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Morphological Processing in Children with Phonological Difficulties

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Executive Summary

Background

We know that children with dyslexia have difficulties in phonological awareness tasks, and that children with a history of repeated ear infections (Otitis Media with Effusion, OME) also often have weaknesses in phonological awareness tasks, probably due to their history of transient hearing loss. The two groups have not previously been directly compared to assess the overlap between them.

Rationale

We were interested in whether children with OME showed the same pattern of phonological and literacy difficulties that dyslexic children showed. We were also interested in whether those children with phonological difficulties who escaped literacy difficulties were more likely to use morphology to help them progress well.

Method

We compared a group of 36 children with dyslexia to 29 children with a history of OME. Each of these two groups was also compared to groups of typically developing children of the same age, and groups of younger typical children at the same reading level. This made a total sample size of 195. We asked the children to complete a wide range of literacy, phonological and morphological tasks. We also retested their literacy skills 18 months later.

Key Terms:

Otitis Media with Effusion (OME): an infection of the middle ear in which fluid in the middle ear can affect hearing levels temporarily. This is very common in the preschool years and some children have repeated ear infections over this period.
Phonology: The sound structure of words – e.g. the fact that the word 'thing' has three separable sounds in it ('th', 'i' and 'ng').
Morphology: the meaning structure of words – e.g. the fact that the word 'unforgettable' has three units of meaning in it ('un', 'forget' and 'able').
Dyslexia: a developmental difficulty in which an individual shows difficulties in reading and spelling that are unexpected given their age, general abilities and education.

Key Findings

- Many children with OME show normal literacy skills, but there is a significant subgroup (around a third) that has literacy difficulties.
- Children with OME and children with dyslexia show different profiles of impairments:
    - Children with dyslexia show difficulties on meta-linguistic tasks, whether they involve phonology (ability to manipulate speech sounds) or morphology (knowledge of grammatical word structure).

    - Children with OME have difficulties only on the phonological tasks or tasks with high perceptual demands.
- Our experimental measures show that children with dyslexia can use morphology in literacy, but they are sometimes inefficient in using it.
- Children with OME have normal morphological skills for their age and should be in a good position to use this knowledge to boost literacy.
- Despite these differences, there are overlaps between the groups: around a third of children with OME showed below average reading, and 25% of the dyslexic children had undiagnosed hearing difficulties.
- All groups progressed in literacy to a similar extent over the 18 months they were followed, and both morphology and phonology were small, but significant predictors of reading comprehension outcome.

Implications for Theory

Children with OME and children with dyslexia show different profiles of impairment, though there is some overlap between the groups.

This work informs the long-running theoretical debate about the nature of the phonological impairment in dyslexia. Our sample of children with dyslexia, in contrast to those with OME, shows meta-linguistic impairments that extend over phonology and morphology. This indicates that their difficulties are unlikely to be due to subtle difficulties in phoneme perception, as suggested by some researchers.

A significant minority of the children with OME showed reading difficulties. We suggest that OME will only result in reading difficulties when accompanied by weaknesses in other areas that may implicate meta-linguistic processes.

Researchers working with children with dyslexia should be aware of the high levels of undiagnosed hearing loss in this group, and should consider screening for hearing difficulties when recruiting samples.

Implications for Teachers and education professionals

1. Children with dyslexia have impairments in morphological awareness, but are able to use morphology in written language.

It is not that children with dyslexia are insensitive to morphology in reading and spelling, just that they are not always using it efficiently.

We know that children with dyslexia particularly benefit from structured, systematic phonics teaching. We argue that the same will be true of morphological teaching – **children with dyslexia need to be taught how to use morphology in a structured, step-by-step way**.

2. Children with OM often show average or good reading, but an increased number of children in this group have below average reading. **A history of OME should be regarded as a preschool risk factor which teachers should be aware of** to a) screen for and support phonological difficulties and b) consider the possibility of mild or moderate hearing loss.

