The Development of Phonological Awareness in Pre-school Children

Julia M. Carroll

A thesis submitted for the degree of Doctor of Philosophy

Department of Psychology, University of York

August, 2001

Abstract

There is now a wealth of evidence suggesting that pre-school phonological awareness is closely related to early reading development. However, little research has investigated the causes of early phonological awareness. This thesis considers the relationships between phonological awareness, language development and letter knowledge in three- and four-year old children.

A one-year longitudinal study was carried out on a group of 67 pre-school children. Measures of language skills, letter knowledge and phonological awareness were taken at three times during the year. Children's awareness of large segments such as syllables and rimes developed earlier than their awareness of phonemes, and speech processing skills influenced later phonological awareness. In addition, performance on a new word learning task suggested that phonological awareness could also influence language development implying that there is some reciprocal interaction between phonological awareness and phonological representations.

Data from the longitudinal study showed that letter knowledge was an important precursor to the development of phoneme awareness. All of the children who were successful on the phoneme matching, completion and deletion task knew at least one letter, and letter knowledge predicted phoneme matching and phoneme deletion over time. These results were confirmed by an intervention study in which children were given training in letters. Only those children who learnt more than two letters showed an ability to isolate phonemes two months after the end of training.

Finally, the language, phonological awareness and early reading skills of children with a family history of dyslexia and children with speech difficulties were examined. Both groups showed poor speech processing skills with correspondingly low levels of phonological awareness, in spite of normal vocabulary levels.

It is proposed that there are two separable types of phonological awareness in the pre-school years; sensitivity to sound similarities and awareness of individual phonemes. While speech processing skills are related to both types of phonological awareness, letter knowledge is causally related to awareness of individual phonemes.

Table of Contents

List of Tables

List of Illustrations

Acknowledgements

Firstly, I know that have I been very lucky to have Maggie Snowling as my supervisor. She has provided support and inspiration at every stage and I feel honoured to have worked with her. I would also like to thank the other members of my research committee, Gerry Altmann and Charles Hulme, and Kate Nation and Peter Hatcher, who have also helped out with numerous crises. This thesis was supported by a studentship from the Biotechnology and Biological Sciences Research Council. Brian Byrne and Judy Bowey also taught me so much while I was working in Australia last year. Thanks must go to the past, present and honorary members of the 'zoo': Yvonne Griffiths, Ian Walker, Catherine Marshall, Andrew Sach, Helen Aslett, Pam Baylis, Tanya Patel, Richard Allen, Paula Clarke, Claudine Crane, Drew Dunn, Kristina Herden, Selina Holmes, Sara Hounsell and Anna Rowlands. They have all made working in York psychology department a very happy experience. Special thanks should go to Helen, Catherine, Tanya and Yvonne, who've all been there for me always and have always given me great advice!

I'd also like to thank family and friends: Jenny and Saff, who've been the best friends a girl could have over the past three years, Katie Earle, who drew the pictures for my stimuli, and Laragh and Stephen Quinney, who helped proof-read my thesis. Thanks should also go to all those school and university teachers who have helped and encouraged me: in particular, at school, Mr Herbison and Mrs Hutchinson, and at university, Dr Robert McHenry and Dr Barlow Wright. Finally, I'd like to thank my family, who've always been supportive of everything I've done, let me hide out at home while I wrote up, and even proof-read parts of my thesis. I know I couldn't have done it without them.

I'd like to thank all of the children, parents, speech therapists and teachers who have helped out with my research. In particular, Nicola

Fielden has been really helpful throughout my thesis. Special thanks should also go to the staff and children at Knavesmire and Haxby Road nursery schools, who have both always made me welcome, even though I hung around for months at a time! This is part of a poem for all of the children who have made doing this thesis such fun.

Author's Declaration

I declare that the work presented within this thesis is my own work and has not been submitted for any other degree or qualification.

1. Literature Review

Phonological awareness and reading development

Phonological awareness can be described as an awareness of the sounds that make up words. However, different researchers have, over the years, defined this skill in several different ways. There are two main dimensions on which definitions vary: the size of the word segments analysed and the role that consciousness plays in the process. These varying definitions have been the source of much debate. Despite this, two findings have remained unchallenged since they were first reported. Firstly, pre-school children find phonological awareness tasks difficult, even when the tasks are made as concrete and as simple as possible. Secondly, phonological awareness is closely related to reading development.

Bruce (1964) was among the first researchers to examine the developmental progression of skills in phonological awareness. He gave a series of phoneme deletion tasks to children between the ages of five and nine years old. The children were asked to delete the initial, medial or final phoneme from a word and pronounce the resulting word. The children showed surprisingly poor performance on this task. All of the five-year-olds were completely unable to complete the task, and only a few of the six-year-olds produced any correct answers. Only the eight- and nine-year-old children showed consistent performance across the task. This study showed that awareness of phonemes within words is not a skill that can be taken for granted.

This discovery was corroborated and extended by further work by Liberman and colleagues (Liberman, Shankweiler, Fischer, & Carter, 1974) who compared syllable and phoneme segmentation in children between four and seven years of age. The children were asked to tap out either the number of syllables or the number of phonemes in a word. Tapping out the number of phonemes was considerably harder for the children, though the number of taps required was equated across the two tasks. There were also developmental effects. The pre-school and kindergarten children were almost completely unable to determine how many phonemes there were in a given word or phrase, though they scored at around 50% correct on the syllable tapping task. This study confirmed that while pre-school children have very little awareness of individual phonemes, as shown by Bruce (1964), they do show some awareness of syllables. However, researchers were still unsure of whether phonological awareness arose as a result of general developmental maturation or as a result of some other factor.

A study by Morais, Cary, Alegria, & Bertelson (1979) examined these alternative hypotheses. They compared phoneme awareness in illiterate and ex-illiterate Portuguese adults. The subjects were asked to either delete a segment from or add a segment to the start of a word. The ex-illiterates significantly outperformed the illiterate subjects, around half of who produced no correct responses. This study showed that the development of phonological awareness is closely related to literacy development.

In fact, there is some evidence to suggest that awareness of individual phonemes only develops when people learn to read and write using an alphabetic system. Read, Zhang, Nie, & Ding (1986) studied adults who had learned to read using either an alphabetic or non-alphabetic orthography in Chinese. They were given the same tasks as those involved in the Morais et al. (1979) study. Very similar results were found. Subjects who had learnt to read using an alphabetic orthography were much better at these tasks than subjects who had learnt to read using a logographic orthography.

These studies suggest that phonological awareness develops as a result of learning to read in an alphabetic orthography. However, other studies published at around the same time suggested that phonological awareness actually influences reading development. Elkonin (1973) was one of the first researchers to advocate training in phonological awareness as a precursor to reading tuition. He found that pre-school children were generally not aware of the single phonemes that make up words, and believed that learning alphabetic correspondences precipitated the development of phonemic awareness. He also believed that phonological awareness would be useful in learning letters, however, and suggested that letters would be learnt more easily if children were taught to focus on the sounds in speech before reading instruction began. He described a study in which children were taught to segment words into phonemes using counters and boxes. This segmentation was learnt more quickly than a task requiring that speech sounds be linked with letters. However, once this skill was in place, the linking of those speech sounds to letters was a relatively easy process.

One of the major arguments in favour of phonological awareness influencing later reading development is that children with reading difficulties show levels of phonological awareness that are lower than those of both chronological and reading age matched controls. Bradley & Bryant (1978) were some of the first researchers to look at the phonological awareness skills of children with dyslexia. They found that these children scored lower on phonological awareness tasks than did younger average readers at the same reading level. This suggests that their difficulties were a cause and not a consequence of their reading difficulties. This finding has been replicated many times with a variety of phonological tasks, and using dyslexic readers of all ages. In fact, dyslexic children seem to have difficulties not only with tests of explicit phonological awareness but also with a range of phonological processing tasks, including short-term memory, nonword repetition and rapid naming of automatised stimuli (Snowling, 2000). Several longitudinal studies of normal development have also found that phonological awareness predicts later reading even when initial levels of reading are controlled (e.g. Bryant, Maclean, & Bradley, 1990; Cataldo & Ellis, 1988; Stuart & Coltheart, 1988). For instance, Cataldo & Ellis (1988) examined the relationships between reading, spelling and phonological awareness in the first three years of schooling. Early phonological awareness predicted later reading and spelling development at each stage of testing.

This argument was strengthened by a further study, (Bradley & Bryant, 1983) that found that poor readers who were given training in phonological awareness showed larger gains in reading than poor readers trained on another language skill such as semantic categorisation. Several other researchers have found similar results. Hatcher, Hulme, & Ellis (1994) found that the most effective intervention for a group of poor readers was a programme combining training in phonological awareness and reading, suggesting that making the link between phoneme awareness and decoding explicit is also useful for many readers. Similar results have also been found with children learning to read in other languages. Lundberg, Frost, & Peterson (1988) found that phonological awareness training for six-year-old pre-readers improved their reading and spelling development in the early years of school.

There are several reasons for the differing conclusions of the early studies of phonological awareness in young children and the later studies investigating the phonological awareness of poor readers. Firstly, and perhaps most importantly, most researchers now agree that there is a reciprocal influence between early reading development and phonological awareness. These two skills are likely to interact throughout development. The second reason for the disparity in results is that researchers are referring in each case to slightly different types of phonological awareness. Liberman et al. (1974) showed that pre-school children generally do show some awareness of syllables, but do not normally show any awareness of phonemes. The studies suggesting that alphabetic literacy is necessary for the development of phonological awareness refer only to the development of awareness of individual phonemes. However, the phonological awareness tasks used by Bradley & Bryant (1978) were rhyme and alliteration oddity tasks. These tasks involve the matching of large sound segments and give the child three possible alternative answers. There is a range of evidence to suggest that the skills required to complete these tasks are quite different from the skills required to complete the phoneme deletion and tapping tasks used by Liberman et al. (1974) and Morais et al. (1979). Pre-school children may well be able to complete the rime oddity tasks before they are able to complete the phoneme deletion tasks. The following section considers theoretical views of the ways in which these phonological awareness tasks can be distinguished.

Theoretical Views of the Development of Phonological Awareness

There is considerable research showing that phonological awareness tasks span a wide range of difficulty. Pre-school children show some ability to recognise rhymes, while even adults find tasks such as phoneme transposition difficult. In the following sections the two most prominent theories for how phonological awareness develops in pre-school children will be considered: Goswami & Bryant (1990)'s theory of levels of phonological awareness, and Gombert (1992)'s theory of epilinguistic and metalinguistic awareness.

Levels of Phonological Awareness

Early research showed that tasks involving syllables were easier for young children than tasks involving phonemes (Liberman et al., 1974). Treiman (1985) proposed that children progressed from syllable to phoneme awareness via an intermediate level of awareness of sub-syllabic units, the onset and rime. The onset is the initial consonant or consonant cluster of a word and the rime is the vowel and final consonant or consonants. Goswami & Bryant (1990) suggest that an awareness of onset and rime occurs before reading instruction, and allows children to decode words by analogy, before they have a full awareness of phonemes.

Treiman (1985) originally proposed that children naturally divide words into the onset and rime prior to reading instruction. She found that eight-year-old children found word games easier when words were split between the onset and rime than games where the onset was split or the word was split after the body. For instance, in one game the children had to change either the first two or last two phonemes in a three-phoneme word. They found it easier to change the first two segments when the words were CCV words and easier to change the final two segments when the words were CVC words. It was also found that four and five-year-old children recognised a consonant more easily when it was a singleton onset than when it was part of a cluster onset, and that beginning readers found written CVC structures easier to decode than CCV words. A potential alternative explanation for this phenomenon is that a CVC structure is a more common structure for words in English. In addition, a consonant cluster is more difficult for a child to analyse, both in perception and production than two consonants separated by a vowel. Overall, therefore, this is not conclusive evidence that children naturally split words into an onset and a rime.

Kirtley, Bryant, MacLean, & Bradley (1989) propose that children should be aware of single phonemes when they coincide with the onset of a word before they are aware of single phonemes within a rime. Sixty-four five-, six- and seven- year-old children were given an oddity task - they had to listen to three words and pick the odd one out. These words shared different combinations of the onset, vowel or coda. It was found that the children scored better on the end-sound task if the central vowel was also contrasted, while this did not make any difference to scores on the initial sound task. This seems to be strong evidence for the idea that children develop an awareness of onset and rime before they develop an awareness of individual phonemes.

Despite the evidence for a developmental progression from large to small segments in implicit phonological tasks, there is some evidence that this may not be the case in explicit phonological tasks. Seymour & Evans (1991, 1994) found that children in fact found both segmentation and synthesis tasks easier at the phonemic level than at the onset-rime level. It may be that the confusion between implicit and explicit tasks in previous studies has obscured the fact that children do not show the same developmental pattern in implicit and explicit phonological awareness.

Seymour & Evans (1994) directly compared the performance of a group of 4-, 5- and 6-year-old children on a set of segmentation and blending tasks. The children were asked to segment words either into onsets and rimes, onsets, vowels and codas, or single phonemes. For instance, they were given a word such as stamp and asked to segment it into 'st-amp', 'st-a-mp' or 's-t-a-m-p'. This task requires an explicit awareness of word segments, in contrast to the standard oddity task, yet compares onset and rime awareness directly with phoneme awareness. There was no difference in performance on the tasks at different levels of awareness. The children found the onset-rime segmentation task just as difficult as the onset-vowel-coda task and the phoneme segmentation task. It is suggested that explicit awareness of word sounds occurs as a result of literacy instruction, and begins at the level of the phoneme.

Duncan, Seymour, & Hill (1997) examined directly the strategies used in onset-rime tasks. It was found that if a six-year-old child was given two words with matching segments, and asked to repeat only the segment that matched, then children found repeating matching onsets easier than repeating matching rimes. This was taken as evidence that early readers focus their attention at the level of the phoneme rather than at the level of the rime. These results suggest that children use phonemic strategies in the earliest stages of learning to read.

Epilinguistic and Metalinguistic Processes

Gombert (1992) proposed a theory that conceptualised the differences between implicit and explicit phonological awareness. He contrasted epilinguistic processes with metalinguistic processes. Metalinguistic processes require a conscious understanding of what one is doing in a phonological task. Gombert (1992) attributed this ability to children only after the age of seven or eight. On the other hand, epilinguistic tasks are ones in which the correct solution can be found without an understanding of the reasoning behind the solution, so without understanding that two words can have a segment in common.

From the age of two years onwards, children show a propensity to make up spontaneous rhymes and poems involving phonological devices, suggesting an early sensitivity to the phonological characteristics of words. This was first noted by Chukovsky (1925, 1968) who documented the spontaneous rhymes of Russian children. This is particularly interesting as the children were brought up in a culture that did not explicitly teach children rhymes or poems or even encourage children to produce them. In fact, children were often told off for "talking rubbish". Heath (1983) also found that both working class black and white children in southern America would often use rhymes and poems spontaneously, though neither group was encouraged to do so.

Dowker (1989) examined the phonological devices used in poems by children between the ages of two and five. She found that 58% of the children produced at least one poem, and that 60% of these poems contained phonological devices of some kind, either rhyme, alliteration or assonance. These findings suggest that children have some form of phonological knowledge from a very young age. This does not imply, however, that this knowledge is explicit in these children, but merely that they enjoy the sounds made from language play of this kind. Possible evidence towards this idea is the fact that Dowker (1989) found that varying the type of device used in the stimuli poems - rhyme or alliteration - did not alter the types of poems produced, suggesting possibly that it is not a conscious activity. Gombert (1992) suggested that young children separate normal language, used for communication, and another language, without meaning, where sound can be manipulated. It is only in middle childhood that children begin to be able to link these two skills.

Gombert (1992) describes standard rhyme detection and rhyme oddity tasks as tasks that only require epiphonological control because they "could perhaps be explained by the simple use of overall similarities between the words presented" (Gombert, 1992, p19). In addition, he points out some studies have not found correlations between phonological awareness tasks such as phoneme inversion and substitution and tasks that use an implicit knowledge of rhyme (e.g. Content, Kolinsky, Morais, & Bertelson, 1986).

Many researchers have found that phonological awareness in three- to six-year-old children can be divided into two types: awareness of large segments such as rhyme and awareness of individual phonemes. This is the result found by Hoien, Lundberg, Stanovich, & Bjaalid (1995), who looked at phonological awareness and later reading ability in a large sample of pre-literate Norwegian children.

Six phonological tasks were used; a rhyme detection task, a syllable counting task, initial phoneme recognition, initial phoneme deletion, phoneme counting and phoneme blending. It was found that the first two tasks loaded on separate factors, and all of the other four tasks loaded on one factor, which could be described as phonemic ability. When these children were followed up one year later, phonemic ability was the factor most closely related to reading ability.

Muter, Hulme, Snowling, & Taylor (1998) followed a group of children from the year before they entered school until the end of their second year. Rhyme detection, rhyme production, phoneme identification and phoneme deletion tasks were given, together with a letter knowledge task. A principal components analysis was performed and two relatively independent factors were discovered, one with loadings from the rhyme tasks and one with loadings from the phoneme segmentation tasks. Using these factors in a regression analysis to predict early reading ability, they found that the segmentation factor was closely related to reading ability, while the rhyme factor was not. They found that the most accurate prediction of later reading ability was found from a combination of phonemic awareness and letter knowledge. This suggests that a task that depends on segmented lexical representations is a better predictor of reading ability than a task that can be solved using overall phonological sensitivity.

Hulme, Hatcher, Nation, Brown, Adams & Stuart (in press) conducted a cross sectional study of the performance of five and six-year-old children on a series of phonological tasks at the level of the rime, onset and phoneme. They found that phoneme awareness was the best concurrent predictor of reading skills, with onset and rime awareness accounting for no additional variance once phoneme awareness had been controlled.

To summarise, there is some evidence in favour of each of these views of the development of phonological awareness. The following section considers more fully how each of these theories accords with findings from experimental studies.

The Development of Phonological Awareness

Global Phonological Awareness

Many researchers have found that pre-school children can solve phonological awareness tasks (e.g. Chaney, 1992; Fox & Routh, 1974; MacLean, Bryant, & Bradley, 1987). These tasks appear to involve segmenting a given word and matching a part of it to another word. However, it has been suggested that many of these tasks can be solved by paying attention to the global similarity between words. Global similarity can be defined as the overall perceptual sound similarity between two words. Some consonants sound more similar to each other than others do, and several studies have shown that pre-school children are sensitive to this sound similarity. Byrne & Fielding-Barnsley (1993) showed that many five-year-old children use global similarity to solve the standard phonological detection tasks, and that this confound may be artificially inflating estimates of the child's ability. They found that half of the children tested (11/22) passed the standard alliteration detection task, but failed the task when both alternative were equally globally similar to the cue word. A similar result was found with a rhyme identity task given to kindergarteners by Cardoso-Martins (1994). It appears that pre-reading children have a tendency to use global strategies for solving phonological awareness tasks.

In addition to research in which global similarity was directly controlled, several researchers have also shown that pre-literate children are susceptible to phonological similarity. Lenel & Cantor (1981) found that four-, five- and six-year-old children found distractor items harder to reject in a rhyme detection task if they also shared one phoneme with the cue word. Cardoso-Martins (1995) found that Brazilian first graders found syllable oddity tasks harder when the odd syllable shared one phoneme with the other two words than when all phonemes differed.

Gombert (1992)'s theory also provides an explanation for the fact that rime matching tasks often seem to be easier for young children than onset matching tasks. This is an unexpected finding given that both tasks would require the same level of awareness according to the theory proposed by Goswami & Bryant (1990). However, two words sharing an onset are likely to be less globally similar than a pair of words sharing a rime, and so a rime task would be easier to solve on the basis of overall sound similarity.

