To cite this output:
Carroll, Julia (2008). The nature of phonological deficits in children with speech and literacy difficulties: Full Research Report ESRC End of Award Report, RES-062-23-0195. Swindon: ESRC

Research Report - The nature of phonological deficits in children with speech and literacy difficulties

- **Introduction**

Previous research has used small, highly selected groups of children to examine phonological impairments. The present study aimed to cast light on the nature of phonological impairments and the specific links between these difficulties and later literacy development by examining three groups of children selected as having poor phonological processing skills: children with a family history of dyslexia, children in regular speech and language therapy and children in mainstream classrooms with low scores on a phonological processing task (nonword repetition). The children were asked to complete a range of phonological processing tasks aimed at assessing whether their difficulties lie in input, output or memory processes, together with whether they show unusual strategies in classification tasks. They were compared to a typically developing control group of the same age and retested six months after the initial test point to assess whether different children show different profiles in their phonological abilities and whether these profiles link to differential progress in literacy.

- **Background**

The most well-supported and researched explanation of reading difficulties in young children is the Phonological Representations hypothesis: that reading difficulties can often be explained in terms of problems in processing and manipulating the sounds in words. These problems would make it particularly difficult for a child to "sound out" new words, a key skill in early reading and spelling. This hypothesis is supported by several different research approaches, including longitudinal studies of typical development (Muter, Hulme, Snowling, & Taylor, 1998), studies of children with reading difficulties (Bradley & Bryant, 1978; Snowling, 1981) or with a genetic risk of reading difficulties (Elbro, Borstrom, & Peterson, 1998) and training studies in which tuition in phonological awareness helps reading development (Hatcher, Hulme, & Ellis, 1994).

Given this hypothesis, it is a small step to assume that children with pre-school speech and language difficulties would show particularly weak early literacy skills. These children, it is assumed, have striking difficulties in working with the sounds in words, and therefore will find it very difficult to learn to read. Further, it would seem clear that the major mediator in determining how impaired a child will be in learning to read is the quality of their phonological skills. However, research suggests that the link is not straightforward.

Several researchers have shown that children with impairments only in phonology (speech processing) seem to have relatively good literacy development. The children most likely to show literacy difficulties are those with language impairments, which would include skills such as vocabulary

and syntax (Bishop & Adams, 1990; Catts, 1991; Nathan, Stackhouse, Goulandris, & Snowling, 2004).

These findings are counter-intuitive, as they seem to imply that phonology does not, in fact, play the most important role in literacy development in children with speech and language difficulties. However, there are reasons for not accepting this conclusion. Most crucially, the severity of a speech problem and the presence of semantic and syntactic difficulties are by no means independent. Children with these broader impairments tend to have more severely impaired phonology than children with speech impairments alone.

For example, Bishop and Adams (1990) found that expressive phonology (in the form of the percentage of their consonants within spoken words that were correctly articulated) was a significant predictor of later reading accuracy in their sample of language impaired children. Therefore, those children with the poorest phonology did have literacy difficulties. However, they also tended to have additional language difficulties. In fact, within this sample, the group of children with 'pure phonological impairment' had better phonology than any of the other groups (Bishop & Edmundson, 1987).

Chiat (2001) argues speech and language difficulties are not independent in that, in many cases, speech difficulties will cause additional language difficulties. Preliterate children learn language through phonology. In other words, each piece of syntax or vocabulary item that a child learns is learnt through processing speech. Therefore in most cases a child with basic phonological processing difficulties will present as a child with both speech and language difficulties. In contrast, a child with speech difficulties and normal syntax and vocabulary is likely to have relatively good speech perception, to allow other aspects of language to develop normally.

Given that there is some evidence to believe that phonological difficulties may be reciprocally related to both language and literacy development, it is important to begin to differentiate between different types of phonological impairments. Some types of impairment seem to be associated with both language and literacy difficulties, while others are associated with only speech difficulties or only literacy difficulties. While there is clearly overlap between these different types of impairments, there are also differences. In order to examine these it is necessary to consider in more detail what form a phonological impairment could take.