3. Children with reading difficulties may sometimes have undiagnosed hearing difficulties

In our study, approximately 25% of children with reading difficulties also showed mild or moderate bilateral or unilateral hearing impairment, which the parents did not report. We do not have a large sample of children, but it seems that it is important to screen for hearing difficulties in children with reading difficulties.

Implications for Policy-Makers

Many children in school may have an undetected mild hearing loss, which would make it harder for them to access the curriculum. Current hearing screening procedures are not picking up these children, and we would advise that children have their hearing tested in more detail and more often.

It was not straightforward to predict which children with OM would have literacy difficulties. **We suggest that a history of OM should be regarded as a preschool risk factor which teachers should be aware of to a) screen for and support phonological difficulties and b) consider the possibility of mild or moderate hearing loss.**

Morphology is a useful skill for children to use in literacy. This provides support for the governments recently increased emphasis on teaching grammar and word structure in spelling (also known as SPAG: National Curriculum, 2014).

However, children with dyslexia may well have difficulties in learning to use these skills efficiently and **should be taught this information in a highly structured way**.

Morphological Processing in Children with Phonological Difficulties

Background

Early literacy education in the UK is dominated by systematic synthetic phonics – explicitly teaching the code that links speech sounds to letters. This enables children to sound out words like C-A-T. Most children rapidly learn to combine phonics with lots of other skills and become good readers. However, some people do not learn to read so easily. Poor literacy limits economic and social opportunities and even health, and is estimated to cost the UK economy £81.3 billion per year (World Literacy Foundation, 2015).

There is a good reason for this focus on phonics. The strongest predictor of literacy achievement, particularly in the early years, is the ability to manipulate speech sounds (phonological awareness). Children who have difficulty with phonology usually have difficulty learning to read. Phonological weaknesses are common in dyslexia but the cause of these difficulties is unknown. There are also some children who learn to read effectively despite problems with phonology. In the research summarised here, we compare children with dyslexia to children with a history of fluctuating hearing levels resulting from repeated ear infections (otitis media with effusion, OME or Glue Ear). These children had variable phonological input but are generally found to have roughly age appropriate reading levels (or mild delays). How do they learn to read despite their phonological challenges? Do they have mild phonological difficulties that can be overcome or do they make use of alternative skills as they learn to read?

Morphological awareness is another key skill for literacy. Morphology refers to grammar and the internal structure of words. This knowledge guides spelling of many words where phonics doesn't provide the complete answer. For example, words like *health* (which contains *heal*) and *sign* (which shares a morpheme with *signal* and *signature*). Like phonological awareness, morphological awareness also predicts literacy attainment but the relationship between phonology, morphology and literacy isn't clear.

The questions underlying the research summarised here are;

1) Is morphology spared or impaired in dyslexia?
2) Is morphology spared or impaired in children with phonological challenges in the absence of literacy delays?
3) Do children with phonological/literacy difficulties need help with morphology?
4) Could morphological skills limit the impact, or even compensate and support reading in children with phonological difficulties?

The Current Study

The sample

Children with dyslexia, a history of OME and typically developing children were recruited through opt in consent from 20 schools across the West Midlands, UK. One hundred and ninety-five children were included in total. The six groups tested are shown in Table 1. The dyslexic group were compared to chronological age matched controls (Dys-CA) and reading age matched controls (Dys-RA), as were the children with a history of OME (OM-CA and OM-RA respectively). Children were included if they were native English speakers, had not been diagnosed with a pervasive developmental disorder and achieved a non-verbal IQ score in the normal range at initial assessment. Children at risk of phonological difficulties and their chronological-age matched controls were 8-10 years old at the beginning of the project.