It is important to emphasise that there are two possible explanations for the finding that children use global similarity to solve phonological awareness tasks. The first, as proposed by Gombert (1992) is that pre-school children do not have a conscious awareness of the sounds of phonemes and so use a general intuition of sound similarity. The second, proposed by Walley (1993) is that pre-school children have global representations of the sounds of words. This theory will be discussed more fully in later sections. The difference between these explanations is that Gombert (1992) does not assume that the underlying representations of pre-reading children are fundamentally different from those of reading children, just that their awareness of word segments is fundamentally different. One way to compare these hypotheses would be to see whether children's tendency to use global similarity to solve tasks varied as a function of the words used – whether they were more likely to use segmental strategies with words with a low age of acquisition, for instance. However, these data cannot be adequately explained by the theory of levels of phonological awareness.

It can be seen from this discussion that in administering phonological awareness tasks to young children it is crucial to consider what skills each task requires. Some tasks require an explicit knowledge of the sound segments that make up words. This ability may well require some early reading instruction or teaching in letter knowledge. Other tasks only require a global sensitivity to sound similarity. It appears that pre-reading children are much more able to complete tasks that can be solved using global similarity. However, performance on tasks that involve explicit understanding of sound segments are more closely predictive of reading success. Since this variable has often been overlooked by researchers investigating pre-school phonological awareness, it will be useful to review past studies to re-examine the tasks they have used.

Phonological Awareness in Three- and Four-Year-Old Children

Three-year-old children do show some knowledge of the sounds involved in their speech. Young children will often correct their own speech during an utterance, showing some awareness of word sounds. In addition, Chaney (1989) describes examples of children as young as two asking questions about word boundaries and word sounds. For instance, one child of two asked "What is it, is it 'pilled' or 'spilled'?". However, it seems likely that this type of ability in young children is unconscious. There are also several studies which aim to look at pre-school phonological awareness in a formal experimental task.

Fox & Routh (1974) asked children between the ages of three and seven to say "just a little bit" of some sentences, phrases, words and syllables. The children therefore had to divide a sentence into phrases, then words, then syllables and finally phonemes. The task got harder as the segments got smaller, but eight of the thirty-two three-year-olds in the study managed to produce at least one phonemic response. However, this result has proved difficult to replicate (e.g. MacLean et al., 1987). In addition, it may be that what the child is doing here does not involve an explicit awareness of phonemes. Instead, the child merely has to begin to say a word and then stop speaking at the correct place. The multiple attempts that were allowed in this study may also have meant that phonemic segmentation ability was overestimated. In general, therefore, this study does not provide clear evidence that children of this age have segmented lexical representations.

Smith & Tager-Flusberg (1982) examined the metalinguistic awareness of three and four-year-old children. The tasks they used included: a speech/non speech discrimination task, in which the child had to determine whether a sound was someone talking or (for instance) a cough or sneeze; a rhyme judgement task; and various tasks assessing the children's understanding of words and how these words refer to concepts and awareness of the syntactic structure of sentences. The speech/non-speech discrimination task was not correlated with any of the other measures, but the rhyme judgement task (which could be solved on the basis of overall sound similarity) was well correlated with all of the general language development measures.

Bryant and colleagues (Bryant et al., 1990; MacLean et al., 1987) followed a group of normally developing pre-schoolers from the age of 3 years 4 months until the age of eight. They found that the most accurate predictors of later reading ability were the rhyming and alliteration oddity tasks given at 4 years and a nursery rhyme knowledge task given at four years old. These factors all predicted reading ability even after IQ, social background and general language ability were controlled for. As Gombert (1992) points out, these tasks may be solved on the basis of global similarity, and so may just illustrate sensitivity to the similarity of global sounds. It is not true that: "to recognise that cat and hat rhyme, it must be understood that the two words, though different, have a sound in common, and this common sound is a segment of those two monosyllabic words" (MacLean et al., 1987, p256).

A study looking at a wider range of phonological awareness measures was conducted by Chaney (1992). This study included phonemic tasks as well as rhyme tasks. The phonological tasks included judgement and correction of the articulation of monosyllabic words; identification and production of words beginning with a specific phoneme; rhyme identification and production; a phonological play task involving deliberate mispronunciations of a target word; and finally a phoneme synthesis task using CVC words.

The first two tasks are not truly metalinguistic, involving articulation of known words. The initial sound identification task was the hardest, with only 14% of the children scoring above chance. Rhyme identification was also difficult, with only 26% of the children scoring above chance. However, both of these tasks could be solved on the basis of global similarity – the children were given a set of possible alternatives from which to choose the correct answer. The phonological play task is similar to the spontaneous language play described earlier, and need not require conscious manipulation of word segments. Phoneme synthesis is perhaps the task that seems most likely to require a conscious manipulation. Perhaps surprisingly, this was also the task the children found easiest, with 93% scoring above chance. This task took the form of a three alternative forced-choice task, and since only the correct card shared any phonemes with the spoken stimulus, the task could be solved using global phonological similarity. The child only needs to hear the first sound and determine which of the three words it sounds most similar to. For instance, if the pictures were of a cat, a pig and a horse, then the first phoneme /p/ would sound most similar to 'pig', and so the child would choose that one. There is no need to assume that the child understands that the series of phonemes are segments of the target word. It seems therefore, that none of these tasks require conscious manipulation of word segments, something that the authors do point out. However, it also appears that these tasks could be solved equally well irrespective of whether global or segmental strategies were used.

Cross-Linguistic Studies of Phonological Awareness

There is another possible explanation for the differing views on the development of phonological awareness that had been somewhat overlooked until recent years. This is the possibility that phonological awareness develops differently in different languages. There is already considerable evidence that the orthography of a language influences phonological awareness, as shown by the studies that show that readers of non-alphabetic orthographies develop a knowledge of phonemes that is at best incomplete (Mann, 1986; Read, 1971). However, it is also likely that the phonologies of different languages give rise to different types of phonological awareness. Since English contains fewer polysyllabic words and has less clear syllable boundaries than both of these languages, it may be found that English speaking children are less likely to develop pre-literate syllable awareness. On the other hand, most of the research suggesting that onset and rime awareness provides a bridge between syllable and phoneme awareness has been conducted on English speaking children. In fact, the reason generally proposed for the development of onset-rime awareness is that English is a language with a high level of regularity at the level of the rime. Many words can be organised into 'word families' on the basis of shared rimes (Treiman, 1985). It is likely therefore that the rime is a more prominent feature in English than in other languages.

Italian is a language with predominantly open syllables, which may lead to syllables being more easily distinguishable than in English, where syllable boundaries are often unclear. Cossu, Rossini, & Marshall (1993) gave a group of Italian children versions of the tasks given to American children by Liberman et al. (1974). They found that the Italian children outperformed the American children at each stage of development. However, since the groups were not closely matched or in fact directly compared with statistical analyses, the conclusions that can be drawn from this study are limited.

Bruck, Genesee, & Caravolas (1997) directly compared the early literacy development of French and English speaking Canadian children. They found interesting differences in the phonological awareness skills of the two groups. The French children showed good performance on the syllable awareness tasks and poor performance on the onset-rime and phoneme awareness tasks. In contrast, the English speaking children did relatively less well than the French speaking children on the syllable awareness tasks and better on onset-rime awareness tasks. The authors explain these differences in terms of the differing phonologies of the two languages. French is a syllable timed language, with clear syllable boundaries and mostly open syllables. In contrast, English is a stress-timed language and the dominant syllable structure is closed. These differences are likely to lead to syllables being less prominent and rime being more prominent in English than in French.

There is also evidence from other languages. Czech is a language with a high incidence of onset consonant clusters, and a relatively low incidence of word final clusters. Caravolas & Bruck (1993) found that pre-literate Czech children are equally good at isolating the initial phoneme of a word whether it forms a singleton onset or is part of a cluster. In contrast, English speaking children find phonemes within clusters much harder to isolate than phonemes that form singleton onsets. It is suggested that Czech children are forced to analyse word initial clusters more fully than English speaking children do, as a result of their prevalence within the language. In contrast, Huang &

Hanley (1994) found that children speaking Mandarin, a language with no consonant clusters, found deleting an initial consonant from a cluster easier than deleting singleton onsets. This was the opposite pattern to that of the British children tested. It was proposed that these children are in fact recoding the clusters as two consonants with a vowel separating them. This would mean that 'stop' would be recoded as 'suhtop', and the task would become a syllable deletion task. This shows that the relationship between the phonological properties of a language and the phonological awareness of children learning that language is by no means straightforward.

There is, therefore, some evidence that differing phonologies lead on to differing types of phonological awareness, even in children who have not yet begun to learn to read. This may provide an explanation for the prominence of different theories in different countries. French and Portuguese speaking children may begin to identify syllables at an earlier point of development than English speaking children do. In contrast, English speaking children are more likely to show poor awareness of phonemes within clusters and good awareness of rimes.

Phonological Development and Phonological Awareness

The previous section illustrates how the phonological awareness of young children is dependent upon their language experience. In fact, Morais (1991) refers to phonological awareness as a 'bridge' between language and literacy. Since phonological awareness is an awareness of the sound segments that make up words, it will be crucially dependent on how children represent and process the phonological structure of those words. This section considers phonological development from birth to early childhood and how it might precipitate the development of phonological awareness.

The Development of Phonological Representations

Children have some knowledge of the phonological structure of their language while still in the womb. Moon, Cooper, & Fifer (1993) found that neonates born to Spanish speaking mothers distinguish between the language of their mothers and an unknown language. They are also able to perceive phonemes categorically, in much the same way as adults do, from only two or three months old (Eimas, Siqueland, Jusczyk, & Vigorito, 1971).

However, over the first year of life infants lose the ability to perceive phonetic distinctions not made in their own language (Werker & Tees, 1984) suggesting that their initial sensitivities become honed by experience. At around the same time, they start to produce phonological sequences for the first time, known as babbling. These sequences are repetitive consonant-vowel sequences, apparently without communicative intent.

Infants generally begin to produce recognisable words at around the beginning of their second year. These words often utilise the same phonemes produced in canonical babbling, and there seems to be some overlap between these stages. However, when children begin to link their speech with meaning there are some changes in the character of their phonological processing. Several researchers have suggested that children begin by representing words at the level of the syllable. Ferguson & Farwell (1975) conducted an observational study of three children in the first six months of learning to talk. They found that use of phonemes was often specific to particular words, and that young children showed a high degree of variability in their use of individual phonemes. For instance, one child initially pronounced all words beginning with /m/ and /n/ as beginning with /m/, apart from no, which was never pronounced in this way. Ferguson & Farwell (1975) suggested that words are initially acquired as syllable-level sets of articulatory movements, or gestures. Therefore words are initially stored as global wholes.

There is also some evidence that at this stage of development children become less focussed on the phonological characteristics of words, and fail to differentiate between phonologically similar forms. Jusczyk & Aslin (1995) found that while seven-and-a-half-month-old infants show a preference for listening to words previously heard in a familiarisation phase, this does not extend to phonetically similar 'foils'. However, different results have been found with older children. Halle & De Boysson-Bardies (1996) repeated this experiment with eleven-month-old infants and found that they showed a preference both for the familiar stimuli that did extend to the phonetically similar foils. As suggested by Werker & Tees (1999), it seems that the older children have begun to attend to the semantic content of words and adopt a more global processing strategy than the younger children do. In fact, Menyuk, Menn, & Silber (1986) suggested that children begin by learning to associate words with various specific contexts, and store only as much phonetic detail as is required to contrast words within the lexicon.

It appears, therefore, that children in the first stages of word learning store these words as unanalysed global wholes, and at some stage in childhood progress from these representations to the phonemic representations that adults have. However, there is some debate within the literature as to when this process occurs, and which factors in development precipitate this change. Studdert-Kennedy (1987) suggested that words are represented as a series of phonemes by the end of a child's third year. These phonemes are structures that represent both the acoustic form and the articulatory gestures of speech, and are therefore used in speech perception and production. These structures form the basis for the conscious representations of phonemes that develop as a child learns to read. Studdert-Kennedy went on to suggest that this early representation of phonemes allows children to learn new word forms more quickly and forms the basis of the vocabulary spurt towards the end of the third year.

In support of this theory, Swingley, Pinto, & Fernald (1999) argued that even two-year-old children show some incremental processing of speech. They showed children of this age a choice of two pictures, and played them a word that corresponded to one of the two pictures. In one condition, the two items shown had names that contained the same onset and vowel, such as doll and dog. In the second condition the two words did not contain any of the same phonemes. They found that the children looked at the correct picture earlier in the no overlap condition. However, in a further experiment, the presence of two rhyming alternatives (e.g. dog and log) did not influence the time taken before the child looked at the correct picture. The authors argue that for the children to alter their behaviour when the two alternative words contained the same onset, but not when they contained the same rime, these children must be able to process word segments before hearing the full word.

However, others argue that the restructuring from global to segmental representations is a much more gradual process. Bloom (2000) reviews evidence for the presence of a vocabulary spurt in the third year of life and concludes that in fact the rate of word learning increases constantly throughout childhood, and that there is no specific point at which rate of word learning increases dramatically over a short period of time. It appears that children in fact get steadily better at word learning throughout childhood. Perhaps phonological representations are also becoming more detailed throughout the pre-school years. It is certainly true that while Studdert-Kennedy assumes that children have linked acoustic and articulatory movements of all phonemes by the third year of life, most children have difficulty in producing and perceiving some phonemes (such as /r/ or /θ/) until at least the fifth year of life (Velleman, 1988).

Walley (1993) suggested that children retain global phonological representations throughout the pre-school years, and that the progression from global to segmental representations is precipitated by three things: language play, vocabulary growth, and the onset of reading tuition. Walley also suggests that a child's phonological awareness is therefore directly dependent on the status of a child's phonological representations.

There is some evidence suggesting that children retain at least partially global representations until the school years. Pre-school children show a tendency to classify words on the basis of their global phonological similarity. Treiman & Breaux (1982) used sets of nonsense syllables that either shared a common phoneme or were globally similar to each other. It was found that children preferred to classify syllables according to global similarity, while adults were more likely to use common phoneme associations. This finding was repeated in the second part of the study, a training study, where it was found that adults were more likely to confuse syllables that shared a common phoneme, while children were more likely to confuse words on the basis of global similarity. These findings suggest that children tend to treat words as global wholes rather than as a series of segments, both when holding them in working memory and when accessing them from long-term memory.

There is also evidence that pre-school children differ from older children and adults in the ways they approach speech perception and production tasks, including experimental tasks such as gating or lexical decision. Walley (1988) performed a lexical decision task with words that were mispronounced either in their initial or final consonant. Adults were better at recognising mispronunciations in the initial position than in the final position. However, four-year-olds did not show this effect, and five-year-olds only showed this effect when the words were highly predictable from the context. This is taken as suggesting that young children do not organise their lexicon by word initial segments, as adults are assumed to do, but in a more global manner.

Gerken, Murphy, & Aslin (1995) suggest that the poor performance of children on lexical decision tasks may be due to extraneous task demands, which cause more problems for children than for adults. They gave four-year-olds a task with fewer memory and processing demands. The children had to listen to phonological sequences and determine whether they were the word *little* or not. In this task, it was found that reaction times varied as a function of the phonological similarity between the test word and the target word, and also that two one-feature changes on different phonemes was easier to reject than one two-feature change on a single phoneme. This was taken as evidence that children do have some knowledge of the internal structure of words. However, as Walley (1993) describes, the development of segmented representations need not be an all or none process, and one would expect four-year-olds to have some knowledge of the internal structure of a highly familiar word such as *little*, even though it does not have many phonological neighbours.

Another line of evidence comes from studies directly comparing child and adult speech perception and production. Nittrouer & Studdert-Kennedy (1987) found that, when classifying fricatives, children were more affected than adults were by the nature of the transition between the consonant and the vowel. On the other hand, they were less affected than adults were by the nature of the following vowel. The researchers took this as evidence that children attend to the stimulus as an undifferentiated whole, rather than splitting the stimulus into a consonant and a vowel. These findings are mirrored by one from a speech production experiment (Nittrouer, Studdert-Kennedy, & McGowan, 1989), in which it was found that young children show more coarticulation between the consonant and the vowel than adults do, and also that their pronunciation of a given phoneme varied more with vocalic context.

One difficulty with Walley's theory that vocabulary, language play and reading tuition all influence the development of segmental representations is that all of the studies described above compare groups of children who differ in both age and in schooling level, and so it is difficult to know whether these differences are due to age-related verbal development or to the onset of alphabetic literacy. However, there is some evidence addressing this issue. Mayo (1999) used the speech perception task devised by Nittrouer & Studdert-Kennedy (1987) with groups of children of the same age who were in different types of schooling – one in which reading tuition had started and one in which it had not. The children receiving reading tuition were more likely to use adult-like perceptual weighting systems in this task. There is also evidence from adult subjects. Morais & Kolinsky (1995) describe a series of studies in which literate and illiterate adults were compared on speech perception tasks. The two groups do not differ on tasks that required low level processing, such as categorical perception, but they did differ on a dichotic listening task in which they had to report the words heard in one ear only. Though overall error rates were the same, the subjects differed in the types of errors they made. The errors of the literate subjects were more likely to be words that differed from the target word by a single phoneme, while the errors of the illiterates were more likely to be words that were globally similar to the target word.

These data suggest that in fact the onset of reading tuition is the most important factor in the development of phonemic representations.

Even adults who have not learnt to read show a tendency to use global similarity in word recognition tasks. Either learning to read in an alphabetic orthography forces a restructuring of phonological representations, or it causes a change in the strategies used in phonological awareness tasks.

In summary, children start learning words by representing their phonological structure holistically. Studdert-Kennedy (1987) suggests that they move from holistic to segmental representations during the third year of life. However, other researchers (e.g. Walley, 1993) have suggested that the transition to segmental representations is much more gradual, and there is a certain amount of evidence that children begin to use more phonemically oriented strategies in speech perception and production after the onset of reading tuition.

The Relationship between Phonological Awareness and Phonological Representations

This pattern of phonological development shows some similarities with the development of phonological awareness discussed in earlier sections. Children begin by processing words globally, and go on to use phonemic strategies soon after the onset of reading tuition. However, some further consideration of the nature of the relationship between phonological representations and phonological awareness is necessary before conclusions can be drawn. Studdert-Kennedy's theory entails a clear distinction between phonological awareness and phonological representations. Phonemes are represented from the third year of life, but children are not able to use them in solving phonological awareness tasks until after the onset of reading tuition. However, Walley proposes that phonological awareness is a direct reflection of the underlying representation of individual words. Part of her theory entails that children are only able to complete phonological awareness tasks with words that are represented segmentally within the lexicon.

The theory proposed by Studdert-Kennedy (1987) distinguishes between phonological representations and phonological awareness. Phonological sequences are represented in an adult-like form from the third year of life, and therefore the onset of phonological awareness must be linked to the development of other skills or strategies necessary to solve the tasks, such as the ability to compare two stimuli, or the ability to consider parts and wholes of objects simultaneously. If this hypothesis is correct, the quality of phonological representations in the pre-school years would not be closely related to the development of phonological awareness, since all words would be well specified enough to allow completion of tasks such as rime and syllable detection tasks.

Walley's theory, however, would predict that phonological awareness is highly dependent on the status of lexical representations. There are two ways in which this relationship could work. This first is that phonological awareness is an external manifestation of the internal state of phonological representations. In this view, phonological awareness for a particular word will depend directly on the degree of lexical segmentation that exists for that word. There is some evidence that quality of representation and phonological awareness are linked at the level of individual words. Metsala (1999) showed that three- to five-year-old children found phonological tasks harder when they involved words that had a higher age of acquisition, or a lower neighbourhood density. These two factors are said to be related to how words are represented in the lexicon Charles-Luce & Luce (1990). Thus it was concluded that phonological awareness for particular words varies according to how fully words are represented in the lexicon. However, these results could also be explained by the fact that phonological awareness tasks are highly dependent on short-term memory, and words that are well represented in the lexicon are more likely to be retained accurately in short-term memory (c.f. Hulme, Roodenrys, Schweickert, & Brown, 1997).