At the first level of analysis, impairment in nonword repetition could indicate deficits in output phonology (producing speech), in input phonology (perceiving speech) or in phonological processing or phonological representation (Stackhouse & Wells, 1997). These deficits would also be non-independent: deficits in input phonology could cause difficulties in the other areas of phonology, together with deficits in wider language skills, as detailed above. To investigate the different possibilities, a battery of phonological tasks is required.

Dodd (1995) suggests that children with speech difficulties can usefully be divided into four different types: those with articulation errors, those with developmentally delay, those with atypical errors and those with inconsistent speech. She argues that children with atypical errors show literacy difficulties because of atypical phonological processing. If this is true, then the type of speech errors shown can give important information about a child's prognosis.

Most measures of phonological processing give a total accuracy score, often combining many different types of items. However, we know that typically developing children often show predictable patterns of errors on these tasks. For example, they tend to rate words sharing manner of articulation as similar, while the same tendency is not shown for words sharing place of articulation (Carroll & Myers, submitted). If children with speech or language difficulties show the same pattern of errors, even if their overall score is lower, then this would suggest that their underlying phonological representations are similar to typically developing children, perhaps suggesting developmental delay rather than disorder. We therefore use a range of items in the phonological processing tasks to assess whether the 'risk' groups show disordered phonological representations.

- **Objectives**

To develop understanding of the different types of phonological impairments that can occur in children beginning school.

In order to address this objective we carried out detailed phonological assessments of four groups: typically developing children, children in speech therapy, children with a history of speech therapy, and children with low speech processing skills but no history of speech therapy. This objective was met successfully: we demonstrated that children show a wide range of speech errors and that these errors are associated with lower performance on the phonological processing measures. However, there was little evidence for qualitative differences in phonological processing: the groups showed the same overall pattern of performance on the different tasks. This is discussed in more detail in the 'results' section.

To develop understanding of how these impairments impact upon literacy development.

This objective was met successfully. We were able to assess whether different patterns of speech difficulty were associated with literacy difficulties. There was some evidence that children with atypical speech showed poorer scores on the phonological awareness and literacy tasks, but the clearest pattern shown was that literacy difficulties were associated with phonological processing difficulties, which were in turn associated with

language difficulties. It seems that language, rather than speech, is the major link to phonological processing.

To help to inform the decision of which preschool children should be given speech therapy and which may need early literacy support.

This objective was largely successfully met. We anticipated that we would find children in Reception and Year 1 whose speech and language difficulties had not been identified and supported. In fact, we found relatively few children who met these criteria. Some caution is needed in regard to this statement, since families with language difficulties may well be among those families who do not respond to detailed written consent forms, and therefore the sample of children is likely to under-represent children from such families. Nonetheless, most of the children who would have benefited from speech and language therapy were known to the local speech and language therapists.

As anticipated, children with phonological processing difficulties were those most at need of early literacy support, indicating the importance of a link between speech and language therapists (who regularly assess phonological processing) and primary school teachers (who may not understand the relevance of this information for literacy tuition).

To increase understanding of how some children with speech and language difficulties escape literacy difficulties.

This objective was met. The data demonstrate that children with purely articulation difficulties are likely to show good literacy development, and the rate of literacy difficulties is only slightly increased in children with pure speech difficulties. On the other hand, children with language difficulties were likely to have later literacy difficulties, and this risk was increased if the child had both language and literacy difficulties.