Table 1: Background characteristics of the six groups

	Dyslexic (n = 36)	Dys-CA (n = 36)	Dys-RA (n = 36)	OME (n = 29)	OM-CA (n 29)	OM-RA (n = 29)
Age (years; months)	9;1	9;1	7;5	9;2	9;2	8;4
Word reading (SS)	83.2 (6.3)	109.1 (5.7)	99.9 (7.3)	97.2 (11.07)	108.4 (7.0)	105.4 (6.6)
Reading Comprehension (SS)	97.0 (9.0)	108.9 (8.8)	105.6 (8.9)	99.5 (8.9)	108.4 (10.7)	107.2 (11.5)
Vocabulary (SS)	89.9 (10.4)	101.9 (11.6)	100.4 (11.2)	90.2 (13.5)	101.1 (12.5)	98.2 (12.5)

Children with dyslexia

Dyslexia is a disorder in which individuals show a greater level of difficulty in reading and spelling than would be expected given their age and level of education. It is a relatively common disorder, with around 10% of the population showing significant weaknesses in reading and spelling. The most well supported theoretical explanation for dyslexia is in terms of underlying weaknesses in phonological processing.

In the present research, 36 children with a standard score below 90 on the British Ability Scale 3 Word Reading subtest (Elliot & Smith, 2011) formed the group of children with dyslexia. A further 13 children were excluded after initial assessment due to below

average nonverbal IQ. The mean standardised score of the sample on the word reading task was 83.2, while their age matched classmates scored a mean of 109.1 on this measure. It is unusual for an assessment for dyslexia to be made until the latter primary years (although children with reading difficulties may well receive additional support before assessment). At initial testing, only 8 children had been assessed as having dyslexia, one of whom was then removed due to low nonverbal IQ. None of the children with dyslexia reported a history of OME.

Children with OME

Middle ear infection (Otitis Media) is amongst the most common infections of early childhood. 46% of 3 year olds have experienced multiple episodes of OM. For days or weeks after most ear infections, a thick sticky fluid remains in the middle ear (Otitis Media with Effusion, OME or Glue Ear), which reduces hearing. The prevalence of OME decreases rapidly through early childhood but chronic and repeated episodes can lead to permanent hearing loss. Hearing loss associated with OME is usually in the mild-moderate range and is sometimes treated with ventilation tubes (grommets) to allow the fluid to drain. Use and effectiveness of this treatment is variable and can also contribute to scarring and associated hearing loss. A mild-moderate hearing loss (permanent or transient) will make the perception of speech sounds difficult, particularly in a classroom environment with background noise and other distractors. Therefore, children with multiple episodes of OME have fluctuating access to detailed phonological information precisely at the age when they develop representations of speech and speech sounds which are crucial for the early stages of learning to read (Studdert-Kennedy, 1987). Nonetheless, children with OME usually acquire age appropriate literacy levels.

In the present study there were 29 children whose parents reported more than seven ear infections by the age of 3 or who had received a medical diagnosis of Glue Ear or OME. None of these children had been assessed for dyslexia. Eleven children with OME reported ongoing clinically recognised hearing impairment at initial assessment.

Typically developing children

Typically developing children had a standardised score between 90 and 120 on the BAS3 word reading. Each child at risk of phonological difficulties (children with dyslexia or OME) was matched to two typically developing children. One typically developing child was the same age as the child with phonological difficulties. One typically developing child had the same reading ability. Comparison between children at risk of phonological difficulties and children of the same age indicates whether literacy skills are impaired or not.

The comparison against children with the same reading ability has become the standard protocol in dyslexia research. It reveals whether or not children with dyslexia follow the typical developmental path. If children with dyslexia are just behind, they should behave like younger children with the same literacy levels. If children with dyslexia differ from younger ability matches then you can conclude that the differences are due to dyslexia and not merely related to a child's reading ability. For a related reason we also matched children by reading ability to the children with OME. Children with OME have been selected on the basis of their phonological experience rather than their reading ability and might not have reading delays. Nonetheless the comparisons with ability matched children are a stronger test than chronological age matched children, enabling us to examine whether phonological and morphological skills in OME are at the level you would expect given their literacy skills.