There is also evidence that suggests that clarity of articulation of a word is related to the degree of segmental awareness of that word. Swan & Goswami (1997) gave dyslexic children a series of pictures to name and measured their articulatory accuracy on this task. They then used the same words in a series of phonological awareness tasks at the level of the onset, rime and single phoneme. They found that the dyslexic children were less accurate in their articulation of these words, which they took as evidence that their phonological representations of these words were less clear. Once articulatory accuracy on the picture-naming task was controlled for, the dyslexics did not differ from controls on the onset and rime tasks. However, on the more difficult phonemic tasks, there were still differences between the dyslexics and the controls. Swan and Goswami concluded that dyslexic children did have poorer phonological representations of words than normal controls, as shown by their performance on the articulation task, and that these poorer representations directly impacted on their ability to complete phonological awareness tasks with these words. However, they also had additional difficulties that further impaired their performance when they were asked to complete tasks at the level of the single phoneme.

The second possibility is that phonological awareness occurs as a result of the knowledge that comes from having segmented lexical representations. According to this theory, more segmental representation in general will improve phonological awareness in general. As vocabulary increases, this puts strain on the lexicon, which forces some kind of reorganisation. However, this change is not tied to individual words. Metsala (1999) also found some evidence for this hypothesis in an experiment in which absolute vocabulary size was related to phonological awareness ability in three- and four-year-old children. Bowey (1996) also found that phonological awareness was closely related to vocabulary size in her sample of five-year-old children.

Neither of these theories accounts for the fact that children normally begin to show some implicit phonological awareness during their fourth or fifth year of life. This is well after the point at which Studdert-Kennedy suggested they begin to represent phonemes, but before they show the qualitative changes in speech perception and production described by Nittrouer and colleagues (Nittrouer et al., 1989; Nittrouer & Studdert-Kennedy, 1987).

Global sound sensitivity may well be related to the way in which the phonological representations of particular words are encoded. Perhaps the changes in speech perception and production noted by Studdert-Kennedy (Studdert-Kennedy, 1987; Studdert-Kennedy & Goodell, 1995) are due to children beginning to encode words according to the gestures contained within them. Several gestures combine to make a single phoneme, but possibly at this early stage children code words at a level lower than the phoneme. Globally similar words would contain many of the same gestures. Harm & Seidenberg (1999) investigated the patterns of activity shown by connectionist models developed to mimic the process of learning to read. The models were trained first to link input and output phonological sequences and then to link these phonological sequences to written word forms. The phonological sequences were presented as series of phonological features (features can be considered similar to gestures for the purposes of the current study). The model contained a phonological attractor structure to 'clean-up' or complete noisy phonological sequences. The presence of this structure means that the patterns of weights on the hidden units can be quite imprecise: they do not have to represent the sequence fully, but only to the level that the word can be differentiated from others in the lexicon by the phonological attractor structure. Models that contained this phonological clean-up structure generalised more readily when asked to read a new word.

The authors compared the patterns of weights from the hidden units to the phonological output features in models with and without damage to the phonological clean-up structure. They examined these weights to one of the vowel features (tongue height) over a set of phonologically similar words (such as 'meat', 'neat' and 'eat'). For the normal model, the patterns of weights from the hidden units across these words were highly similar. The damaged model, however, showed different patterns of activation for each word. Thus, the normally developing model 'recognised' similarities in underlying structure. This meant that, during the reading phase of the study, models were more likely to be able to produce the correct phonological sequence when asked to read the nonword 'geat'. This pattern of encoding phonological sequences might also form a basis for some kind of global sound sensitivity. Harm and Seidenberg found that the network showed very similar activation states in the phonological clean-up units for rhyming words, even prior to learning to link these to written words. It may be, therefore, that this similarity in output states for similar sounding words allows children to detect phonological similarities between words without an explicit awareness of the sound segments within that word.

If this hypothesis is correct, then one would expect to find that the main factor influencing the development of global sound sensitivity would not be the overall number of words known, as proposed by Walley (1993), but the accuracy and detail of phonological representations within the lexicon. It would be difficult to measure this directly. However, two tasks that depend on the quality of phonological representations are word identification tasks such as listening for mispronunciations and speech production tasks such as accuracy of articulation. Such tasks could therefore provide an index of the quality of phonological representations.

The links between phonological representations and phonological awareness are therefore still uncertain. A further complication is that the development of phonological awareness may in itself influence the development of phonological representations. The following section examines in more detail the relationships between phonological awareness and the two major factors that have been suggested in this section to precipitate its development: vocabulary growth and alphabet knowledge.

Factors Influencing Phonological Awareness

Walley (1993) suggested that three factors contribute to the development of segmented representations throughout the pre-school and early school years. These are increasing vocabulary size, experience with phonological devices such as rhyme and alliteration, and beginning to read and learning letters. However, the relationship between each of these factors and phonological representations has been the subject of some debate, and still remains uncertain. In the following sections, the evidence that vocabulary growth and letter knowledge are closely related to the development of phonological representations and phonological awareness will be considered.

Vocabulary Growth in Pre-school Children

If the theory proposed by Walley is correct, then one would expect to find that vocabulary level in children influenced the development of phonological awareness. There is evidence that vocabulary is closely related to phonological skills such as phonological awareness and nonword repetition. The direction of causality between these variables is a matter for some debate, however.

There is a substantial amount of research examining the associations between vocabulary level, new word learning ability and phonological short-term memory. In general, the data suggests a pattern of complex reciprocal relationships between these factors, and it has been difficult to tease out the causal connections that may exist. In addition, there is some evidence that the relationship between these variables may change and develop throughout the pre-school and early school years.

Gathercole & Baddeley (1989), in a one year longitudinal study of four-year-old children, found that there was a correlation between initial nonword repetition and later vocabulary size, and proposed that nonword repetition was a causal factor in vocabulary growth. They suggested that the ability to hold new sequences of phonemes on-line for a short period of time would result in a more efficient creation of long-term representations of these sequences of phonemes - in other words, better learning of new words.

However, there are other possible interpretations of the relationship between vocabulary size and nonword repetition. Snowling, Chiat, & Hulme (1991) pointed out that a good vocabulary in itself may improve nonword repetition performance. A good vocabulary will familiarise the child with the prosodic structure of words and give them knowledge of common phoneme sequences. Both of these factors may well bolster nonword repetition performance, by allowing the short-term memory trace to be bolstered by input from long-term memory. This process has been named redintegration(e.g. Hulme et al., 1997). The more sequences stored in long-term memory, the more likely it is that there will be phoneme sequences similar to the nonword in question and the more efficient the process of redintegration will be. In other words, the causal relationship may run in the opposite direction.

To compare these alternative explanations, more detailed studies are required. There are three main ways in which the hypotheses could be examined. Longitudinal studies over a wider age range allow a comparison of whether nonword repetition predicts vocabulary, or vice versa, over the pre-school and early school years. A closer examination of the short-term and long-term measures used would allow a determination of the skills and factors involved in each of the tasks, while intervention studies, in which children were trained to recognise new words, would allow an examination of the relationship between the variables in a dynamic manner.

Gathercole, Willis, Emslie, & Baddeley (1992) followed up the children tested in the original study (Gathercole & Baddeley, 1989) for a further four years, to determine in which way the causal relationship between the two variables lay. They found evidence for a reciprocal relationship. Using the technique of cross-lagged correlations between the two variables, there was also evidence that the relationship changed between the ages of four and eight years. Nonword repetition at four years predicted vocabulary at five years, even after controlling for original vocabulary level. However, from five years onwards, vocabulary size influenced nonword repetition ability more than vice versa. The authors suggested that increasing vocabulary size and more efficient phonological memory could account for this change. A larger vocabulary will mean that there are more items available to allow successful support of short-term memory. In addition, it may be that phonological memory improves so much over the pre-school years that short-term memory capacity no longer limits the learning of new words. Most words are short enough for a six-year-old to hold them in memory for long enough to allow the transfer to long-term memory to begin.

Another possible explanation for the dynamic relationship between these variables may be related to the pressures on new word learning in each of these periods. Pre-school children learn many words with clear meanings, so learning the semantics of words will be relatively easy at this stage of development. In contrast, the phonological sequences will be relatively unfamiliar to them, and therefore difficult to learn. On the other hand, school-age children have many phonological sequences already in place, and these will go some way towards 'bootstrapping' the word learning progress. At this stage, the child will be beginning to learn words with more and more complex meanings; abstract nouns and adverbs, for instance. This will mean that the limiting factors on vocabulary growth will be semantic and conceptual ability, rather than phonological knowledge.

A more careful analysis of the measures used in these studies should allow more definite claims to be made about the processes involved in the tasks. Gathercole & Baddeley (1989) suggested that nonword repetition was the purest possible measure of short-term memory, as digit span and word span relied heavily on long-term representations of words. However, Snowling et al. (1991) proposed that nonword repetition actually relies heavily on the lexical representations a child already has, to support short-term memory with a process of redintegration. They suggest that digit span will be a purer measure of short-term memory, as the words involved will be overlearnt by all subjects and therefore will not vary much as to the strength of their representations in memory.

Gathercole (1995) compared nonword repetition performance for nonwords of high and low rated word-likeness. They found that nonwords that were less word-like were harder for children to remember correctly, and so concluded that nonword repetition does indeed involve influence from long-term vocabulary processes. They concluded from this study that nonword repetition of nonwords with low word-likeness was therefore the purest measure of short-term memory, with the smallest influence from long-term vocabulary. In contrast, Metsala (1999) proposed the opposite conclusion. She suggests that repetition of nonword with low word-likeness will in fact be the task that is most closely related to vocabulary development, since it is the task that will place the greatest demands on the 'segmental recombination skills' of the lexicon, which will improve as absolute vocabulary size increases.

Avons, Wragg, Cupples, & Lovegrove (1998) compared the influence of nonword repetition and digit span on vocabulary in a two-year longitudinal study of children beginning at five years old. They found that, while nonword repetition and digit span both predicted concurrent vocabulary, only digit span remained a significant predictor of vocabulary score over time. Vocabulary at Time 1, on the other hand, did not predict digit span at Time 2. A similar relationship was found between rhyming ability and vocabulary. Early rhyming ability was related to concurrent and later vocabulary, but vocabulary was not related to later rhyme scores. These findings support the notion that digit span is the 'purest' measure of short-term memory and also the theory that short-term memory does contribute to vocabulary development.

This study also provides evidence that phonological awareness contributes to vocabulary development. It has also been suggested that the link between vocabulary development and nonword repetition could be sub-served by phonological awareness. Metsala (1999) found that vocabulary and nonword repetition were closely correlated in a sample of three- to five-year-old children. The shared variance in this association was entirely accounted for by the phonological awareness measures also given, however.

Phonological awareness tasks may require skills very similar to those involved in nonword repetition tasks. Both tasks involve short-term memory, in that words must be held on-line for a few minutes to allow operations to be performed on them. In addition, if the ideas proposed by Snowling et al. (1991) are correct, then both processes will involve the segmentation of words and the matching of segments across words. Bowey (1996) examined the relationship between vocabulary, nonword repetition and phonological awareness in five-year-old children. Vocabulary and nonword repetition were closely related, but this association disappeared once phonological awareness was controlled. Digit span was, however, still related to vocabulary once phonological awareness had been controlled for. It is concluded that phonological awareness tasks and nonword repetition tasks both provide an index of the degree of segmentation of underlying phonological representations. This, in turn, is influenced by absolute vocabulary size. The link between digit span and vocabulary also suggested that there is a relationship between these two factors, as Gathercole & Baddeley (1989) originally proposed.

Bowey (in press) followed up this correlational study with a longitudinal study that looked at vocabulary, nonword repetition and phonological awareness in a group of four and five year old children. In this study, nonword repetition did account for further unique variance in vocabulary growth once phonological awareness had been controlled. However, early vocabulary also predicted nonword repetition at Time 2 once nonword repetition and phonological awareness at Time 1 had been controlled. There appears to be a pattern of reciprocal causation between these variables.

Another way to examine the relationship between short-term memory and vocabulary is to look at performance on a new word learning task. As this is a form of intervention, it provides a controlled method for looking at the causal relationship between these variables. Gathercole & Baddeley (1990) compared the performance of five-year-old children who had scored either high or low on a nonword repetition task, on a new word learning task. The children had to learn four known names (i.e. Simon) and four nonword names (i.e. Pommel). The groups did not differ in the known name condition, but they differed in the nonword name condition. The children who were poor at repeating nonwords were less good at this task. This seems like good evidence that nonword repetition ability is related to new word learning.

Gathercole, Hitch, Service, & Martin (1997) attempted to examine the relationship between vocabulary and short-term memory in more detail by comparing a range of new word learning measures and a range of short-term memory measures. Both digit span and nonword repetition were related to performance on the new word learning tasks that required an establishment of new phonological representations. Present vocabulary level was related to these new word learning tasks, and also to the word-word learning tasks that did not require the establishment of new phonological representations. When partial correlations were carried out controlling for vocabulary level, digit span was still related to new word learning ability, but nonword repetition was not. The links between nonword repetition and new word learning ability were due to the influence of vocabulary level on both variables. The researchers concluded that digit span may be a purer measure of short-term memory than nonword repetition, and that short-term memory does have a causal influence on new word learning.

Not all researchers have found that a span task is a better predictor of new word learning than nonword repetition, however. Michas & Henry (1994) found that span and nonword repetition were both equally related to performance on a new word learning task. The span task they used involved a series of monosyllabic nonwords, and therefore is subject to the same objections that have been levelled at the nonword repetition task. The new word learning tasks, in contrast, were interesting. The first task was a standard formal word learning task. The children were shown a picture of an object and given its name and definition. A week later the children were assessed using production, comprehension and definition recall measures. In addition to this, the children were taught one word incidentally. They were asked to pass the maroon pen, rather than the red one, at the start of the session. They were then given production and comprehension tests for this word one week later. Sixty-six percent of the children showed comprehension of the word. Unfortunately, since only one word was taught in this way, it is impossible to determine from this experiment the relationship between performance on this task and performance on the phonological memory tasks.

This technique of incidental learning is one that may be used to measure word learning in a more realistic way than normally occurs in these tasks. As Carey (1978) pointed out, the average six-year-old knows around 14,000 words. This works out at a learning rate of about nine words a day, every day, from the age of eighteen months onwards. Yet formal experiments attempting to tap this ability seem to show that children are often poor at learning new words. Carey (1978) suggested that young children initially make a basic "fast mapping" of a word from a single encounter, and that thorough knowledge of a word builds up over an extended period of time. It seems, therefore, that experimental procedures are unlikely to mimic the true word learning process. The child is often presented with a word without the linguistic and environmental context that surrounds a new word in normal learning. In addition, the child is expected to learn the word in a few encounters, rather than the many encounters that will normally occur in natural word learning.

For this reason, studies investigating incidental word learning, where a word is mentioned to a child in the process of normal conversation, should provide interesting results. Carey & Bartlett (1978) describes a study in which three and four-year-old children were taught a new colour word, 'chromium' for olive green, as part of a conversation apparently incidental to the main task. Six weeks after two single exposures, one week apart, more than half of the children showed some knowledge of the meaning of this word. They were shown an olive green chip and asked what colour it was. In a pre-test, all of the fourteen children had said green. In the post-test, eight of the fourteen children changed their response to 'don't know' or to brown or grey, suggesting that they had learnt that green was not the correct name for the colour, but that they couldn't remember what the correct name was.

Heibeck & Markman (1987) replicated this experiment using a wider variety of names and semantic categories. They found that children could indeed learn something about a word from a single exposure, but that production of this word after a single exposure was rare. As well as the standard production and comprehension tasks, they were given a semantic categories task, in which the experimenter would say " This book isn't maroon, because it's ___", and the child would have to fill in the final word with a word from the same semantic category, i.e. blue, in this case. Most of the children succeeded on this task, showing some understanding of the meaning of a new word from a single exposure.

A major shortcoming of all of these experiments is that they have involved teaching only a single word, and so they do not allow reliable analysis of individual differences among the children. A task that may be more flexible in this respect was developed by Elley (1989). In this experiment, seven- and eight-year-old children were read a story three times over the course of a week. This story contained several words unknown to the children. It was found that exposure to the words in context alone caused a 17% increase in the number of words known. If this exposure was accompanied by an explanation of the words by the teacher reading the story, this increase rose to 40%. Vocabulary gains were much lower with another story, which the children did not seem to engage with. This suggests that children can learn several new words incidentally in a few encounters with them, and that the effectiveness of a new-word learning task will vary with the amount of interest the child has in the task.

There is, therefore, some evidence that new word learning is effective in a naturalistic environment, where words are not so much taught as heard. Common sense would suggest that this would mimic natural word learning more than the paired associate learning that is normally used in these experiments. However, no one has investigated the links between performance on this type of task and phonological memory. Gathercole et al. (1997) comes close to this, with a story book task about a spaceman on a new planet adapted from Aguiar & Brady (1991). However, the new words and definitions used here are not embedded in the text in the same way they would be in a natural story. The child is told, for instance " the spaceman then saw a foltano. Can you repeat that? A foltano is a noisy, dancing fish." The new words are not integrated into a story, merely described. In addition, testing sessions are started within the same session and continued, with feedback, until the child is successful, as in a standard paired associate learning trial. This task is an improvement on learning a pairing between a word and a nonword, but they are still a long way from the natural word learning process. A task modelled on the Elley (1989) task, therefore, seems an ideal way to examine new word learning in a natural, yet controlled, environment.

Several people have suggested that the link between nonword repetition and vocabulary level may be explained from the point of view of underlying phonological representations. It has been suggested that young children begin to represent words as unanalysed global wholes and gradually begin to represent words in a more segmental fashion throughout childhood. If this is the case, then the more segmented a child's lexical representations are, the better able they will be to use lexical representations to support nonword repetition. In addition, the more segmented lexical representations are, the better performance will be on phonological awareness tasks. Several studies have examined the relative influences of nonword repetition and phonological awareness on vocabulary acquisition (e.g. Avons et al., 1998; Bowey, 1996; Metsala, 1999). All of these studies suggest that there is a large amount of shared variance between these two tasks, and that the links found between nonword repetition and vocabulary may be due to the links that phonological awareness has with both factors.

De Jong, Seveke, & van Veen (2000) looked at the effects of phonological awareness on new word learning ability. Fourteen non-reading five-year-old children were trained on phonological sensitivity and letter-sound awareness. A control group was trained in semantic categorisation. The trained children performed better than controls on a task in which they had to learn phonologically unfamiliar words. It is suggested that these children had an increased sensitivity to phonological segments, which allowed them to learn new words more effectively. The word learning task used in this study took place entirely in one session, however, and performance on the task did not correlate with existing vocabulary level in these children. There is therefore some doubt as to whether this task is in fact tapping the processes that underlie long-term vocabulary acquisition or whether it is more closely related to an ability to maintain short-term memory traces over time.

It appears, therefore, that two different influences on the learning of new words can be discerned. The first is, as Gathercole & Baddeley (1989) originally proposed, that the ability to hold words on-line accurately is related to the ability to establish new phonological representations. This is shown by the relationship between digit span and new word learning described by Gathercole et al. (1997), as well as the links found between digit span and vocabulary found by Avons et al. (1998). The second influence is that of the structure of phonological representations themselves on the learning of new words. The more segmentally words are represented in long-term memory, the better the learner's ability to manipulate word structure and to use this information to support the short-term representation of new words.

Since nonword repetition is a task that is dependent on both of these skills, it is not surprising that it is particularly closely related to vocabulary growth. However, because of the variety of sub-skills that are used in the task, it should not be considered a clear index of either short-term memory or structure of underlying phonological representations.

There is also evidence to suggest that the relationship between these variables is developmentally dynamic and changes throughout childhood. Gathercole et al. (1992) found that the relationship between short-term memory measures and vocabulary changed at around five years of age. Avons et al. (1998) found that while vocabulary and nonword repetition measures were closely linked at four and five years, they were not correlated when the children were tested again at six years old.

