poor readers who were excluded from the participant group due to concerns that they may have undiagnosed hearing loss, that were confirmed on follow-up. It is very worrying that as many as 25% of the poor readers aged 7;5–10;9 that we sampled had some degree of undiagnosed hearing loss. Future research could examine the hearing profile of this group in more detail.

There are, of course, some limitations to the data. Group sizes are relatively small, and designations of OM are based on retrospective parental report rather than medical evidence. It is unfortunate that our hearing measurement took place at a later time point than the cognitive measures. Further research could consider a longitudinal approach to examine this issue in more detail. Given that recruitment relied on parent return of consent forms and questionnaires, we cannot know how representative this sample of children is. It is possible that we have over-sampled children whose parents have concerns about their literacy or hearing, since they are particularly likely to respond. These limitations do not, however, undermine the significance of our findings.

The contrast between these two groups in morphological skills has important implications for remediation. Children with a history of OM had intact morphological awareness, and therefore would theoretically be able to use this skill to support their literacy development (Breadmore & Carroll, 2016a). Poor readers had impairments in morphological awareness, meaning that they might be less able than typically developing children to use this information to support their literacy without additional support. They also required more prompts to successfully solve a dynamic morphological awareness task. Recent research has touched on the question of whether teaching children with dyslexia to use morphology is a useful approach to remediate literacy difficulties (Goodwin & Ahn, 2013). Our findings suggest that these children would need structured support to develop their morphological awareness and to apply these strategies in reading and writing, in much the same way as they need structured support in phonological awareness.

This study is the first direct comparison between the literacy, phonological and morphological awareness of children with OM and poor readers. The comparison highlights differences and similarities between the groups. These findings are theoretically important because they emphasize that the impairment shown in reading difficulties should not be characterized as a straightforward "phonological impairment", but rather an impairment in metalinguistic processing.

ACKNOWLEDGEMENTS

We would like to thank all of the children, parents, teachers and research assistants involved in the research. This research was funded by a Nuffield Foundation Grant for Research and Innovation (reference EDU/40250).

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

How to cite this article: Carroll JM, Breadmore HL. Not all phonological awareness deficits are created equal: evidence from a comparison between children with Otitis Media and poor readers. *Dev Sci*. 2018;21: e12588. https://doi.org/10.1111/desc.12588