Methods

At initial assessment children completed a battery of standardised and experimental measures examining literacy skills in general, and also use of phonological and morphological information in speech and literacy. 18 months later the children's reading, spelling and phonological awareness was retested and they completed a hearing screen. This report focuses on the key findings in relation to phonological and morphological processing.

Literacy

Single word reading, passage reading accuracy and rate, reading comprehension and spelling were assessed at initial assessment (using BAS3 word reading and spelling subtests and the York Assessment of Reading Comprehension). At follow-up, these measures were re-administered (with the exception of BAS3 spelling).

Spoken language skills: Vocabulary and Semantics

Children completed three language measures focused on understanding of word meanings: The British Picture Vocabulary Scale III, a receptive vocabulary measure; the Word Definitions task from the BAS3, an expressive vocabulary measure; and Word Classes from the CELF4, a measure of semantic understanding.

Spoken language skills: Phonology

A range of phonological skills were studied in two oral tasks and two literacy tasks administered at initial assessment, each task evaluating a different aspect of phonology. The standardised oral measure was the Clinical Evaluation of Language Fundamentals (CELF4) Phonological Awareness subtest (Semel, Wiig, & Secord, 2006). This task was repeated at the 18 month follow-up. The CELF4 phonological awareness task has 17 sections examining different aspects of phonological awareness; including identification,

segmentation and blending and manipulation of speech units ranging from phonemes to syllables. The overall score provides a broad measure of phonological skills, while the subtests can be used to examine particular aspects of phonological processing.

The Dynamic Phonological Awareness task is an oral phoneme deletion task that taps into phoneme segmentation and blending. Children were asked to repeat a nonword and then delete a phoneme. If their initial response was incorrect, the assessment becomes dynamic – the experimenter gives the child a series of prompts to help the child to arrive at the correct response. This task therefore includes a standard measure of phoneme deletion (accuracy of their first response) and a dynamic measure (the number of prompts needed to get to the correct response). Dynamic assessment is very sensitive measure for phonological awareness, providing a measure not only of what children currently know but also how much help is needed to teach them to figure out the answer.

Spoken language skills: Morphology

Morphological skills were examined in four speech and literacy tasks administered during the initial assessments. The standardised measure was the CELF4 word structures subtest (Semel et al., 2006). In this task children see a picture and complete a sentence spoken by the experimenter by making a morphological change. For example, the child is shown a picture of one horse and two horses, "*Here is one horse. Here are two* _____". The task includes inflectional and derivational morphology.

The Dynamic Morphological Awareness task is a spoken sentence completion task, supported by pictures and a series of prompts to help the child arrive at the correct response. This task uses nonwords to ensure that children use morphology to generate novel inflections and derivations – they cannot use semantic and lexical knowledge to produce their answer because the nonwords are not in their vocabulary. This task therefore includes a standard measure of generative morphological awareness (accuracy of their first response) and a dynamic measure (the number of prompts needed to get to the correct response).

Use of phonology and morphology in literacy tasks.

Phonological and morphological skills are important for literacy development because we use this information when we are reading and spelling. There could be a difference between what children know about morphology and phonology, and their ability to use this information.

Our first task measured use of phonological and morphological information when holding words in short-term memory. Children were asked to remember a list of words shown one at a time on a computer screen, then say whether or not a given probe word was on the list.

The probe words sometimes overlapped in phonological/orthographic information, sometimes in semantic information, and sometimes in morphological information (i.e. they included a morpheme that was present in the list).