Letter Knowledge in Pre-school Children

The Relationship between Letter Knowledge and Phonological Awareness

Several researchers have found that letter knowledge is closely related to later reading success (Adams, 1990). Muter et al. (1998) and Stuart & Coltheart (1988) both carried out longitudinal studies of the first two years of learning to read. Both studies reported that a combination between phonological awareness and letter knowledge was the best predictor of early reading ability. Studies of children at familial risk of dyslexia have often found that these children have below average levels of letter knowledge in the pre-school years (e.g. Gallagher, Frith, & Snowling, 2000; Locke, 1997; Scarborough, 1990). It appears that the development of letter knowledge is critically related to progress in reading. However, there is also evidence to suggest that letter knowledge may play a causal role in the development of phonological awareness.

Studies examining the phonological awareness of pre-readers (e.g. Liberman et al., 1974) and illiterate adults (e.g. Morais et al., 1979) have shown that reading seems to play a role in the development of explicit phonemic awareness. Read et al. (1986) compared Chinese readers who had learnt a non-alphabetic script with readers who had learnt an alphabetic script (Pinyin). Only those readers who had learnt an alphabetic orthography showed explicit phonemic awareness. This suggests that learning letters plays a crucial role in the development of phonemic awareness.

There is also more direct evidence of the close relationship between letter knowledge and phoneme awareness from correlational and longitudinal studies. Bowey (1994) compared phonological awareness in readers and non-readers with differing levels of letter knowledge. Readers performed better than the non-readers in all of the tasks, and the children who had high levels of letter knowledge performed better than the children who had low levels of letter knowledge on the phonemic tasks. There was no difference between the non-reading groups on the onset – rime tasks, however. The authors suggested that letter knowledge aids the development of phonemic awareness.

Johnston, Anderson, & Holligan (1996) examined the relationship between letter knowledge and phonemic awareness in a group of pre-reading five-year-old children. She found only one child who had phonemic awareness without having some knowledge of letter-sounds. In a series of multiple regressions, letter knowledge was a better predictor of phonemic awareness than a measure of rhyme production was. These data suggest a link between letter knowledge and phonemic awareness, but are only correlational and so do not imply causality. Data from longitudinal studies do, however, converge with these findings.

Wagner, Torgeson, & Rashotte (1994) conducted a longitudinal study of a group of 244 children from kindergarten to second grade, in an effort to examine the reciprocal influences of phonological processing abilities, decoding and letter knowledge on each other and on reading development. Phonological processing abilities influenced later development of reading and letter-name knowledge. There was no evidence from this study that reading development influenced the development of phonological processing abilities. However, letter knowledge did have a significant longitudinal effect on phonological analysis and synthesis abilities.

Burgess & Lonigan (1998) examined the relationship between phonological awareness and letter knowledge in a group of pre-reading four- and five-year-old children. They found evidence of reciprocal relationships between the two abilities, with phonological awareness predicting growth in letter knowledge, and letter knowledge predicting growth in phonological awareness once age and general language abilities were taken into account.

Though these studies imply a close relationship between letter knowledge and phoneme awareness, training studies provide a less clear picture. Gibson & Levin (1975) review studies looking at the influence of teaching letter-names on reading development, and find no conclusive evidence that teaching letters in pre-school accelerates reading development. However, these studies use letter-names rather than letter-sounds, and the effect of the intervention on phonological awareness is not assessed.

Ball & Blachman (1991) compared the effects of training phoneme segmentation and letter-sound knowledge in a group of kindergarten children. They found that the children who had had letter knowledge training alone did not improve more than controls on a phoneme segmentation task. These children did, however, have an average age of 5;7 years and already knew around 10 letter-sounds each. It is therefore likely that these children had already begun to develop some phoneme awareness.

Murray, Stahl, & Ivey (1996) conducted an intervention study that looked at growth in phonemic awareness as a result of letter training. Three classes of pre-school children were given either alphabet books, where letters were explicitly linked to words (i.e. A is for apple), letter-name books, where letters were included in the story and named incidentally, but not linked to words, or story books not including letter-names. The classes were given four books from one category to read once a day for three weeks. The children in both the alphabet book condition and the letter-name condition improved in letter knowledge, though the children in the alphabet book condition made greater improvements in phonological awareness than the children in the letter-name condition. This study suggests that learning letter-sound correspondences and the relationship between letters and words may facilitate the development of phonological awareness.

In summary, results from training studies have been mixed. It is possible therefore that the link between letter knowledge and phoneme awareness is in fact due to an as yet unidentified third factor influencing both of these skills. This could be some more general factor such as the accuracy of phonological representations within the lexicon or overall speed of learning. On the other hand, it is also possible that the lack of consensus is due to the differences in the ages and ways in which letters have been taught in different countries.

The Development of Letter-name and Letter-sound Knowledge

Knowledge of letter-names and knowledge of letter-sounds are clearly closely linked. There is, however, considerable evidence that they are differentially predictive of later reading and phonological awareness development. For instance, Caravolas, Hulme, & Snowling (in press) found that letter-sound, but not letter-name, knowledge predicts early spelling development in a group of British children. In contrast, both letter-sound and letter-name knowledge predicted independent variance in reading development.

This finding is not universal across studies, and this may be partially due to the nature of letter knowledge when considered as an experimental measure. Many tests in developmental psychology aim to measure the strength of an underlying concept, such as awareness of phonemes, or to provide an index of the development of a range of knowledge, such as vocabulary level. On the other hand, a letter knowledge task measures specific knowledge of a small set of items. There are only 26 letters to be learnt in total. This means that performance on this task will be highly dependent on the way in which individual children are taught letters. To make matters more complex, teaching practice is highly variable across different cultures, especially with respect to the teaching of letter-names and letter-sounds. Thus, the relationship found between the knowledge of letter-names and letter-sounds, and also the relationship between letter knowledge and early reading abilities, will vary according to the way in which letter-names and sounds have been taught.

For example, in America children enter kindergarten at the age of five. Before this time, children are generally taught letter-names informally at home and in pre-school (Adams, 1990). In contrast, they are not taught letter-sounds until formal schooling begins. Treiman, Tincoff, Rodriguez, Mouzaki, & Francis (1998) describe how children generally learn the name for any given letter before they learn the sound for a letter. Treiman and her colleagues show that within this system, children use letter-names to help them to learn letter-sounds. For these children, letter-sounds that form the first phoneme in the letter-name (e.g. B and /b/) are the easiest to learn, with letter-sounds that form the final phoneme in the letter-name (e.g. S and /s/) next easiest to learn and letter-sounds that do not feature in the letter-name (e.g. W and /w/) hardest to learn. They also found that children had slightly more difficulty with letters that represent more than one phoneme (e.g. c and g) than letters that consistently represent one phoneme.

McBride-Chang (1999) conducted a longitudinal study of the development of letter-name and letter-sound knowledge in a group of American pre-schoolers. She found that letter-sound knowledge lagged behind letter-name knowledge and that letters whose names began with the target sound were easier to remember both in name and sound form. She also found that both skills were independently related to reading development, but that letter-sound knowledge was more closely related to phoneme awareness.

In contrast, children in New Zealand are not explicitly taught letter-sounds at any point during reading tuition. Within this system, children are not taught how to 'sound out' words but instead are taught words as unsegmented wholes. Letters are referred to solely by name. Thompson, Fletcher-Flinn, & Cotterell (1999) describe how children taught within this system use both letter-names and induced sublexical relations when learning letter-sound correspondences. Therefore, for both American and New Zealander children, correspondence with letter names and consistency of the letter-to-phoneme correspondences were important factors in which letter-sounds were learnt earliest.

In England, more emphasis is placed on learning letter-sounds than on learning letter-names. This is especially true since the introduction of the National Literacy Strategy. Children are given some tuition in letter-sounds in their final year of pre-school, and are expected to have some concept of the role of letter-sounds before they begin formal schooling. Children enter reception class in the term before their fifth birthday, and the National Literacy Strategy states that children should know all twenty-six letter-names and sounds by the end of this year, though more importance is placed on the learning of letter-sounds (Department for Education and Employment, 1998).

Hence, Caravolas et al. (in press) describes how the levels of letter-name knowledge lag behind letter-sound knowledge in the first two years of schooling. Therefore English children are less likely to be able to use letter-names when learning letter-sounds. This also makes it likely that letter-name knowledge will play a smaller role in the development of phoneme awareness and reading.

These differences in the early tuition of letters will also mean that there will be differences in the way that different nationalities learn letter-sounds. Both McBride-Chang (1999) and Treiman et al. (1998) found that American children use letter-names when learning letter-sounds. They found no evidence that the rate of learning different letters was influenced by the phonetic qualities of these letter-sounds. Studies with British children have found differing results, however.

Stuart & Coltheart (1988) conducted a three year longitudinal study of the relationship between phonological skills, letter knowledge, and early reading development in British children between the ages of four and eight. They found that letter-name and letter-sound knowledge were closely related. In addition, both of these skills correlated highly with concurrent phonological awareness scores, though letter-sound knowledge showed the closest relationship to early reading development.

Interestingly, letter-name knowledge showed a different pattern of development from letter-sound knowledge. Stuart & Coltheart (1988) showed that children found letter sounds that represented obstruent phonemes easier to learn than those that represented non-obstruent phonemes. Since obstruents are more likely to occur at syllable boundaries, it is likely that children become aware of these phonemes earlier and thus they are available to link to specific letters more quickly. In contrast, children who learn letter-names before letter-sounds are more likely to link letter-sounds to letter-names than to use their phonetic qualities in remembering them.

Caravolas et al. (in press) conducted a three-year longitudinal study of children in the first two years of British schooling. They found that letter-sound knowledge was closely related to phoneme awareness and to early spelling ability, while letter-name knowledge was more closely related to early reading development. Arguably, this may be due to the way in which letter-names and letter-sounds are taught. In British schools, letter-sounds are taught extensively, and with links made to the phonemes within words that they represent. Letter-names are taught less thoroughly and the role of them is made less explicit. Therefore the children that learn letter-names are likely to be children who learn associations between visual and verbal stimuli quickly and easily. These are likely to be the same children who learn sight words quickly when beginning reading.

Most of these studies (e.g. Caravolas et al., in press; McBride-Chang, 1999) have shown that letter-sound knowledge is more closely related to the development of reading and phoneme awareness than letter-name knowledge. This is likely to be because letter-sounds are more directly relevant in decoding new words. However, this relationship is highly dependent on the way in which letter-sounds have been taught. If letter-names and whole words are taught before the introduction of letter-sounds, the child may begin to induce the alphabetic principle from this knowledge.

In summary, it seems that letter knowledge does play an important role in the development of phoneme awareness. It also seems that letter-sound knowledge is more closely related to the development of this ability than letter-name knowledge. It is also important to remember that differing results have been found in different cultures, however, and that letter knowledge is highly dependent on the way in which letters are taught.

The Relationship between Phonological Awareness and Language Development

As described in earlier sections, phonological awareness is highly dependent on language development. Surprisingly, there is not a great deal of research investigating which specific skills in pre-school development could be related to the development of phonological awareness. However, there is more research examining the question from other angles. Several researchers have looked at the development of both phonological awareness and early language skills in children at familial risk for reading difficulties. In addition, there is some research examining the phonological awareness of children with pre-school speech and language difficulties. This section considers the evidence gathered from each of these areas in turn.

Normally Developing Children

MacLean et al. (1987) reported on the first phase of a longitudinal study looking at the development of phonological awareness from the age of three years four months until the age of eight. As well as considering which variables were most accurate at predicting reading success, they also examined which variables were related to pre-school phonological awareness. They found that nursery rhyme knowledge and socio-economic status were the best predictors of later performance of phonological awareness tasks. They suggested that learning nursery rhymes fosters the development of rhyme awareness in pre-school children.

Olofsson & Neidersoe (1999) conducted a longitudinal study of a group of 205 Danish children from when they were three years old until they reached the age of twelve. A range of language measures and phonological awareness measures were given at six years old, and phonological awareness at eight years old. (At the time of this study, children began school at seven years old in Denmark). It was found that performance in the 'receptive language' tasks at six years old was the strongest predictor of phonological awareness at eight years old. However this only explained 10% of the variance in total, so it is difficult to conclude much from this study.

Chaney (1998) followed a group of children from two to six years old in an effort to determine what skills in pre-school led on to good reading and phonological awareness in the school years. General language development at three years old predicted phoneme deletion scores five years later. Receptive vocabulary did not predict the development of phonological awareness.

There is also some evidence that speech perception may be related to the development of phonological awareness in normally developing children. McBride-Chang (1996) evaluated the influences of speech perception, phonological awareness, rapid naming and short-term memory on reading level in a group of eight-, nine- and ten-year-old children. The model that best fit the data was one in which speech perception influenced reading indirectly through its relationship with phonological awareness. Manis et al. (1997) examined the speech perception of a group of dyslexic children, and found that a sub-group of them showed abnormal speech perception, and that these deficits were related to deficits in phoneme awareness.

In summary, there is some evidence that phonological abilities in pre-school children are related to general language abilities. In particular, speech perception may be related to the development of phonological awareness. However, there is a clear need for further research into this area.

Children at Genetic Risk of Dyslexia

Several researchers have attempted to look for possible indicators of dyslexia and future reading ability in the pre-school years. There are two good reasons for using this approach in dyslexia research. The first is that research into the precursors of reading ability may shed light on the underlying deficits that cause dyslexia. The second reason is that if potential dyslexics can be discovered before reading failure occurs, then early remediation may improve their long-term reading prospects. Typically, studies looking at the predictors of dyslexia in pre-school children have revealed slightly different results from studies looking at development in normal children.

Scarborough (1990) was one of the first researchers to examine the language development of a group of children who had a family history of dyslexia. They were first seen at two and a half years old, and were given a range of naturalistic and experimental language measures. It was found that children who were diagnosed dyslexic at seven years old showed a poorer range of syntax and more consonant errors in articulation than children who did not go on to become dyslexic did. Children with dyslexic parents who did not themselves go on to become dyslexic did not differ significantly from normal controls. Vocabulary at the age of two years did not distinguish the groups, but the differences did become significant when a vocabulary test was re-administered at three and a half years old and again at five years old. The other good predictor of later reading ability in this sample was a test of letter knowledge administered at five years old.

Elbro, Borstrom, & Peterson (1998) conducted a study of Danish children with a family history of dyslexia. These children were followed from kindergarten level, at the age of six, to the age of eight. In this study, vocabulary was found to be substantially poorer in children who went on to become dyslexic. However, the syntactic development of the children was similar in both groups of children. Phonemic awareness, phonological short-term memory and letter knowledge were also poorer in the children who went on to become dyslexic. Another clear difference between the two groups of children was that the children who went on to be dyslexic had poorer articulation of complex words. However, the groups were not distinguished by an auditory discrimination task or a task in which the children had to repeat nonsense syllables as quickly as possible. Elbro et al. (1998) suggested that these children do not have poor articulation skills in general, but that instead they have indistinct phonological representations of known words, and that this causes poor articulation of complex words and also poor phonemic awareness.

Gallagher et al. (2000) conducted a longitudinal study of a group of children at familial risk of dyslexia. The children were recruited at three and a half years old and followed until the age of six. It was found that those children who scored more than one standard deviation below the mean on a reading test at six years old had poorer nonword repetition, letter knowledge and nursery rhyme knowledge and lower vocabulary levels than controls at 45 months old. The groups did not differ on articulatory accuracy, as measured by the Edinburgh Articulation Test. However, when composite scores were developed, it was found that the speech factor, together with letter knowledge was the strongest predictor of later reading development.

These findings are echoed by another study of children with familial risk of dyslexia performed by Locke (1997), who followed a group of children from six months to five years old. The findings from this study are limited at this point in that it is not yet known which of the children have gone on to become dyslexic. Therefore the analyses are limited to global differences between the children at genetic risk of dyslexia and the controls. It was found here that vocabulary level at three years old distinguished the two groups well, confirming the result described by Scarborough (1990). However, unlike the Scarborough (1990) study, early language development and syntactic complexity of utterances in the first three years did not distinguish the two groups, though the differences approached significance. There were also differences that bordered on significance for articulation accuracy of the children's utterances in the first two years. The two measures that most clearly distinguished the two groups, however, were rhyme detection and a short-term memory task involving both words and nonwords, both of which were administered at six months intervals between three years and five years. The two groups of children also differed on a letter knowledge task and a phoneme detection task administered at five years old. These results suggest that there is a difference between children with and without a family history of dyslexia. However, information regarding whether or not these children become dyslexic will make conclusions from these data clearer.

Lyytinen, Poikkeus, Laakso, Eklund, & Lyytinen (in press) conducted a large-scale study comparing children with a family history of dyslexia with normal controls throughout infancy and early childhood. A wide range of measures was used, including auditory discrimination, language measures, and phonological processing tasks such as syllable deletion, digit span and rapid automatised naming. The children were given auditory discrimination tasks at 6 months, 18 months and 30 months old. It was found that the children with a family history of dyslexia showed less clear discrimination of minimally contrasted words at 6 and 36 months, but not at 20 months. In addition, both groups reached early language milestones at about the same ages, though the family at-risk group showed poorer expressive vocabulary and phonological awareness at 3;6 years. There were also differences between the groups when considering only those children who were late talkers. Late talkers in the control group had generally resolved their language difficulties 18 months later. However, children in the family at-risk group who were late talkers still showed language delays at follow-up testing. The family at-risk group as a whole also went on to show deficits in language, short-term memory and phonological processing at five years old.

In general, at-risk studies present a fairly unitary picture, at least from the age of three onwards. Children who go on to become dyslexic display smaller vocabularies at the ages of three and four. However, their vocabulary levels are average both until 2 years old and after about seven years old. They also display poor phonological awareness and poor letter knowledge at the ages of four and five. In addition, there is some evidence that these children display inaccurate articulation of known words. This is found right from the age of two (Scarborough, 1990) to the age of six years (Elbro et al., 1998). These deficits all seem possible results of early deficits in phonological representations. The fact that the vocabulary deficits of these children are time-limited may be related to the fact, discussed earlier (e.g. Halle & De Boysson-Bardies, 1996), that when children first begin to link word sounds and meanings, they are not sensitive to small phonetic differences between word forms. However, between the ages of three and five years old, vocabulary acquisition is likely to be highly dependent on phonological processing skills, as children begin to contrast similar sounding words and to set up a lexicon.

It is tempting to conclude that, since children at risk of dyslexia show these deficits in early childhood, they must be causally related to the development of dyslexia. However, it is more likely that these pre-school deficits and the phonological awareness deficits associated with dyslexia in the school years are both due to a third underlying phonological processing deficit that manifests itself in different ways throughout development. Vocabulary acquisition and articulation require high levels of phonological skill in the pre-school years, when not many phonological sequences are familiar. However, over time these become more automatic, and more difficulties are experienced in tasks such as learning letters and in manipulating word sounds.

Children with Speech and Language Difficulties

If language is causally related to the development of reading, then difficulties in language in the pre-school years should influence later reading progress. Several studies have in fact shown that children with pre-school speech and language difficulties run the risk of developing literacy difficulties in the school years. However, there is considerable debate within the literature concerning which skills in speech and language development are most closely related to later reading development.

For instance, Bishop & Adams (1990) conducted a prospective study of a group of children who had impaired language development at four years old. They found that those children whose speech and language difficulties had resolved by five and a half years old did not go on to have significant reading difficulties when compared to normally developing controls. However, those children whose language difficulties had not resolved continued to show receptive and expressive language deficits three years later, in conjunction with reading difficulties. When these children were reassessed at fifteen years old (Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998), it was found that there were still clear differences between the three groups in terms of reading outcome. However, the children whose speech and language problems appeared to have resolved still showed lower reading and phonological awareness levels than matched controls, suggesting that early language difficulties had left them with long-term underlying problems in phonological processing.

These deficits seem to occur both in formal phonological awareness tasks and in more informal measures of the use of rhyme. Joffe (1998) measured nursery rhyme reproduction in a group of 4 six-year-old children with speech and language impairments. She found that the children knew the rhymes, but tended to reproduce them as stories, omitting the phonological devices of rhythm, rhyme and alliteration. In addition, the children performed significantly below controls on a range of phonological awareness measures.