- **Methods**

Participants

Two hundred and ten children in the first three years of formal schooling were recruited. The majority of the children (188) were in either reception or year 1 (first two years of schooling). Forty-six children were recruited because of a family risk of dyslexia. In this case, either a parent or sibling had a diagnosis of dyslexia. Most of these children were recruited through local Dyslexia Action centres, screening in mainstream classes or through general advertising in schools and public places. Thirty-six children were recruited because of a history of speech and language difficulties. These children were recruited mainly through screening in mainstream classes and general advertising, though some were recruited through Speech and

Language Therapists. Speech and Language Therapists were asked to refer children who showed speech or phonological difficulties, with or without additional language difficulties. Ten children in this group were recruited in a school with a specialist speech and language unit. The typically developing children (128) were largely recruited through mainstream classrooms in Warwickshire, UK. Twelve children (10 control children and 2 children from the at-risk groups) did not complete the Picture Naming, Forced Choice, Priming, Nonword Learning or Mispronunciation Detection tasks due to time constraints. Attrition was low: three children were lost to the study between the two test points. Their data from Time 1 is included in the Time 1 analyses.

Tasks

Language. Four subtests of the Clinical Evaluation of Language Fundamentals Preschool 2nd UK edition were used: *Sentence Structure, Word Structure, Expressive Vocabulary* and *Recalling Sentences.* These measures assess receptive and expressive language at the word level and the sentence level. The first three measures combine to give a single Core Language measure.

Speech production. The children were asked to complete two speech production tasks, the *Diagnostic Evaluation of Articulation and Phonology* (DEAP), and a non-standardised *Picture Naming* task scored for percentage consonants correct. The DEAP has a brief screening measure in which children are asked to name ten pictures, and asked to produce in isolation any sound which they pronounce incorrectly (with the exception of age-appropriate errors, such as /f/ for /th/). If they can produce at least one of these sounds, the Phonology subtest is carried out and if they cannot produce all of the sounds tested then the Articulation subtest is conducted. Forty-seven of the 210 children completed the Articulation task and 167 completed the Phonology task. These tasks involve further picture naming and sound production to provide an estimate of each child's error patterns. The phonological errors that can be explained by difficulties in articulating a sound in isolation are excluded. Error patterns are awarded if a child shows five examples of a particular error type (e.g. fronting, gliding or cluster reduction). These error patterns were classified as to whether they are age-appropriate, developmentally delayed or disordered. Children were then classified according to their worst error pattern (e.g., if a child showed both delayed and disordered error patterns, they would be classified as having disordered speech). An experienced speech and language therapist independently scored 10% of the sample, and achieved inter-rater reliability of 99% on the screener, 93% on the Phonology task and 95% on the Articulation task.

The children completed an additional non-standardised *Picture Naming* task. The words used were 2-4 syllables long, and contained several consonant clusters, in contrast to the relatively simple words used on the

DEAP. This task was scored in terms of percentage consonants correct of the pictures children spontaneously named correctly. Inter-rater reliability was 97%.

Literacy Tasks. Three types of tasks were included: *Reading*, *Spelling* and *Letter Knowledge*. Two reading tasks were used: *British Abilities Scales II Word Reading* and *Reception Reading Words.* Both tasks are single word reading tasks in which children are asked to read words aloud. The *British Abilities Scales II Word Reading* task is one in which the words become increasingly difficult and the task is discontinued if children make eight or more errors in a block of ten. The *Reception Reading Words* task presents the 45 key sight words that were expected to be known by children at the end of their first year in school in the UK under the previous National Literacy Strategy. This is therefore a sensitive measure for children at the earliest stages of learning to read. A total reading measure was created by calculating the z-scores of both measures and adding them.

In the *Spelling* task, children were shown eight pictures and asked to spell the words corresponding to each of them. Rather than a dictation exercise the children were encouraged to spell the words from their own pronunciation. The spellings were scored as conventionally correct, and also according to a phonetic spelling system described in Caravolas, Hulme, & Snowling (2001). According to this system, children are awarded four points for a correct representation of a phoneme, and three points for a representation that differs in a single phonetic feature. For example, the spelling attempt 'tuk' for 'duck' would score 11/12, as /u/ and /k/ are correctly represented, and /d/ is represented by a sound that differs only in voicing. A total spelling score was created by calculating the z-scores of both measures and adding them.