To examine use of this information in spelling, children completed a sentence completion spelling to dictation task designed to tap phonological and morphological skills. Children were presented with a written sentence with a missing nonword. The experimenter read the sentence aloud along with the missing nonword and the children filled in the gap. The target nonwords were matched so that the same sounds occurred at the end of simple one-morpheme nonwords and complex nonwords where the sounds formed a suffix. For example, the sound at the end of the nonword in the sentence *"He called his pet rat Poama"* can only be spelled using phonological analysis but that could lead to several different spellings (a, er, ur etc.). Use of phonology in spelling was measured by rating the phonological plausibility of these spelling – whether the spellings which children produced could plausibly be pronounced to sound like the nonword target. In contrast, the same sound at the end of the sentence *"A person who soams is a soamer"* should be spelled <er> because it is a suffix. This measures the ability to use morphological context to guide spelling.

Use of phonology and morphology during reading was measured by studying eye-movements in response to reading pseudohomophones - nonsense words that sound like real words. Children read sentences that contained pseudohomophones while their eye-movements were measured. The more time spent looking at the pseudohomophone, the harder it is for that child to access the meaning through the phonological routes to reading.

Key Findings

Hearing levels

At the 18 month follow-up we conducted a hearing screen with the intention of identifying the number of children in the OME group who had ongoing hearing loss. Clinically recognised levels of hearing loss were defined as an average pure tone threshold equal to or over 25 dB (the threshold for mild hearing loss in children; (Ear Foundation, 2015). Of the children with OME, two had bilateral and three had unilateral hearing loss at clinically recognised levels (with hearing loss >15dB in the other ear). A further seven children with OME had very mild unilateral or bilateral hearing loss (average pure tone thresholds equal to or greater than 15 dB but less than 25 dB).

For completeness, all children participating in this study completed the hearing screen. Unexpectedly, four children with dyslexia also had bilateral hearing loss and one had unilateral hearing loss. Four children with dyslexia had very mild hearing loss. While it is alarming that these children's hearing difficulties had not been identified despite the difficulties they were having in learning to read, it is important to note that the proportion of children with dyslexia who had hearing difficulties may be inflated in this study due to sampling bias. Parents opted into the study knowing it was about hearing and literacy difficulties. If parents had concerns about their child's hearing they may have been more likely to take part. However, with that in mind, none of the parents of poor readers reported any knowledge of hearing loss. Within the typical sample no child had clinical levels of hearing loss, and 13/130 had very mild hearing loss.

Literacy and Vocabulary skills

Children with dyslexia, by definition, had lower word reading skills than their CA controls and similar levels to their RA controls. The pattern was the same on spelling and passage reading accuracy. Their reading comprehension showed a mean standard score in the average range (standard score 98.0), though lower than that of the control groups. Their vocabulary and semantic scores were on the lower side of the average range for their age, though raw scores were slightly higher than the levels achieved by the younger RA controls.

Children in the OME group showed a wide range of literacy outcomes, with reading age equivalents ranging from 5;10 years to 12;3 years. In terms of the group mean, they scored within the average range based on standardised score but this was below the level of the CA controls from the same classrooms. This profile was the same across the other literacy tasks. Their vocabulary and semantic scores were on the lower side of the average range for their age.

Phonological and Morphological Awareness

Across the phonological and morphological awareness tasks, the dyslexic group were impaired in comparison to CA controls and did not differ from RA controls, though there were trends for the dyslexic children to require more prompts in the dynamic awareness tasks. This demonstrates that children with dyslexia have a weakness in morphological awareness in addition to their weakness in phonological awareness.

The OME group did not show such a consistent profile. They showed no difficulties on the morphological awareness tasks, scoring in line with CA controls. On the standardised phonological awareness task, they scored below the level of RA controls, but on the dynamic phonological awareness task, they did not show difficulties.

This result was surprising because we anticipated that the dynamic phonological awareness measure would be more sensitive than the standardised phonological awareness task. In order to investigate this we examined performance on the different types of phonological awareness tasks within the standardised measure. We found that the OME children showed a specific weakness on the segmenting and blending tasks, while the dyslexic children showed a specific weakness on the phoneme deletion and substitution tasks. We therefore concluded that the two at-risk groups have a different profile of phonological awareness impairment.