Many researchers have found that children with speech and language difficulties, rather than speech difficulties alone, are more likely to develop reading difficulties. Catts (1991) assessed a group of speech and language impaired children on a battery of language and phonological processing tasks in kindergarten and related these to reading ability one year later in first grade. He found that those children with only speech impairments showed similar reading levels to controls. In contrast, the children with additional language impairments showed significantly worse performance than controls. Similar results were found in a study of six-year-old children diagnosed with language impairment two years earlier (Levi, Capozzi, Fabrizi, & Sechi, 1982). However, it does appear that the speech and language impaired children in both of these studies were generally more severely impaired (in both speech and language) than the other group, rather than showing qualitative differences in performance.

One study that avoids the criticism of differing levels of severity is that of Leitao, Hogben, & Fletcher (1997). They compared four groups of six-year-old children: speech impaired, language impaired, speech and language impaired, and normally developing age matched controls. The group with speech and language impairment had language levels close to the language-impaired group and speech levels close to the speech impaired group. The children were given tests of phonological awareness, rapid naming and phonological working memory. The control children out-performed the impaired children on all tasks, and the mixed group had the most difficulty on the tasks, followed by the language-impaired group. The speech-impaired group showed a bimodal pattern of responses: some of the children performed at a similar level to controls, and some of them performed at a level closer to the language-impaired children. On further investigation, it was found that the children who performed at a level similar to language-impaired children showed a pattern of 'deviant' speech errors, while the children who performed at near normal levels showed patterns of 'delayed' or 'inconsistent' speech errors, according to the framework developed by Dodd (1995).

Other studies have supported the idea that children with only speech impairments can also show deficits in pre-reading skills such as phonological awareness. Bird, Bishop, & Freeman (1995) examined the literacy development and phonological awareness of children with expressive phonological impairments at three points in time: 5 years 10 months, 6 years 7 months and 7 years 7 months. The children with phonological impairments performed at a significantly lower level than the control children on all of the phonological awareness, reading and spelling tasks. When children were matched to controls with the same reading age as them, they still showed significantly lower nonword reading and spelling scores. Half of the children had language difficulties in addition to phonological impairments, but these children did not have significantly lower scores than the children with only phonological impairments on any of the tasks. The best predictor of literacy outcome within the phonologically impaired group was initial level of expressive phonology, so that the children with the poorest speech were also those children who showed the weakest phonological awareness skills. They suggested that children with phonological impairments are more likely to represent words as global wholes than as a series of phonemes, and are therefore less likely to be able to match individual phonemes across words.

There appears to be a close relation between expressive phonology and the development of phonological awareness. Webster & Plante (1995) conducted a longitudinal study looking at the relationship between articulation and phonological awareness. They found close links between the two scores: children who had particularly poor phonology were more likely to have poor phonological awareness. Moreover, as articulation improved, so did phoneme awareness. There appeared to be a specific point in the development of expressive phonology that allowed children to complete the phonological awareness tasks used.

There also appears to be a relationship between articulation and awareness of specific phonemes in normally developing children. Thomas & Senechal (1998) examined awareness of the phoneme /r/ in three-year-old children who were divided into groups according to whether they consistently substituted /w/ for /r/ in speech. It was found that those children who consistently substituted /r/ were less likely to distinguish /r/ and /w/ in phoneme discrimination and judgement tasks, even when performance on the same task with a correctly articulated phoneme was controlled for. It was concluded that articulation and phoneme awareness depend on the same underlying network of phonological representations.

Stackhouse, Nathan, & Goulandris (submitted) examined a group of 47 four-year-old children who were selected as having primarily speech difficulties. Their performance was assessed on a range of tasks, examining language, input and output speech processing, lexical representations, phonological awareness and emerging alphabetic skills. The children with speech difficulties scored at a level significantly below that of controls on all of these measures. However, there was a subgroup of children with additional language difficulties who performed least well on all of the tasks. The children with only speech impairments showed similar levels of performance to controls on a task in which they had to match a spoken word to one of two pictures with phonologically similar labels (i.e. coat and goat), suggesting that they had intact phonological representations, and that their difficulties were concentrated in phonological output. In contrast, the children with additional language difficulties had more general phonological processing problems.

There is a certain amount of evidence that corroborates this conclusion. Orsolini, Sechit, Maronato, Bonvino, & Corcelli (2001) examined the performance of children with specific language impairment on input and output phonology tasks. The children were compared to age-matched and language-matched controls and to a group of children with 'slow phonological development'. It was found that most of the children with specific language impairment showed normal performance on a mispronunciation detection task. However, there was a subgroup of children who showed severe difficulties on this task. None of the children with slow phonological development exhibited particular problems on this task. It is possible that the input processing difficulties shown by children with specific language impairment become more evident when the tests used involve less familiar words. This is the conclusion drawn by Dollaghan (1998), who found that children with specific language impairment took longer than controls to identify newly learnt words when they were presented in a gating paradigm.

Bird & Bishop (1992) examined the relationship between auditory processing more closely in a group of boys with 'pure' phonological impairments. Each child had 30 nonword pairs selected for him on the basis of the phonemes they confused in output. They also completed a series of phonological awareness tasks, including initial phoneme matching, rhyme judgement and rhyme generation. All of the phonologically impaired children showed difficulties on the phoneme matching tasks, and a subgroup of the children also showed difficulties on the auditory discrimination tasks, especially when asked to discriminate phonemes they did not distinguish in speech. The authors concluded that these children have difficulties not with identifying phonological input, but with categorising this input. These children may not analyse input at the level at the phoneme, thus making it more difficult to recognise the same sounds across linguistic contexts.

It seems likely that groups of children with specific language impairment are likely to be a highly heterogeneous group, including children with a range of possible causes for their disorder. However, it does seem to be the case that at least a subgroup of children with speech and language difficulties has problems in processing and storing phonological input. Perhaps these are more likely to process words at the level of the syllable rather than at the level of the phoneme. On the other hand, most children with speech difficulties, whether or not they have additional language difficulties, seem to have problems with tasks in which they have to process and produce phonological output sequences. In fact, Bishop, North, & Donlan (1996) cite nonword repetition as one of the best behavioural markers for inherited language impairments. Deficits also normally include phonological awareness and short-term memory tasks, as well as expressive phonology itself. While the first difficulty is likely to lead on to far-ranging problems when a child begins to learn to read, the second type of deficit is also likely to cause some problems in the acquisition and efficient use of the alphabetic principle.

Conclusions

The review of the literature concerning the development of phonological awareness in the pre-school years has produced several interesting conclusions, as well as some potential areas for further research. There are two main theories concerning the development of phonological awareness in pre-school children. The first suggests that children move from awareness of syllables to awareness of onset and rime and finally onto an awareness of single phonemes, and the second suggests that children move from epiphonological strategies to metaphonological strategies as they learn to read. These theories are not mutually exclusive, but unfortunately many previous studies confound segment size and the processes necessary to complete the task, and further clarification of the relative importance of these two factors on the development of phonological awareness is necessary. It is also likely that some of the differing results found in different studies are due to differences in the phonologies of different languages. English speaking children seem to have particular difficulty with analysing consonant clusters, for instance.

However, there is a large amount of evidence suggesting that phonological awareness tasks can be distinguished into at least two types – those that require an explicit knowledge of the individual phonemes that make up words, and those that can be solved on the basis of overall global similarity between two stimuli. Many phonological awareness tasks for young children can be solved using global strategies, though it is those tasks that require phonemic strategies that appear to be better predictors of later reading ability.

Phonological development seems to progress in a similar way to phonological awareness in the pre-school years. Children begin with global phonological representations, and progress to segmental representations soon after the onset of reading tuition. One theory of the development of phonological awareness assumes that it is dependent on the degree of segmentation of phonological representations. However, it is difficult to account for the fact that children develop global phonological sensitivity at around four years old. This may be due to co-activation of words containing similar articulatory features or gestures.

The two factors suggested to be most closely related to the development of phonological awareness are vocabulary growth and letter knowledge. There is evidence in the literature that both of these skills are in fact closely related to the development of phonological awareness. However, they seem to be related to different types of phonological awareness. Vocabulary growth is related to implicit phonological processing tasks such as nonword repetition and rhyme recognition, while letter knowledge is more closely related to the development of explicit phoneme awareness. Nevertheless, in both cases there is evidence of reciprocal causation between the skills.

Vocabulary and letter knowledge are two skills that children with familial history of dyslexia seem to show difficulties with in the pre-school years. They also show poor articulation of complex words and phonological awareness. All of these skills could be indices of impaired phonological representations before the onset of reading tuition. In addition, children with language difficulties in the pre-school years are likely to go on to develop reading difficulties in the school years. In the pre-school years they show lower levels of phonological awareness and difficulties with tasks requiring phonological output processes.

Overall, these studies produce a coherent picture. There are at least two types of phonological awareness, though it is still uncertain which theory provides the best explanation of the data. Vocabulary and letter knowledge are closely related to the development of implicit phonological awareness and explicit phoneme awareness, respectively, and children at risk of reading difficulties during the school years often show deficits in these areas. However, it is still uncertain whether these skills are causally related to the development of phonological awareness, or whether all of these skills are in fact dependent on some further underlying factor. In the following chapters, data is presented that allows us to examine the evidence for each of the theories of the development of phonological awareness. The relationship between vocabulary, letter knowledge and phonological awareness, will also be considered, both in normally developing pre-schoolers and in children at risk of reading difficulties.

2. The Development of Phonological Awareness

Introduction

This chapter examines the development of phonological awareness in a group of children followed longitudinally for the year preceding the onset of formal schooling. The development of these children over the course of that year is considered with respect to two alternative theories of the development of phonological awareness.

The first theory, proposed by Goswami & Bryant (1990), is that during the pre-school and early school years, children progress through three levels of phonological awareness: from awareness of syllables to awareness of onsets and rimes and finally to phoneme awareness. This theory proposes that children become aware of each of these different word segments in turn, and that children use this conscious awareness of sound segments to complete phonological awareness tasks. The second theory is proposed by Gombert (1992), and suggests that phonological awareness can be separated into two types: epilinguistic awareness and metalinguistic awareness. Epilinguistic awareness consists of a general sensitivity to sound similarity and metalinguistic awareness consists of a conscious awareness of sound segments, normally phonemes.

Goswami (1999) proposed a modification of the original Goswami and Bryant (1990) hypothesis to take account of Gombert's distinction between epilinguistic and metalinguistic awareness. She suggests that children progress through two stages of awareness: epilinguistic and metalinguistic, and that phonological awareness within these stages progresses from syllables to rimes and then to individual phonemes. This chapter looks at children's performance on a range of phonological awareness measures and considers the evidence for each of these theories.

Tasks measuring syllable, rime and initial phoneme awareness were presented three times over the course of a year. These tasks all took the same form and were therefore to some extent comparable. The tasks used a two alternative forced choice presentation. The child was given a cue word, and then asked which of two alternative words matched that cue word. In the syllable matching task, the children had eight trials in which the initial syllables of two two-syllable words matched (such as puppet and puppy) and eight in which the final syllables matched (such as jigsaw and seesaw). In the rime and initial sound matching tasks CVC syllables were used. The children had to match words with the same rime (such as dish and fish) or with the same initial phoneme (such as bath and bike). Goswami & Bryant (1990)'s theory predicts that the children would find the syllable matching task the easiest, and that the rime and initial phoneme tasks would be of about equal difficulty, because they both involve the same level of awareness (onset-rime).

Since the tasks are all epilinguistic by Gombert (1992)'s characterisation, there are no specific predictions about which tasks would be easiest. However, since Gombert proposes that children use overall sound sensitivity to complete epilinguistic tasks, it might be predicted that the easiest task would be the one with the word pairs that sound most similar overall. In this study, that would be the rime task. While the segments to be matched in the syllable task are larger (full syllables rather than just rimes), the syllable task uses two syllable words and therefore a larger proportion of each pair of words will sound different. For instance, the words 'firework' and 'fireman' have three phonemes in common but they also have three differing phonemes. In contrast, the rhyming words 'cat' and 'hat' share two phonemes and only differ on one phoneme, and so would sound more similar overall. The initial phoneme matching task would be the hardest, since the word pairs share one phoneme and differ on two phonemes.

A further test of whether children use overall sound similarity when solving phonological awareness tasks was provided by the distractors used within the rime and initial phoneme tasks. In a sub-set of the items used, the target word and the distractor word are matched for global phonological similarity to the cue word. If children are using global phonological strategies, they are likely to find these distractors harder to reject than unrelated or semantically related distractors. On the other hand, if they are in fact segmenting and matching sections of words to solve the task, as suggested by Goswami (1999), children should not be unduly affected by distractors equated in global phonological similarity, since these words do not have full onset or rime segments in common.

Byrne & Fielding-Barnsley (1993) and Cardoso-Martins (1994) directly examined the performance of children on phonological matching tasks in which the distractors were equated in global similarity. In both studies, the children found the task in which global similarity was controlled much more difficult than the standard phonological matching task. In fact, many of the children who passed the standard tasks failed the tasks in which global similarity was controlled. This suggests that children do use global phonological similarity to solve standard phonological awareness tasks. Children's tendency to use global strategies in phonological awareness has not been examined in a longitudinal context, however. It may be that children begin by using global strategies, start to use segmental strategies at the beginning of formal schooling and go on to develop an explicit awareness of the phonemes within words.

A way of assessing Goswami's (1999) theory about the development of implicit and explicit phonological awareness is to consider whether children always show some implicit phonological awareness before going on to develop explicit awareness of individual phonemes. This could be done by comparing performance on implicit and explicit phonological tasks at the same point in time. In order to examine this, three tests requiring explicit phonological awareness were included in the test battery at Time 3. These were syllable completion, phoneme completion and phoneme deletion, taken from the Phonological Abilities Test (Muter, Hulme, & Snowling, 1997). If Goswami's theory is correct, all of the children who are successful on these tasks should also be successful on the implicit phonological awareness tasks.

This study therefore examines the evidence in favour of two theories of the development of phonological awareness. A one-year longitudinal study was carried out, examining performance on implicit and explicit phonological awareness tasks at the level of the syllable, the rime, and the initial phoneme.

Method

Participants

Sixty-seven children were tested three times over the course of a year. At Time 1 the average age was 3;10 years, with a range from 3;2 years to 4;5 years. At Time 2 the average age was 4;2 years and at Time 3 the average age was 4;9 years. Twenty-eight children were male and thirty-nine were female. The sample consisted of two groups of children from separate state-run day nurseries. While both groups contained children from a wide range of socio-economic circumstances, the children in group 1 were from a nursery in a slightly more middle class area. Most of the children began formal schooling between Time 2 and Time 3 of testing.

Procedure

The children were tested individually in a quiet corner of the nursery. The tasks were presented in a fixed order, in an effort to allow the children to progress from easier to harder tasks. Syllable matching was presented first, then rime matching and finally the initial phoneme matching task. The explicit phonological awareness tasks were presented at Time 3 only, in a separate session from all of the implicit phonological awareness tasks. The tasks were administered over a period of between a week and a fortnight, depending on the number of days a week a child attended the nursery.

Phonological Matching Tasks

All of the tasks used follow the two alternative forced choice format used by Locke (1997). The tasks were presented in sets of eight with feedback following each trial. Most of the words used were taken from an age of acquisition database (Morrison, Chappell, & Ellis, 1997) as being words of high frequency that were in most children's expressive vocabulary at younger than three and a half years of age. The pictures used were in the main taken from the Snodgrass & Vanderveldt (1980) picture set. A few words were not from this database, however, and pictures of these words were drawn freehand as black and white line drawings. All of the pictures were given to children of the same age in a pilot study to ensure that they were readily nameable, and that the words were in the children's vocabulary. The rime and initial phoneme tasks were presented at each point in testing. When the initial sound matching task was given to the first group at Time 1, substantial floor effects were found. This meant that fifteen children in the group 2 sample were not given this task, as it was assumed that they would have been at floor on the task. The syllable tasks were not given at Time 3 as ceiling effects were anticipated.

Initial Syllable Matching Task:

This task began with two compound words and then used no further compound words as the matched targets. The words used were two-syllable words, with two exceptions (television and telephone). Most of the words used were taken from the Morrison et al. (1997) database. These words had a mean rated frequency of 3.30 (on a scale of 1-5) and a mean age of acquisition of 26.1 months. The eight items not taken from this database were as follows; fireworks, fireman, reindeer, rainbow, butter, island, puppy and puppet. All of these words were tested in a pilot study to ensure that the children were familiar with them. The items used on each trial are shown in Table 2.1.

Table 2.1: Stimuli used in the initial syllable matching task

Type of trial	Cue word	Alternative Response	
		Correct	Incorrect
Unrelated distractors:	FIREWORKS	fireman	doctor
	PENCIL	penguin	balloon
	TELEVISION	telephone	orange
	ISLAND	iron	hammer
Semantic distractors:	REINDEER	rainbow	zebra
	BUTTER	button	sandwich
	WINDOW	windmill	table
	PUPPY	puppet	rabbit

At the start of the task, the children were introduced to a puppet, Gerry Giraffe, who liked to collect words that started with the same syllable. For each trial, Gerry held a picture card, and the children were asked, for instance, "Gerry has a picture of butter. Which of these words, sandwich or button, has the same sound at the beginning as butter?" If the child said they didn't know, they were encouraged to "think carefully and then choose". When they had chosen, the cards were turned over to see if they were correct - the correct alternative had a coloured sticker on the back that was the same colour as the cue card. The distractor card had a differently coloured sticker. If they had picked correctly, the experimenter said, for instance, "Yes, that's right. Butter and button have the same sound, 'but', at the beginning. Sandwich is the odd one out." If they had chosen the wrong alternative, they were told "No, button and butter have the same sound, 'but', at the beginning. Sandwich is the odd one out." In this way, the children were given immediate feedback after every trial, as previous researchers (e.g. Content et al., 1986) had found that feedback on phonological awareness tasks can facilitate understanding of the task requirements.

<u>Final Syllable Matching Task:</u>

This task took the same format as the initial syllable matching task, except that the words had to be matched by examining the final syllable. Again, most of the words and pictures were taken from the Morrison et al. (1997) database as two-syllable high-frequency words with an age of acquisition of below three and a half years. The mean rated frequency of these words was 2.63 (on a scale of 1-5) and the mean age of acquisition was 29.4 months. The eight words used that were not from the database (postman, palace, bracelet, bucket, see-saw, greenhouse, tree house and garden) were tested in a pilot study to make sure that they were within the vocabulary of three year old children. As before, the tasks started with two sets of compound words, and then used no further compound words. Four of the eight distractors used were semantically related to the target word. The words used are presented in Table 2.2.

Table 2.2: Stimuli used in the final syllable matching task.

Type of Trial	Cue word	Alternative Response	
		Correct	Incorrect
Unrelated distractors:	SNOWMAN	postman	tractor
	LADDER	spider	giraffe
	JIGSAW	seesaw	tortoise
	ROCKET	bucket	flower
Semantic distractors:	GREENHOUSE	tree-house	garden
	NECKLACE	palace	bracelet
	MONKEY	donkey	squirrel
	TROUSERS	scissors	jumper

This task was presented in the same way as the previous task, except that the puppet used this time was Roger Badger, who liked to collect words that had the same final syllable.

Rime Matching Task:

As before, the task was presented as a two-alternative forced choice task. The words used were, as far as possible, single syllable CVC words selected from the Morrison et al. (1997) database as being of high frequency and having a low age of acquisition. The mean rated frequency of the words (on a scale from 1-5) was 3.31, and the mean age of acquisition was 27.5 months. One word (pen) was used twice in different trials. Twelve of the forty-six words used were not from the Morrison et al. (1997) database (dish, red, white, green, man, night, pin, tin, rock, top, tap, and mop) and these were tested in a pilot study to ensure that the words were known to three year old children. Four of the words were not CVC words, but had initial consonant clusters (i.e. CCVC words).