Letter name and letter sound knowledge were assessed by showing the children each of the 26 letters individually in a random order. If children gave the letter sound for a particular letter, they were praised and asked if they knew the letter name, or vice versa. A total letter knowledge measure was created by adding the scores on these two tasks.

Phonological processing. The children were asked to complete six tasks measuring phonological processing: *Nonword Repetition*, *Phonological Awareness, Forced Choice, Priming, Nonword Learning* and *Mispronunciation Detection*.

The *Nonword Repetition* task contained 30 nonwords from two to five syllables in length. These words were taken from the Children's Nonword Repetition Test (Gathercole, Willis, Baddeley, & Emslie, 1994).

The *Phonological Awareness* task was a two alternative initial sound matching task. The children were shown three pictures, a cue and two alternative responses.

The *Forced Choice* task is modelled on the methodology of Storkel (2002). Children are shown a character and told that she or he likes words that sound 'a little bit like' the target word. They hear several words that vary in their phonological relationship to the target. Similar words should be given to the character. There are two conditions – matching by initial sound and matching by final sound. Within each condition, there are five types of item: same word, same sound, shared manner of articulation, shared place of articulation and no shared features.

The *Priming* task used a cross modal paradigm. Children are asked to name a picture as quickly as possible, while hearing a 'distracter' word in headphones. There were five types of distracter words: same word, same initial sounds, same final sounds, shared manner of articulation and unrelated.

The *Nonword Learning* task involved learning nonsense words as names for animals. Nine words were taught in three groups of three, and number of confusions between the nonwords in each triad was recorded. The nonwords shared different phonological relationships (shared manner, shared place or shared initial phoneme).

The *Mispronunciation Detection* task assessed children's sensitivity to slightly mispronounced words. It was presented on a laptop using DirectRT. The child sees a picture and hears it named, either correctly or incorrectly. The child is asked to say whether or not the word was correctly pronounced. They received feedback on their response. Half of the words were correctly pronounced and half were incorrect. The incorrect words had either a consonant deleted (e.g. 'cocodile' for 'crocodile') or had two consonants transposed (e.g. 'crocolide' for 'crocodile'). Total scores for each of the three conditions (correct, deletion or transposition) were calculated and D prime sensitivity scores were calculated to take account of any biases in responding.

Time 2 Testing

Six months after the initial test point, all children were retested on the literacy tasks and an abbreviated battery of the speech and language tasks.

Standardisation of Scores

Given the relatively wide age range included within the sample, scores standardised for age were used. The DEAP and CELF tasks were already standardised. The other measures, excluding Picture Naming, were residualised for age and then standardised with respect to the typically developing children so that the control group had a standard score of 100 and a standard deviation of 15 for each measure.

Classification of Speech and Language Difficulties

A child was classified as having a speech difficulty if they showed an error pattern that was not appropriate for their age on the *Phonology* test (defined as making five errors that could be attributed to a particular error type, such as cluster reduction or gliding, and was not explained by difficulties in articulating that phoneme in isolation. A child was classified as having a language difficulty if they achieved a Core Language score which was more than 1 SD below the control group.

- **Results**

First, there was significant crossover between the risk groups: 45.6% of the children with a family history of dyslexia had received speech therapy in the past or were currently receiving speech therapy, and 34.5% of the children in speech therapy had a first degree relative with dyslexia. Children with low speech processing skills but no history of contact with speech therapists were relatively rare, which indicates good coverage from speech therapists in Warwickshire.

The overall findings are that as a single group, the 'at-risk' children show lower scores than the typically developing children in all of the phonological processing measures. As hoped, there is a wide range of skills in all of the measures tested. However, there is no evidence of qualitative impairments in phonological processing in any of the groups; while children with speech and language difficulties show lower overall scores, they found the same items easy or difficult and seemed to be using the same underlying processing strategies. For example, both at-risk and typical children found pairs of nonsense words sharing an initial phoneme harder to learn than pairs of words that shared manner of articulation.