Phonological and Morphological Strategies in Literacy

Short Term Memory

Children with OME showed a very similar profile of performance across the conditions to the typically developing children. All groups found the morphological distractors the most confusing, with the semantic and phonological distractors intermediate between those and the unrelated words.

The children with dyslexia did not show the same pattern as either CA or RA controls. The RA controls, who were largely novice readers, found the morphological distractors equally as confusing as the phonological distractors, suggesting that they might be relying on letter-sound similarities in both cases. The dyslexic children found the morphological items highly confusing, much more so than the phonological items. This shows that the dyslexic children do use morphology in memory for words, but that they might not be using it very efficiently.

Nonword Spelling

As with the other tasks, we saw differences in the profile of the dyslexic and OME groups on the nonword spelling task. The dyslexic children used morphological strategies in

spelling less than their CA controls and to a similar extent to their RA controls. Again, this shows that children with dyslexia are sensitive to morphological information. However, it contrasts with the short term memory task in that it shows that their use of morphology in spelling is in line with their reading age.

Children with OME showed a specific weakness in using inflectional suffixes, but showed good use of derivational suffixes. We hypothesise that this is because inflectional information involves more perceptually difficult processes, since inflections are generally one or two phonemes while derivations are normally syllabic.

The results suggest different causes for the spelling difficulties in each case: dyslexic children had difficulties in generalizing more complex morphological relationships, while the OME children's difficulties had a phonological/perceptual basis.

Eye Movements in Reading

For all of our groups, replacing real words with nonwords caused disruption to eye movements. We can divide eye movement measures into early measures (how long the eye stays on a word when it is first read) with later measures (how much the word is re-read after moving elsewhere). For the pseudohomophones (e.g. 'endid' for 'ended'), most groups were affected in both early and late measures. The dyslexic children were less disrupted in early measures, suggesting that they were tending to sound out words in any case. We conclude that dyslexic children are impaired in the development of rapid word recognition.

Longitudinal Follow up

For the most part, standard scores in word reading, passage reading and reading comprehension are very similar at the two time points for each group. This shows that on average, each group showed the expected amount of progress.

A structural equation model was formed examining the predictive effect of time 1 word level literacy, semantics, morphological awareness and phonological awareness on time 3 word level literacy and reading comprehension. Semantics and morphological awareness had small, but significant, effects on word level literacy after controlling for literacy at time 1, and all four measures were significant predictors of later reading comprehension.

This demonstrates that good morphological awareness is associated with better progress in word level literacy and in reading comprehension.

Conclusions

This is the first study to directly compare the phonological and morphological profile shown in children with dyslexia and children with OME. The comparison is an informative one: the two groups show different profiles of impairment, though there is some overlap between the groups.

This work informs the long-running theoretical debate about the nature of the phonological impairment in dyslexia. Some researchers have argued that children with dyslexia have subtle perceptual impairments, while others have suggested that the difficulties shown by this group are more specifically in the realm of meta-phonological processing. Our work provides evidence for the latter interpretation: the children with dyslexia showed difficulties in phoneme deletion and substitution, but better performance than the OME group on blending and segmenting, the tasks that might be expected to focus particularly on perceptual skills. The dyslexic group also showed parallel difficulties in morphological awareness, suggesting broader meta-linguistic weaknesses, while the OME children showed normal morphological skills.

This has practical, as well as theoretical implications. It implies that children with dyslexia should be given broad-based support with various aspects of meta-linguistic skills, and that a pure focus on phonological intervention will not be enough.

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Peer Reviewed Journal Articles providing further details

Breadmore, H.L. & Carroll, J.M. (2016). Effects of orthographic, morphological and semantic overlap on short-term memory for words in typical and atypical development. *Scientific Studies of Reading, 20*, 472-489, DOI: 10.1080/10888438.2016.1246554

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