There were 16 trials, presented in two blocks of eight, with a break in between. Within the 16 trials, on eight trials the distractor was semantically related to the cue card, and on four the distractor was equated for global similarity to the cue card with the correct pairing. Any distractor equated for global similarity with a rhyming pair shared two of the three phonemes with the cue word. On the remaining four trials the distractors were unrelated to the target words.

Global phonological similarity was calculated in the same way as it is calculated in Treiman & Breaux (1982). The ratings used for calculating the global similarity between two words are those found by Singh & Woods (1971) and Singh, Woods, & Becker (1972). These investigators asked adults to rate the similarity of pairs of vowels or pairs of consonants on a 7 point scale, with 0 representing identical phonemes and a high score indicating highly dissimilar phonemes. To calculate the phonological similarity between two words, corresponding pairs of phonemes were compared. The overall similarity of a pair of words was the sum of the similarity ratings of each pair of corresponding phonemes. Identical phonemes were given a rating of 0. For instance, /dɪʃ/ (dish) and /bitʃ/(beach) have a total similarity rating of 9.5 (/d/ and /b/ have a similarity rating of 3.5, /ɪ/ and /i/ have a similarity rating of 2.8, and /ʃ/ and /tʃ/ have a similarity rating of 3.2. /dʌk/ (duck) and /dɪʃ/ on the other hand, have a similarity rating of 8.79 (0+4.19+4.6). While dish and duck share a common initial phoneme, their vowels and final consonants are quite dissimilar, as shown by their high scores. This means that the two word pairs have very similar levels of global similarity, but only one word pair shares a common phoneme.

The items used in the rime matching task are shown in Table 2.3 with their global similarity ratings in brackets. For word pairs where the two words did not have the same structure, for instance where one word began with a consonant cluster when the other did not (e.g. frog-dog), an average between ratings for each of the two consonants in the cluster and the matching consonant in the other word was taken.

Table 2.3: Stimuli used in the rime matching task

Type of Distractor used	Cue word	Alternative Response	
		Correct	Incorrect
Unrelated distractors:	DISH	fish (3.9)	pen(11.72)
	QUEEN	green (7.9)	book (15.05)
	FROG	dog (4.35)	wheel(14.98)
	NIGHT	kite (5.0)	bath (13.05)
Global distractors:	TOP	mop(4.7)	tap (4.05)
	PIN	tin (3.1)	pen (2.22)
	HOUSE	mouse(4.6)	horse(5.19)
	BELL	shell(5.1)	ball(4.77)
Semantic distractors:	CAT	hat(4.1)	dog (13.65)
	VAN	man(4.2)	bus (12.96)
	TREE	key (4.1)	leaf (8.80)
	LEG	peg (5.0)	foot(14.62)
	HAIR	chair(4.7)	comb(14.52)
	RED	bed(4.8)	white(10.62)
	SOCK	rock (5.0)	shoes(14.73)
	GOAT	coat(3.9)	sheep (13.6)

This time, the puppet Ryan Lion was used, and the children were told that he liked to collect words that rhymed. For each trial, Ryan held a picture card and the children were asked, for instance, "Ryan has a picture of a cat. Which of these words, dog or hat, rhymes, or sounds the same at the end?" As before, the children were given immediate feedback after every trial.

<u>Initial Phoneme Matching Task:</u>

This task was presented on a subsequent day to the rime matching task, and took the same form - two blocks of eight trials. The words were one syllable CVC words taken from the Morrison et al. (1997)

database, selected for being of high frequency and having a low age of acquisition. The mean rated frequency of these words (on a scale of 1-5) was 4.2 and the mean age of acquisition for the words was 25.3 months. Seven of the words were used twice in different trials. Five words were used that were not from the Morrison et al. (1997) database; these were mouth, nut, beach, dish and bean. These words were tested in a pilot study to ensure that they were known to most three-year-old children. On this task, four of the distractors were semantically related to the cue word, four were matched for global similarity, and four were matched for both global similarity and were semantically related to the cue word. The words used are shown in Table 2.4.

Table 2.4 : Stimuli used in the initial phoneme matching task.

Distractor Type	Cue word	Alternative Response	
		Correct	Incorrect
Unrelated distractors:	BELL	boat (10.22)	dog (12.95)
	PEN	pig (9.35)	thumb (12.55)
	LEG	leaf (8.35)	fork (13.57)
	CAT	comb (10.33)	wheel (14.84)
Semantic distractors:	SHEEP	shoes (10.45)	pig (12.0)
	BOWL	bed (10.12)	cup (13.86)
	NOSE	nut (8.86)	mouth (11.88)
	BUS	bath (8.16)	van (12.96)
Global distractors:	DISH	duck (8.79)	beach (9.5)
	HORSE	hat (9.41)	mouse (9.09)
	FOOT	fish (10.25)	book (7.5)
	BOOT	bean (10.45)	cup (11.41)
Global and semantic distractors:	MOON	mouse (8.61)	sun (9.17)
	BOOT	bike (9.25)	shoes (9.2)
	BED	ball (9.61)	chair (9.6)
	HAT	house (9.72)	coat (9.73)

This time the puppet used was Carrie Cow, who liked to collect words with the same initial sound. As before, feedback was given after each trial.

Explicit Phonological Awareness Tasks

Syllable and Phoneme Completion:

At Time 3, the children were also given the syllable completion and phoneme completion tasks from the Phonological Abilities Test (Muter et al., 1997). For the syllable completion task, the child was shown a picture and told, for instance, "This is a cabbage. The word cabbage has two parts. I'll say the first part and you say the second part. Ca-", and the child would be expected to reply 'bidge' to complete the word. There were two practice items, and eight test items. For the phoneme completion task, the child was shown a picture of a one syllable word and told, for instance, "Here is a gate. The word gate has two parts, I'll say the first part and you say the second part. Gay-". The child was expected to produce the final phoneme, /t/. Again, there were two practice items and eight test items. In contrast to the procedure detailed in the handbook, the children were given feedback on their answers in an effort to facilitate understanding of the task.

Phoneme Deletion (initial sound)

The phoneme deletion (initial sounds) task from the Phonological Abilities Test (Muter et al., 1997) was also used at Time 3 only. In this task, the children were shown a picture and told, "Here is a hat. What is hat without the /h/?" There were four training items and eight test items. With the training items, the word was segmented for the child. For instance, the experimenter would say, "Here is a hat. Hat has two sounds: h-at, h-at. So what is hat without the /h/?" After each item the child was given corrective feedback. This task was not presented if the child scored less than 2 correct on the phoneme completion task.

Results

Data Preparation

During the matching tasks it was found that some children would only pick items from the same side throughout a task. If a child had picked all of his or her answers on a task from the same side, their score on that task was omitted from the analyses. Scores on the two syllable tasks were not significantly different on a two-tailed t-test at Time 1 ($t= 2.01$, $df=50$, ns) or Time 2 ($t= 2.00$, $df=61$, ns). Scores on the two tasks were therefore combined to create a single 'syllable' variable.

Summary Data for the Implicit Awareness Tasks

The means and standard deviations for each of the phonological matching tasks at each point of testing are described in Table 2.5. In these tasks, the maximum possible score was 16, and the expected score due to chance would be 8. According to the binomial distribution, given a task with sixteen trials, a score of 12 is significantly above chance level. The percentage of children who scored at a level significantly above chance on each of the phonological matching tasks is also shown in Table 2.5.

Table 2.5: Means and standard deviations (in parentheses) for each of the phonological matching tasks at each point in testing

Variable	Time 1	Time 2	Time 3	Effect of Time
Syllable (max.=16)			-	
Mean	9.62	10.88		F(1, 47)=15.93,
Standard deviation	2.68	3.12		p<0.01
% above chance	14.93	38.81	-	
Rime (max.=16)				
Mean	9.53	11.27	12.47	F(2,45)=22.2,
Standard deviation	3.59	3.60	3.52	p<0.01
% above chance	23.88	44.77	65.67	
Initial phoneme (max.=16)				F(2,39)=20.39,
Mean	8.24	8.65	11.18	p<0.01
Standard deviation	1.92	2.92	3.58	
% above chance	2.99	16.42	50.75	

Each of the tasks was analysed using a repeated measures ANOVA with Time of Testing as a within subjects variable. Post-hoc difference contrasts showed that performance on each of the tasks improved at each time of testing. It can be seen from the percentage of children above chance at each time of testing, that the syllable and the rime tasks are easier than the initial phoneme task, and in fact show similar mean scores. At Time 1, mean scores on the syllable and rime tasks were similar, but more children scored significantly above chance in the rime task. Examination of the individual scores showed that while the scores on the syllable matching task were normally distributed around the mean, scores on the rime matching task, while not being significantly skewed, showed a more bimodal distribution: scores either clustered around chance or around ceiling. Overall, the implicit phonological awareness tasks do show a pattern of progression over time. However, this is not clearly from syllables to onsets and rimes to phonemes. Instead, it seems that scores on the syllable and rime awareness tasks are quite similar. In fact, fewer children were above chance on the syllable matching measure than on the rime matching measure at both Time 1 and Time 2. However, scores on the phoneme matching measure were substantially poorer. There appears to be a stronger distinction between large and small units than between syllable and onset-rime awareness.

Summary Data for the Explicit Phonological Awareness Tasks

Means and standard deviations for the explicit phonological awareness tasks are shown in Table 2.6. While there is no chance level for these tasks, it was considered that children who scored more than 1 correct on any task showed some understanding of the task requirements, and so the percentages of children who scored more than one correct for each task is also shown.

Table 2.6: Mean scores and standard deviations (in parentheses) for each of the explicit phoneme awareness tasks at Time 3

	Maximum Score	Mean	% children who scored >1
Syllable completion	8	5.56 (2.57)	87.88
Phoneme completion	8	4.04 (3.38)	63.64
Phoneme deletion	8	1.58 (2.60)	31.82

It can be seen that scores for the completion tasks are much higher than scores for the deletion task. However, the scores on the syllable and phoneme completion tasks mask a pattern of bimodal distribution: children are either clustered around floor or ceiling for each of the tasks. This pattern is most marked for phoneme completion, as shown in Figure 2.1.

Figure 2.1: Stem and leaf plot showing individual scores on the syllable and phoneme completion tasks.

Syllable completion		Phoneme Completion
000000	0	00000000000000000000
00	1	0000
00	2	0000
0000	3	0000
0000	4	
000000	5	000
000000000	6	0000
000000000000000	7	000000000000
000000000000000000	8	000000000000000

It seems therefore that these tasks measure a unitary ability or concept – children were either able or not able to complete the task. However, the phoneme deletion task shows substantial floor effects – almost two thirds of the sample score failed to score in this task, as shown in Figure 2.2.

Figure 2.2: Stem and leaf plot showing individual scores on the phoneme deletion task.

	Phoneme Deletion
0	000000000000000000000000000000000000000000
1	000
2	0000000
3	0
4	0
5	000
6	0
7	00000
8	000

Correlations between the Phonological Awareness Tasks

All of the phonological tasks were entered into a correlation matrix, shown in Table 2.7. Bivariate correlations are shown above the diagonal, while partial correlations controlling for age are shown below the diagonal.

Table 2.7: Correlations between performance on the implicit and explicit phonological awareness tasks at each point of testing

	syll t1	syll t2	rime t1	rime t2	rime t3	initial t1	initial t2	initial t3	syll comp	pho comp	pho del
syllt1	*	**.476***	**.464***	**.577***	**.522***	.213	**.400***	**.399***	**.338**	.135	**.382***
syllt2	**.484***	*	**.539***	**.666***	**.406***	**.352**	**.425***	**.416***	**.558***	**.421***	**.434***
rhyt1	**.481***	**.513***	*	**.516***	**.458***	.134	.264	**.519***	**.478***	**.395***	**.344**
rhyt2	**.537***	**.657***	**.500***	*	**.641***	.078	**.425***	**.587***	**.587***	**.333**	**.365***
rhyt3	**.522***	**.375***	**.419***	**.631***	*	-.195	**.409***	**.605***	**.588***	**.298**	**.433***
initial t1	.217	**.395**	.185	.103	-.166	*	.288	-.144	-.178	.000	.112
initial t2	**.400***	**.431***	.271	**.428***	**.418***	.293	*	**.314**	**.354***	.224	**.411***
initial t3	**.410***	**.386***	**.483***	**.575***	**.580***	-.112	**.321***	*	**.600***	**.576***	**.421***
syll comp	**.363***	**.531***	**.417***	**.523***	**.552***	-.131	**.378***	**.563***	*	**.678***	**.411***
pho comp	.137	**.394***	**.356***	**.311**	**.259**	.035	.226	**.552***	**.659***	*	**.525***
pho del	**.402***	**.397***	.277	**.339***	**.385***	.173	**.431***	**.370***	**.326***	**.492***	*

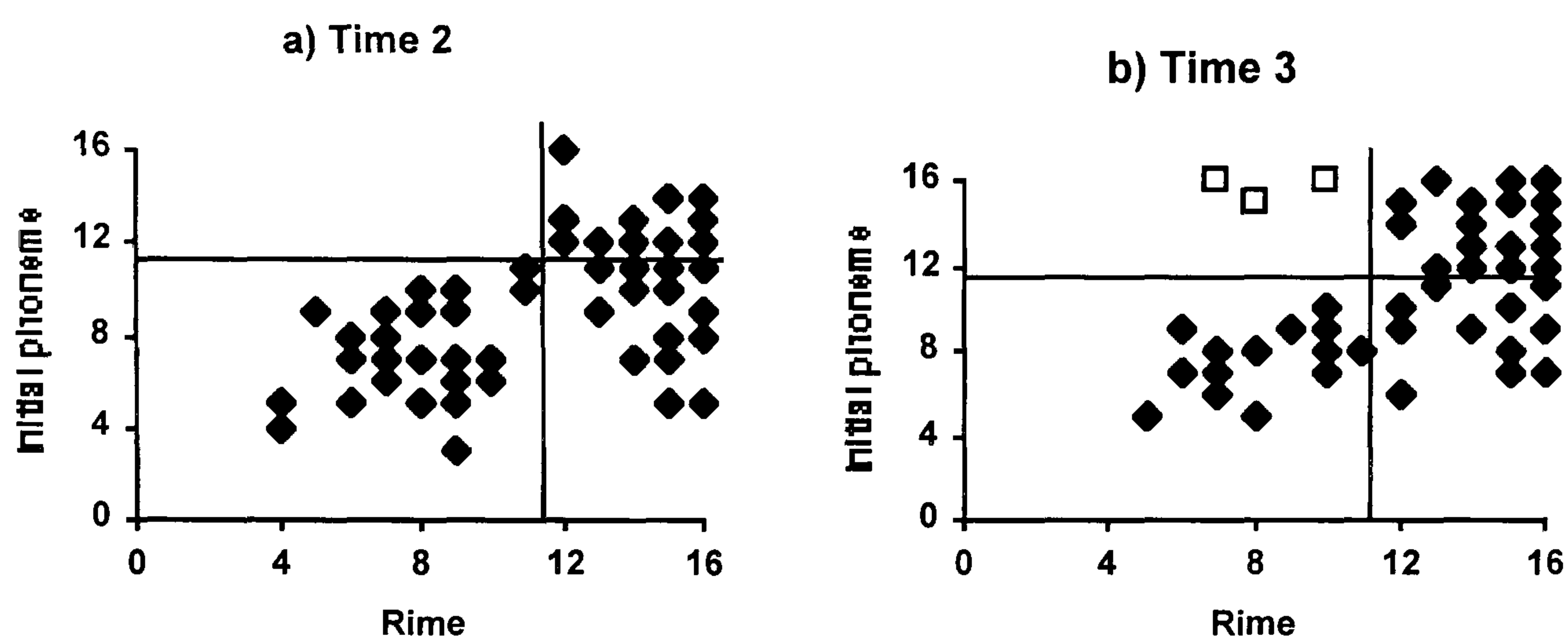
(Coefficients in bold are significant at p<0.05, * indicates they are significant at p<0.01

The phonological tasks, with the exception of the initial phoneme task at Time 1, were all highly inter-correlated. The lack of correlation in the case of initial phoneme matching at Time 1 is probably due to the fact that only two children performed above chance on this task. Controlling for age does not weaken the strength of these correlations to any great degree. Since syllable completion, phoneme completion and phoneme deletion were not normally distributed, non-parametric correlations (Spearman's Rho) were also calculated. The only change in the patterns of correlations was that the correlation between phoneme completion and initial phoneme matching at Time 2 dropped out of significance (Rho=0.181, ns). Other than this, all correlations remained equally strong. Principal component analyses at all three points of testing yielded single factor solutions, and so are not reported here.

Does Awareness of Large Segments Necessarily Precede Awareness of Individual Phonemes?

The question of whether awareness of large segments necessarily precedes awareness of individual phonemes is examined by looking at a series of scatter diagrams. If children must progress through stages of awareness from large segments to small segments, no one would be expected to be above chance on initial phoneme matching without also performing above chance on rime matching. The relationship between these two tasks at Time 1 is not illustrated because performance on the initial phoneme matching task was essentially at floor with only two children scoring significantly above chance. Scatter diagrams showing the relationship between rime and initial phoneme matching measured concurrently at Times 2 and 3 are shown in Figure 2.3.

Figure 2.3: Graph showing the relationship between scores on the rime and initial phoneme matching tasks measured concurrently at Times 2 and 3.



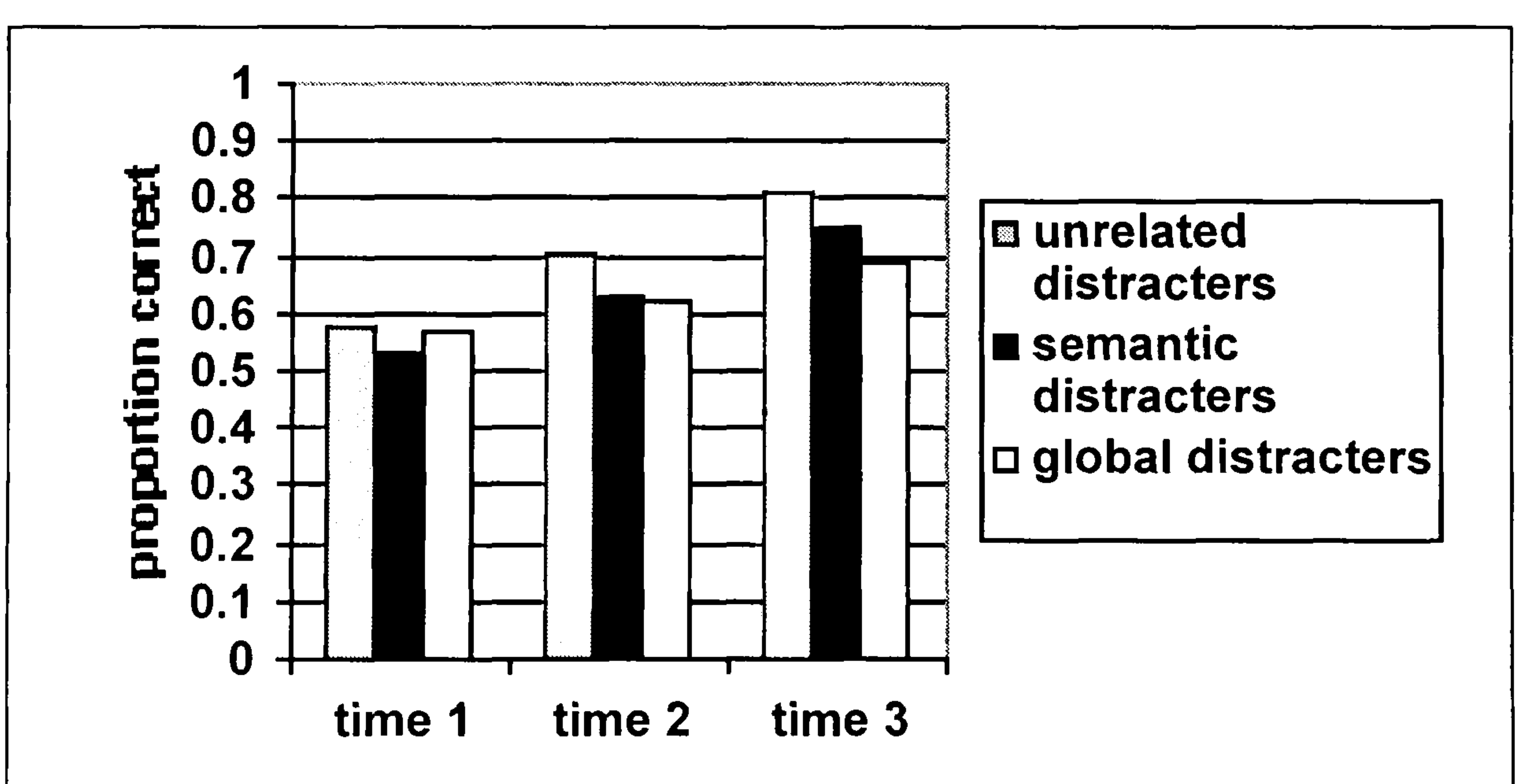
(NB: lines drawn on the diagrams indicate the level above which children are significantly above chance.)