Several hypotheses have been proposed to suggest which children are most likely to go on to have literacy difficulties. Dodd (1995) suggests that children who make atypical speech errors are likely to have literacy difficulties because their phonological system is developing abnormally. We found 12 children in our sample who made atypical speech errors, 20 children who showed error patterns which were developmentally delayed, and 23 children with difficulties in articulating particular consonants. In previous research in which expressive phonology was assessed purely in terms of percentage consonants correct, the three groups would all have been included in a single 'speech impaired' group. However, as the majority of the children who had pure articulation problems had no additional literacy difficulties, the groups should be separated.

Children with atypical speech errors had lower spelling and phonological skills than controls, and both delayed and disordered groups showed lower reading skills than the controls. These results are broadly in

line with the predictions of Dodd (1995), but they suggest some additional weaknesses in the children with developmental delay. However, Dodd further hypothesises that the reason children with disordered speech are more likely to show literacy difficulties is because they have unusual phonological representations. While these children did show weaknesses in phonological processing tasks, the pattern of their errors was similar to those in other groups; there was little evidence for qualitatively different patterns of phonological processing between groups.

The most prominent view of the link between speech and literacy difficulties is the 'language deficit' hypothesis proposed by Bishop and Adams (1990) and Catts (1993). This proposes that children with both speech and language difficulties are likely to have literacy difficulties, while children with pure speech difficulties are likely to show good literacy. Within our sample, we had 20 children who showed pure speech processing difficulties, 25 children who showed language difficulties without any phonological error patterns, and 10 children who showed both speech and language difficulties. Only the two groups with language difficulties showed significantly lower reading and spelling scores than the control children. In addition, only the two language impaired groups showed significant difficulties on the two input phonological processing tasks, nonword learning and mispronunciation detection. This suggests that the children with isolated speech processing difficulties did not have difficulties in phonological processing in input, and indicates a possible hypothesis that input phonological processing difficulties may be the key factor in literacy difficulties in this group of children.

Structural equation modelling of the data has also been carried out. This allows investigation of the data as continuous variables rather than dividing the groups according to a given cut-off score. The measurement model shows a very close association between language and phonological processing at Time 1. In using the model to predict literacy at Time 2, two different approaches were used. In the first, the auto-regressor (literacy at Time 1) was included. This predicted literacy at Time 2 to a very high level, and no other variable made a significant additional contribution. If the auto-regressor was not included, phonological processing was the strongest predictor of literacy, and no other factors made a significant contribution once this was controlled.

- **Activities**

  The research was presented at four conferences over the two year period:
  - The British Psychological Society Developmental Section Conference, September 2007, Plymouth, UK.
  - The British Dyslexia Association International Conference, April 2008, Harrogate, UK (invited to form part of a symposium).
  - The Society for the Scientific Study of Reading Conference, July 2008, Asheville, North Carolina.

- The International Association for the Study of Child Language, July 2008, Edinburgh, UK (invited to form part of a symposium).

The work was well received at these conferences and as a result I was invited to present the work at three university seminar series:

- Coventry University, October 2008
- Institute of Education (FRiLL group), November 2008
- Nottingham Trent University, December 2008

Over the two years I have been an active member of the Sheffield Phonological Awareness Workshop group. This is a group of around 20 researchers in the broad area of phonological development who meet for presentations and discussions two or three times a year. The research was presented at two of these meetings.

- **Outputs**

Three publications in peer-reviewed journals are planned on the basis of this research. The first has already been submitted. This is a paper examining the overlap between the groups of children with a family history of dyslexia and children in speech and language therapy, submitted to *Scientific Studies of Reading* (impact factor 2.6).

The two further papers will examine the nature of phonological processing impairments in each group, and the prediction of literacy difficulties over the six month period. These will be aimed at *Developmental Psychology* and *Journal of Child Psychology and Psychiatry*.

A dataset will be submitted to the Data Archive in the near future.

- **Impacts**

Several speech therapists and teachers have asked to be kept up-to-date with the results and outputs of the project, but as yet the research is not to my knowledge being used in practice.

- **Future Research Priorities**

An application for further funding to carry out a follow-up study of this project and another project has been made to the ESRC. The follow- up would allow more definitive classification of children into those with and without literacy difficulties. A more detailed literacy assessment would be carried out, including reading comprehension, for example. It is anticipated that early language skills would be particularly closely related to later reading comprehension, while phonological processing may be more closely related to spelling and word reading.

In addition, it is clear that the links between phonological processing and language development have been underestimated in this and previous research. Thus it would be important to carry out a more detailed analysis of

the links between language development and phonological development and awareness.

References

Bishop, D. V. M., & Adams, C. (1990). A prospective study of the relationship between specific language impairment, phonological disorders and reading retardation. *Journal of Child Psychology and Psychiatry, 31*(7), 1027-1050.

Bishop, D. V. M., & Edmundson, A. (1987). Language impaired 4-year-olds: Distinguishing transient from persistent impairment. *Journal of Speech and Hearing Disorders, 52*(2), 156-173.

Bradley, L., & Bryant, P. (1978). Difficulties in auditory organisation as a possible cause of reading backwardness. *Nature, 271*, 746-747.

Caravolas, M., Hulme, C., & Snowling, M. J. (2001). The foundations of spelling ability: evidence from a three year longitudinal study. *Journal of Memory and Language, 45*(4), 751-774.

Carroll, J. M., & Myers, J. M. (submitted). The role of phonetic features in the phonological representations of young children.

Catts, H. (1991). Early identification of dyslexia: evidence from a follow-up study of speech-language impaired children. *Annals of Dyslexia, 41*, 163-177.

Catts, H. W. (1993). The relationship between speech-language impairments and reading disabilities. *Journal of Speech and Hearing Research, 36*, 948-958.

Chiat, S. (2001). Mapping theories of developmental language impairment: premises, predictions and evidence. *Language and cognitive processes, 16*, 113-142.

Dodd, B. (1995). *Differential Diagnosis and Treatment of Children with Speech Disorder*. London: Whurr Publishers.

Elbro, C., Borstrom, I., & Peterson, D. K. (1998). Predicting dyslexia from kindergarten: the importance of distinctness of phonological representations. *Reading research quarterly, 33*(1), 36-60.

Gathercole, S. E., Willis, C., Baddeley, A. D., & Emslie, H. (1994). The children's test of nonword repetition: A test of phonological working memory. *Memory 2*, 103-127.

Hatcher, P. J., Hulme, C., & Ellis, A. (1994). Ameliorating early reading failure by integrating the teaching of reading and phonological skills: the phonological linkage hypothesis. *Child Development, 65*, 41-57.

Muter, V., Hulme, C., Snowling, M. J., & Taylor, S. (1998). Segmentation, not rhyming, predicts early progress in learning to read. *Journal of Experimental Child Psychology, 71*, 3-27.

Nathan, E., Stackhouse, J., Goulandris, N., & Snowling, M. J. (2004). The development of early literacy skills among children with speech difficulties: A test of the "Critical Age Hypothesis". *Journal of Speech, Language and Hearing Research, 47*, 377-391.

Snowling, M. J. (1981). Phonemic deficits in developmental dyslexia. *Psychological Research, 43*, 219-234.

Stackhouse, J., & Wells, B. (1997). How do speech and language problems affect literacy development? In Hulme & Snowling (Eds.), *Dyslexia: Biology, Cognition and Intervention*.

Storkel, H. L. (2002). Restructuring of similarity neighbourhoods in the developing mental lexicon. *Journal of Child Language, 29*, 251-274.