There are no children who score above chance on the initial phoneme task who do not also score above chance on the rime task at Time 2. There were three children who are above chance on the initial phoneme task but who were at chance on the rime task at Time 3. These children are shown as squares, rather than diamonds, on the scatter diagram. This pattern of performance was unusual. Closer examination of the three children showed that they were all children from the group 2 sample who had been in reception class for a term and a half before Time 3 testing, and they all showed high levels of letter knowledge. Two of the three children actually showed above chance performance on the rime task when tested at Time 2. Perhaps this 'dip' in performance reflects confusion about the phonological relation being tested, since their school tuition focussed on awareness of single phonemes. It may also, however, reflect general error of measurement. It is possible that children will show different patterns of performance on the items depending on whether or not the distractors are matched for global phonological similarity or not. To investigate this idea, further scatter diagrams were drawn looking at performance solely on the unrelated and semantic distractors in each of the tasks. Exactly the same results were found – no children who scored above chance on alliteration matching at Time 2 scored at chance on rime matching, and at Time 3 the same three children were above chance on the initial phoneme matching measure and at chance on the rime measure.

The Influence of Global Similarity between Stimuli on the Rime and Initial Phoneme Tasks

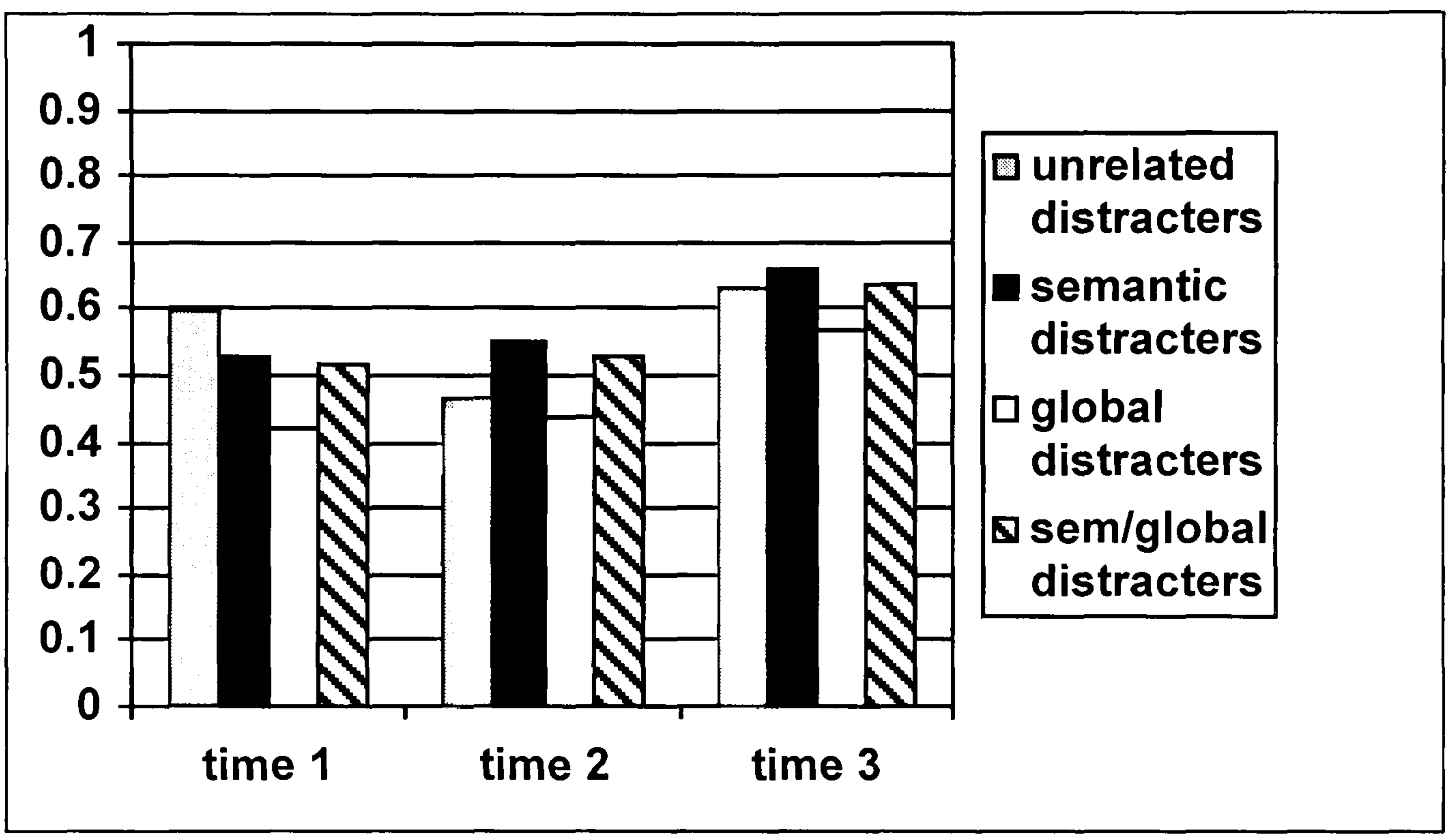
Both the rime and initial phoneme tasks varied the types of distractors used across items. The rime task contained items where the distractor items were unrelated to the cue words, semantically related to the cue word, or globally phonologically similar to the cue word. The initial phoneme task contained all of these three types of distractor, and additionally four items in which the distractors were both semantically and globally related to the cue word. Performance on the different distractor types over time is shown in Figure 2.4 for the rime task and Figure 2.5 for the initial phoneme task.

Figure 2.4: Performance on the different distractor types within the rime task over time



It can be seen from the graph that, while performance on the rime task varies very little across distractor types at Time 1, by Time 2 performance on the unrelated distractors is slightly better than performance on the other two distractor types. An ANOVA was carried out with Type of Distractor and Time of Testing both considered as within subjects variables. There was a significant main effect of Time of Testing (F(2,59)=16.519, p<0.01) and a main effect of Distractor Type (F(2,59)=5.112, p<0.05). The interaction between these two variables was not significant. Post-hoc difference contrasts showed that the main effect of Type was due to children finding the semantic and global distractors significantly harder to reject than the unrelated distractors. The main effect of Time was due to a significant increase in performance between times 1 and 2.

Figure 2.5: Performance on the different distractors within the initial phoneme task over time



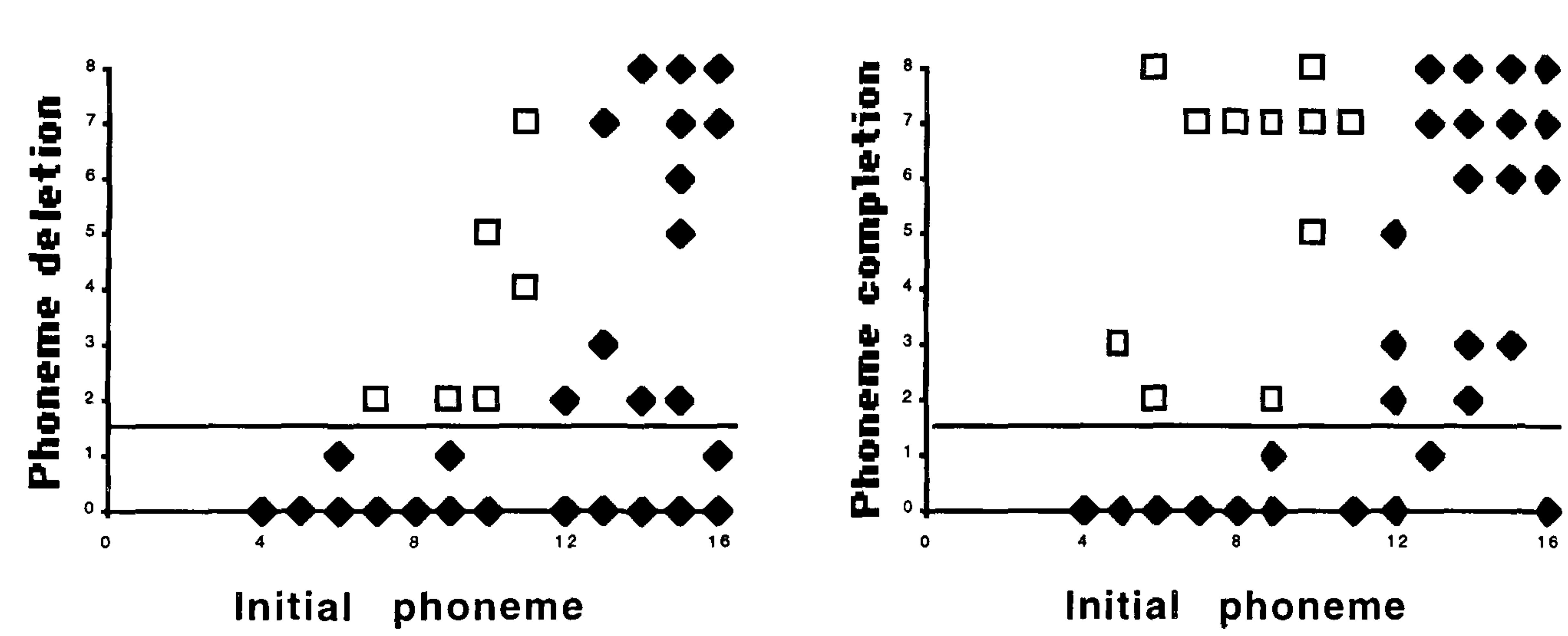
Performance on the different distractor types on the initial phoneme matching task showed a slightly different pattern. While performance on the global distractors was still poorer than performance on the other distractors, performance on the semantic distractors was somewhat elevated. An ANOVA was carried out with Time of Testing and Type of Distractor entered as within subjects variables. There was a significant main effect of Time of Testing (F(2,39)=4.819, p<0.05) and a main effect of Distractor Type (F(3,38)=10.626, p<0.01). The interaction between Time of Testing and Distractor Type was marginal (F(6,35)=2.301, p=0.056). Post-hoc difference contrasts showed that the global distractors were significantly harder to reject than the unrelated distractors, which were in turn harder to reject than the semantically related distractors. Children also showed a significant increase in performance between Time 2 and Time 3. The marginal interaction was due to the fact that at Time 1, the children found the unrelated distractors easier to reject than the semantic distractors, while at Time 2, the pattern was reversed. Perhaps the children began to learn that semantically related items were always the wrong answer, and learn to avoid choosing them. It was, however, still the case that the globally related distractors were the most difficult to reject.

The preceding analyses make the general assumption that distractor words are either globally similar to the cue words or unrelated to them. Phonological similarity is not an all or none relationship, however. Byrne & Fielding-Barnsley (1993) reported that performance on each item in an alliteration matching task depends on the degree of difference in phonological similarity between the cue and the distractor word. It can also be argued that there is a range of degrees of semantic relatedness between two items. For instance, knife and fork are more closely associated than bed and chair (Moss, Hare, Day, & Tyler, 1994). In an effort to tap the effect of semantic similarity, six adults completed a rating scale of degree of semantic relatedness for each of the cue items and targets, and between the cue items and the foils. The difference in semantic relatedness between the two word pairs was then calculated. The resulting phonological and semantic similarity variables were then used in a set of multiple regressions predicting the children's accuracy on each item, with the items from the rime and the initial phoneme matching tasks combined. The results of these analyses indicated that the phonological similarity between the word pairs accounted for a significant 13.7% of the variance in performance on that item, even when difference in semantic similarity had been accounted for. In contrast, semantic similarity did not account for a significant proportion of the variance whether entered on the initial or on the final step (6.9% and 4.7%, respectively). These findings suggest that the children were not relying on semantic strategies to solve the phonological awareness tasks.

Does Implicit Awareness of a Segment Necessarily Precede Explicit Awareness of a Segment?

The second question posed in this chapter was that of the relationship between tasks requiring implicit and explicit awareness of a phonological segment. For instance, is it necessarily the case that only the children who can complete the initial phoneme matching task complete the phoneme completion and deletion tasks? To examine this question, a series of scatter diagrams was plotted comparing performance on the implicit and explicit tasks involving phonemes. The scatter diagrams showing the relationship between initial phoneme matching and phoneme completion and deletion at Time 3 are shown in Figure 2.6.

Figure 2.6: Scatter diagram examining the relationship between performance on the initial phoneme matching task and phoneme completion and deletion at Time 3



(NB: bold lines indicate the level above which children are significantly above chance)

While the phoneme completion task does not have a chance level, it was assumed that children who scored zero or one correct do not have an understanding of the task. Thirteen children answered at least two trials correctly on the phoneme completion task, but were at chance on the initial phoneme matching task. It is not likely to be the case, therefore, that the skills necessary for successful completion of the initial phoneme matching task are also necessary for successful completion of the phoneme completion task. The same results were found when the trials in which the distractors that were not matched for global phonological similarity were considered. Some caution should be exercised in interpreting these results, however, as performance on both of the tasks will be subject to general error of measurement due to attention and other factors. In addition, task demands are quite different for these two tasks.

As before, phoneme deletion did not have a chance level. However, a score of two or more on the task was assumed to show that a child had some understanding of the operation involved. Six children performed at chance on the initial phoneme matching task yet were above chance on the phoneme deletion task. It does not appear to be the case that the skills necessary for success on the initial phoneme matching task are also necessary for success on the phoneme deletion task. No characteristics could be found that differentiated the sub-group of children who were above chance on phoneme deletion yet at chance on phoneme matching from the other group: they did not have particularly high levels of letter knowledge and they came from both group 1 and group 2. These data suggest a less clear distinction between phoneme completion and deletion and initial phoneme matching than the distinction between rime and initial phoneme matching tasks that was assumed to be due to unit size.

Discussion

A one-year longitudinal study examining the development of phonological awareness in a group of pre-school children was carried out. A set of phonological matching tasks were given three times over the course of the year, and three explicit phonological awareness tasks were also given at the final point in testing. The children improved in all of the phonological matching tasks over the course of the year before they entered formal schooling. In addition, the syllable and rime matching tasks seemed to be easier for the children than the initial phoneme matching task. Very few children were successful on the initial phoneme matching task without also being successful on the rime matching task. However, several children were successful on the rime matching task without being successful on the initial phoneme matching task.

This pattern of responses provides only minimal evidence that children move through levels of awareness, as proposed by Goswami and Bryant (1990). The children did find that the rime and syllable matching tasks were easier than the phoneme matching task, as predicted by this theory. However, the phonemes used within this task all constituted word onsets, and as such should have tapped the same level of awareness as the rime matching task. In fact performance on the initial phoneme matching task was substantially lower. In addition, it was not the case that syllables were easier to match than rimes. These two tasks were almost equally difficult, suggesting that performance was largely determined by the size of the segment to be matched, rather than the linguistic status of that segment.

Children also found that the distractors that were equated for global phonological similarity with the target words were harder to reject than distractors that were semantically related or unrelated to the cue word. This was true for both the rime and initial phoneme matching tasks, and did not alter over the year of testing. There was no evidence that the children were less susceptible to global similarity effects as they became older. It was also found that the differences between target word and distractor in global similarity to the cue word accounted for a significant proportion of the variation in performance on the different items. In contrast, the difference between the target word and distractor in semantic similarity to the target word did not account for a significant proportion of the variance. This suggests that pre-school children have a tendency to use global phonological similarity to complete phonological awareness tasks, as suggested by Gombert (1992).

In fact, there were very few effects of semantic similarity throughout the study. In the alliteration task, the children actually found the globally and semantically matched distractors easier to reject than the globally matched distractors. It seems possible that the children detected the fact that any word semantically related to the cue word was bound to be the wrong answer.

There are two possible alternative explanations for the fact that children show a tendency to use global phonological similarity to complete phonological matching tasks. The first is that when children first begin to complete phonological awareness tasks, they tend to adopt a global processing approach. The second is that pre-school children have global representations of words, as suggested by Walley (1993). The present study does not allow us to choose between these alternatives. One possible way to compare these hypotheses would be to use words systematically varied for familiarity. According to Gombert, children should show similar performance across different types of word, while Walley would predict that performance would be better for words that are more familiar, as these become segmentally represented earlier (c.f. Metsala & Walley, 1998).

Performance on the explicit phonological awareness tasks varied largely as a function of task demands, rather than as a function of the segment employed within the tasks. A bimodal pattern of responses was found on the syllable and phoneme completion tasks, suggesting the emergence of a unitary skill, rather than the development of segmental representations that develop on a word by word basis. If it were the case that this task was highly dependent on the underlying representations of individual words, we might expect that performance would vary according to the word used. Instead, it appears that children are either completely unable to complete these tasks or are able to complete them almost entirely successfully. This provides tentative evidence against Walley's theory, though a task in which the words were systematically varied for familiarity would allow stronger conclusions.

Several children showed some success on the phoneme completion and deletion tasks without being above chance on the initial phoneme matching task. The relationship between these tasks is not the same as the relationship between rime and initial phoneme matching ability. The ability to match initial phonemes across words is not a necessary precursor to the ability to isolate final phonemes or to delete initial phonemes.

In fact, there was little evidence that children developed an implicit knowledge of phonemes as a precursor to explicit phoneme awareness, as suggested by Goswami (1999). Several children who were not yet able to complete the phoneme matching task were successful on the phoneme completion and phoneme deletion tasks. One possible explanation for this is that, as some researchers (e.g. Morais, 1993) have suggested, the development of explicit phonological awareness and the development of phoneme awareness are essentially bound up with one another, both developing as a result of reading tuition and learning letters. This possibility will be investigated more fully in Chapter 5.

If we assume that the children who score significantly above chance on the initial phoneme matching task are using metaphonological strategies, this begs the question of why children find some of these explicit phoneme awareness tasks harder than others. These results are consistent with those of Hulme et al. (in press), who found that children found phoneme deletion tasks significantly more difficult than oddity or matching tasks, even when the stimuli used in all tasks were the same. On closer examination of the tasks, they seem to differ slightly in the skills required. Phoneme completion only requires a child to isolate the final phoneme of a word. In contrast, the initial sound matching task requires children to match sounds across words, while the phoneme deletion task requires them to manipulate phonemes mentally. Byrne & Fielding-Barnsley (1989) suggest that phoneme identity (identifying phonemes within words) and phoneme invariance (matching phonemes across words) are separable skills that that both form part of full phoneme awareness. These skills may develop at different rates in different children, and this may explain the individual differences found across these tasks.

In summary, therefore, this study has provided evidence in favour of Gombert's theory of epiphonological and metaphonological development. Children seem to begin to solve phonological awareness tasks by using global phonological strategies, as described in Gombert's stage of epilinguistic awareness. If, as proposed by Goswami & Bryant (1990), the children were using segmental awareness of linguistic units to solve the tasks, it would be expected that the syllable task would be easier than the rime and initial phoneme matching tasks, which was not the case. The syllable and rime matching tasks were of about equal difficulty, while the initial phoneme matching task was harder. It was not found that children's use of epiphonological strategies decreased throughout the study: global similarity effects were still evident at Time 3. Many of the children showed a tendency to use global phonological strategies throughout the period of testing. Finally, there was no evidence that the children showed an implicit knowledge of phonemes before they developed explicit phonological awareness. There is therefore no evidence favouring Goswami (1999)'s modification of her original theory, and so it is concluded that Gombert's theory of the development of phonological awareness provides the best explanation of these data.

3. The Relationship between Language Development and the Development of Phonological Awareness

Introduction

There is good reason to believe that phonological awareness has its roots in general language development. Phonological awareness tasks analyse children's knowledge of word sounds, and one would expect that they would therefore be highly dependent on the status of a child's lexical representations. This chapter investigates the relationship between language development and the two types of phonological awareness described in the previous chapter.

When children first begin to learn words, they seem to represent them as global wholes (e.g. Ferguson & Farwell, 1975). In contrast, adults represent words as a series of segmented phonemes. There are differences of opinion concerning how and when children move from global to segmental representations. Studdert-Kennedy (1987) suggests that children learn to represent words as a series of phonemes early in their language development. When they first learn words, they represent them as a set of gestures, with little knowledge about the relative timings of these gestures. This accounts for many of the speech errors seen in young children. However, children then begin to recognise the gestures and to remember the relative timings of them. He specifies that this knowledge develops halfway through the third year, allowing children to learn new words much more quickly and precipitating the start of the vocabulary spurt. However, researchers such as Walley (1993) suggest that in fact the transition from global to segmental representations occurs more gradually and is not complete until after the onset of schooling.

There is a certain amount of evidence that suggests that literate and pre-literate children differ in their approach to speech perception and production tasks. For instance, Nittrouer and colleagues (Nittrouer et al., 1989; Nittrouer & Studdert-Kennedy, 1987) has found that children throughout the pre-school years show a greater reliance than adults on transitional cues rather than within-phoneme cues.

Given this finding, it is still unclear how to account for the development of phonological awareness on the basis of the development of phonological representations. Children begin by representing words as global wholes. Once they have learnt to read, they show evidence of having segmental representations in their approach to phonological awareness tasks. This fits with the finding that explicit phoneme awareness only develops after the onset of reading tuition. However, these theories do not explain the fact that before the onset of formal schooling, children learn to use global phonological similarity to solve phonological awareness tasks. This skill is not normally present in children younger than four, despite the fact that Studdert-Kennedy (1987) suggested that children begin to represent the internal structure of words halfway through their third year. The skill also does not seem to be linked to a particular stage in general cognitive development, such as the onset of pre-operational reasoning (c.f. Fowler, 1991).

However, global sound sensitivity may still be related to the way in which the phonological representations of particular words are encoded. Perhaps the changes in speech perception and production noted by Studdert-Kennedy (Studdert-Kennedy, 1987; Studdert-Kennedy & Goodell, 1995) are due to children beginning to encode words according to the gestures contained within them. Several gestures combine to make a single phoneme, but possibly at this early stage children code words at a level lower than the phoneme. Globally similar words would contain many of the same gestures. Harm & Seidenberg (1999) investigated the patterns of activity shown by connectionist models developed to mimic the process of learning to read. The models were trained first to link input and output phonological sequences and then to link these phonological sequences to written word forms. The phonological sequences were presented as series of phonological features (features can be considered similar to gestures for the purposes of the current study). The model contained a phonological attractor structure that 'cleans up' or completes noisy phonological sequences. The presence of this structure means that the patterns of weights on the hidden units can be quite imprecise: they do not have to represent the sequence fully, but only to the level that the word can be differentiated from others in the lexicon by the phonological attractor structure. Models that contained this phonological clean up structure generalised more readily when asked to read a new word.

The authors compared the patterns of weights from the hidden units to the phonological output features in models with and without damage to the phonological clean up structure. For the normal model, the patterns of weights from the hidden units across similar sounding words were highly similar. The damaged model, however, showed different patterns of activation for each word. Thus, the normally developing model 'recognised' similarities in underlying structure. This pattern of encoding phonological sequences might form a basis for some kind of global sound sensitivity. Harm and Seidenberg found that the network showed very similar activation states in the phonological clean up units for rhyming words, even prior to learning to link these to written words. It may be, therefore, that this similarity in output states for similar sounding words allows children to detect phonological similarities between words without an explicit awareness of the sound segments within that word.

If this hypothesis is correct, then one would expect to find that the main factor influencing the development of global sound sensitivity would not be the overall number of words known, as proposed by

Walley (1993), but the accuracy and detail of phonological representations within the lexicon. It would be difficult to measure this directly. However, two tasks that depend on the quality of phonological representations are word identification tasks such as listening for mispronunciations and speech production tasks such as accuracy of articulation. Such tasks could therefore provide an index of the quality of phonological representations.

In the 'mispronunciation detection mispronunciations' task, the child is introduced to a puppet, and told that he often makes mistakes while speaking. They are asked to listen closely to the words that the puppet says and tell him if he has said them right or wrong. These words are mispronounced by a single phoneme, which differs in either place or voicing from the target phoneme. For instance, 'aeroplane' is articulated as 'aeroblane'. If a child's representation of the word 'aeroplane' is not fully specified, then they might accept this slightly altered word as correct. This measure therefore provides an index of the degree of detail encoded in a child's phonological representations.

Articulation is also highly dependent on the status of a child's lexical representations. In fact, it is likely to be more highly dependent on lexical representations than the listening for mispronunciations task. Children must have representations that are detailed enough to allow accurate reproduction of the word, which requires that the gestures required and their relative timings are highly specified. This is especially true for polysyllabic words, words containing consonant clusters and words with unusual stress patterns.

Within the listening for mispronunciations task, children only have to recognise that a particular feature is wrong, rather than having to produce it correctly. Articulatory accuracy is a more precise test that all of a word is correctly specified, while listening for mispronunciations merely tests a child's knowledge of a single phoneme within that word. Of course, the articulation task also involves further skills not involved in the listening for mispronunciations task. Children have to retrieve a word from their lexicon and articulate it accurately. It may therefore be related to other tasks that require phonological outputs such as letter naming.

As well as being indices of the status of phonological representations, both spoken word identification and speech production will themselves influence these representations. When a known word is perceived, this allows consolidation of known features and the elaboration of an incomplete representation. When a word is articulated, the motor programme that is activated may well provide feedback to the phonological representations, and a child will also be able to hear the word they have spoken, prompting a link between production and perception of the same word. In fact, there is some evidence that production and perception of specific phonemes is closely linked. Velleman (1988) asked twelve children between three and five years old to learn labels containing the phoneme /θ/, and to distinguish minimal pairs contrasting this phoneme. She found that performance on the two tasks using /θ/ were correlated, though performance on the two tasks using the /s/ phoneme did not show a significant correlation. Velleman concluded that this is because difficulties with articulation of the /s/ sound are due to motor difficulties, while difficulties with the /θ/ phoneme are more likely to occur at the representational level.

There is also some evidence that articulation of specific phonemes is related to awareness of that phoneme. Thomas & Senechal (1998) examined awareness of the phonemes /r/ and /m/ in a group of three-year-old children. At this stage in development, just under 50% of the children tested always substituted /w/ for /r/, while a further 19% of them sometimes made this error. All but 2 of the 80 children produced the control phoneme, /m/, accurately. The children were divided into three groups according to the accuracy of their articulation of the phoneme /r/ and were given phoneme awareness tasks testing knowledge of this phoneme. The groups did not differ on cognitive ability, vocabulary, digit span or letter knowledge. However, the groups did differ on awareness of the phoneme /r/ once awareness of the control phoneme had been taken into account. This was true on a phoneme recognition task, a phoneme judgement task and an auditory discrimination task.

This chapter looks at the relationships between the phonological awareness measures described in the previous chapter and three word-level language tasks: receptive vocabulary, mispronunciation detection and articulatory accuracy. It was anticipated that the implicit phonological awareness tasks and receptive vocabulary would be correlated, because both phonological sensitivity and vocabulary learning will be influenced by the structure of existing representations, but that there may not be a close relationship between the two. However, it was expected that the two tasks measuring spoken word identification and production – listening for mispronunciations and articulatory accuracy – would predict the development of both global sound sensitivity and segmental awareness. However, spoken word identification and production should not affect segmental awareness once global sound sensitivity had been controlled, as it would have the same influence on both skills.

Method

Participants

The same sample of children was used as in the previous chapter. These were sixty-seven children from state-run day nurseries in York. They were tested three times over the course of a year, with mean ages of 3;10, 4;2 and 4;9 years at each time of testing respectively. At Time 1, mispronunciation detection and articulation scores were available for the group 2 children only.

Procedure

Phonological Tasks

The phonological tasks used are described fully in Chapter 2 (pg. 68). These included two alternative forced choice matching tasks at the level of the syllable, the rime and the initial phoneme of the word.

Receptive Vocabulary

Vocabulary knowledge was measured using the British Picture Vocabulary Scale long version (Dunn, Dunn, Whetton, & Pintilie, 1982). In this test, the child hears a word and is asked to point out which picture the word depicts from a set of four alternatives. The test continues until a child makes six errors in eight items.

Mispronunciation Detection

In this task, the children were introduced to a puppet that looked like Cookie Monster, from Sesame Street. They were told that he was just a baby monster, who was just learning to talk. Sometimes he said words right, but sometimes he said words wrong. They were asked to listen carefully to what he said and to tell him if he had said each word right or wrong. Three practice items were given, with full feedback, and a brief discussion of what the monster said, and what he was trying to say, to make sure that the child understood the task. The child then heard twenty-three words. The words varied as to whether they were one-syllable words or three-syllable words, and whether they had a high or low age of acquisition. Eight of the twenty-three words were correctly pronounced, and fifteen were mispronounced in a single consonant. Seven of these had their initial consonant mispronounced (e.g. nuck for duck), and eight had a later consonant mispronounced, either a medial consonant (e.g. golilla for gorilla) in the case of the three syllable words or a final consonant (e.g. moush for mouse) in the case of the one syllable words. These words are shown in Table 3.1. The words that the nonwords are derived from are shown in parentheses.

Table 3.1: Words used in the mispronunciation detection task

Word Type:		1 syllable		3 syllable	
Age of Acquisition		<3 yrs	4 yrs	<3 yrs	4 yrs
Condition	unchanged	hat moon	nail swan	kangaroo umbrella	crocodile screwdriver
	initial phoneme changed	vish (fish) nuck (duck)	tice (dice)	delephone (telephone) panana (banana)	domato (tomato) garavan (caravan)
	final/medial phoneme changed	moush (mouse) flad (flag)	goad (goat) torsh (torch)	aeroblane (aeroplane) elevant (elephant)	golilla (gorilla) envenope (envelope)
	Age of Acquisition (months)	24.2	47.8	24.05	51.78
	Frequency (1-5)	2.89	2.34	2.89	2.71
	No. of phonemes	2.34	3.67	6.83	7.17

<u>Articulation</u>

In order to measure the quality of each child's articulation, they were given a confrontation naming task. The test involved twenty-one pictures of objects that the children were asked to name. The names were two- and three-syllable words with an observed age of acquisition of less than four years. Seven of the words had an unstressed initial syllable (e.g. gorilla), seven of them contained consonant clusters (e.g. screwdriver) and seven of them contained vowels as a full syllable (e.g. caterpillar). Eleven of the words were also used in the mispronunciation detection task. If a child failed to name an item correctly they were given a semantic clue. If they were still unable to name the picture, they were told the correct name and re-tested on that item at the end of the test. If the child still failed to produce that item then it was assumed that the child did not know that word and it was removed from that child's total. Each child's responses were recorded onto minidisk and transcribed at a later date. The transcriptions were then scored as percentage consonants correct for all of the words that the child had produced spontaneously.

Results

Data Preparation

On the phonological matching tasks, some of the children always picked a card on one side of the array. Some children also showed no variation in their responses to the mispronunciation detection task, either always answering 'yes' or always answering 'no' to each question. In each case, these children were removed from the following analyses. In addition, two children refused to complete the articulation task at Time 1.

Summary Data for the Language Tasks

The summary data for the language tasks is shown in Table 3.2. Standard scores are shown for the vocabulary task, to allow interpretation of the scores against the norms for the general population. However, raw scores were used in the correlation and regression analyses later in this chapter. Two scores are shown for the mispronunciation detection task: total number of items correct and a 'proportion of correct detections' score. This score included 'a correction for guessing' (McNicol, 1972); the proportion of false alarms was subtracted from the proportion of correct detections of mispronunciations, and the resulting number was divided by the proportion of 'yes' responses to mispronounced words. This calculation controls for any bias the children may have had when guessing responses.

Table 3.2: Mean performance (and standard deviations) of the children across the language tasks at each time of testing

Variable	Group	Time 1	Time 2	Time 3
Vocabulary	1	104.89 (11.32)	109.21 (11.59)	111.89 (10.71)
(standard score)	2	97.45 (11.08)	97.24 (9.02)	96.34 (8.57)
Articulation	1	-	83.69 (11.34)	88.41 (8.81)
(% consonants correct)	2	73.96 (15.21)	77.00 (14.89)	83.33 (13.68)
Mispro. detection: raw	1	-	17.68 (4.31)	19.03 (2.56)
score (/23)	2	14.26 (3.49)	15.96 (2.76)	18.25 (3.27)
Proportion	1	-	0.647 (0.369)	0.766 (0.203)
correct responses (corrected for guessing)	2	0.265 (0.414)	0.506 (0.264)	0.721 (0.260)

A repeated measures analysis of variance on the raw scores from the vocabulary task showed that there was a significant effect of Time of Testing ($F(2,64)=89.43$, $p<0.001$) and a significant effect of Group ($F(1,65)=20.04$, $p<0.001$), with the group 1 children outperforming the group 2 children at each point of testing. There was also a significant interaction between these two variables ($F(2,65)=10.39$, $p<0.001$). Post-hoc contrasts showed that the differences between the groups increased as time went on. Repeated measures analyses of variance were carried out on the articulatory accuracy and mispronunciation detection tasks at times 2 and 3, as these were the time points when the full sample were tested. For the articulation task there was a significant effect of Time of Testing ($F(1,63)=33.47$, $p<0.001$) and a significant effect of Group ($F(1,63)=4.46$, $p<0.05$), but no significant interaction between the two factors. For the mispronunciation detection task (raw scores) there was a significant effect of Time of Testing ($F(1,62)= 16.49$, $p<0.05$), but no significant effect of Group ($F(1,62)<1$,ns). Analysis using the corrected 'proportion correct' score produced the same results; there was a significant effect of Time of Testing and no significant effect of Group. Since the raw scores on the mispronunciation detection task showed a pattern that was more normally distributed, these scores are used in all of the following analyses.

A further analysis was carried out comparing the different types of items in the mispronunciation detection task. There were significant effects of Word Length ($F(1,64)=18.21$,$p<0.001$), with performance on the three-syllable words being better than performance on the one-syllable words, and of Age of Acquisition ($F(1,64)=9.12$,$p<0.01$), with the late-acquired words being recognised more readily than the early-acquired words. These differences between different word types suggest that performance on the task was influenced by lexical factors such as age of acquisition. However, the finding that late-acquired words were recognised more easily than early-acquired words was surprising. Cronbach's Alpha reliability coefficients were also calculated for the mispronunciation detection task at each of the three points of testing. The reliability coefficients were 0.676 at Time 1, 0.769 at Time 2 and 0.635 at Time 3. In general, therefore, performance on each of the language measures improved over time, and group 1 showed significantly better performance than group 2 on the receptive vocabulary and articulation tasks.

Correlations between the language and phonological awareness variables are shown in Table 3.3. Bivariate correlations are shown above the diagonal and partial correlations controlling for age are shown below the diagonal. Correlations were carried out for the full sample, with the exception of correlations including mispronunciation detection or articulation at the first point of testing, when only one of the two groups completed the task.

Table 3.3: Correlations between the language tasks and the phonological awareness variables (n=67)

	vocab t1	vocab t2	vocab t3	mispro. t1 (n=23)	mispro. t2	mispro. t3	artic t1 (n=27)	artic t2	artic t3	syll t1	syll t2	rime t1	rime t2	rime t3	pho t1	pho t2	pho t3
vocab t1	*	**.746***	**.609***	.367	**.572***	**.482***	.166	**.286**	.213	**.276**	**.362***	**.314**	**.336***	**.439***	.031	.219	**.504***
vocab t2	**.744***	*	**.706***	.366	**.593***	**.424***	.048	**.257**	.179	**.374***	**.388***	**.284**	**.391***	**.438***	.040	**.350***	**.508***
vocab t3	**.611***	**.716***	*	.401	**.495***	**.360***	.040	**.304**	**.275**	**.473***	**.458***	**.312**	**.363***	**.481***	.093	**.344***	**.424***
mispro. t1	.357	.341	.408	*	**.549***	.513	.258	.349	.364	.243	.286	.108	.434	.332	-.130	.052	**.550***
mispro. t2	**.573***	**.599***	**.495***	**.557**	*	**.549***	.211	.251	.234	**.365***	**.478***	**.323**	**.472***	**.528***	-.027	**.304**	**.482***
mispro. t3	**.477***	**.396***	**.372***	**.484**	**.564***	*	**.680***	**.470***	**.348***	.156	**.285**	.156	**.365***	**.281**	-.066	.174	**.408***
artic t1	.148	-.001	.039	.214	.212	**.655***	*	**.889***	**.840***	.054	.270	.097	.068	.022	.364	-.121	.277
artic t2	**.278**	.240	**.305**	.332	**.250**	**.456***	**.895***	*	**.840***	.121	.293	.156	.131	.155	.038	**.353***	**.257**
artic t3	.211	.177	**.275**	.366	.234	**.353***	**.863***	**.843***	*	.067	**.348***	.152	.104	.136	.150	**.382***	.181
syll t1	**.277**	**.379***	**.473***	.247	**.365***	.160	.054	.121	.067	*	**.476***	**.464***	**.577***	**.522***	.213	**.400***	**.399***
syll t2	**.352***	**.365***	**.466***	.254	**.484***	.244	.229	**.275**	**.349***	**.484***	*	**.539***	**.666***	**.406***	.352	**.425***	**.416***
rime t1	**.301**	.247	**.321**	.051	**.329**	.086	.024	.127	.149	**.481***	**.513***	*	**.516***	**.458***	.134	**.264**	**.519***
rime t2	**.327**	**.375***	**.366***	.417	**.474***	**.341***	.030	.114	.101	**.582***	**.657***	**.500***	*	**.641***	.078	**.425***	**.587***
rime t3	**.431***	**.413***	**.493***	.295	**.539***	.230	-.046	.129	.132	**.537***	**.375***	**.419***	**.631***	*	-.195	**.409***	**.605***
pho t1	.046	.069	.096	-.102	-.024	-.027	.424	.058	.156	.217	**.395***	.185	.103	-.166	*	.288	-.144
pho t2	.218	**.353***	**.345***	.050	**.304**	.177	-.129	**.354***	**.382***	**.400***	**.431***	.271	**.428***	**.418***	.293	*	**.314**
pho t3	**.499***	**.486***	**.435***	**.524**	**.492***	**.365***	.226	.234	.179	**.410***	**.386***	**.483***	**.575***	**.580***	-.112	**.321**	*

(correlations significant at $p<0.05$ are shown in bold, while * indicates correlations significant at $p<0.01$)

Next, principal component analyses were carried out including only the language variables (vocabulary, mispronunciation detection and articulation). Single factor solutions were found at each point in testing, and so are not reported here. The three phonological awareness variables were then included in the analyses. These analyses were conducted using a Varimax rotation to extract factors with an Eigenvalue of larger than 1. The results are shown in Table 3.4. Since only a subset of the sample completed the mispronunciation detection and articulation tasks at Time 1, they are not included in this principal component analysis.

Table 3.4: Principal component analyses including the language and phonological awareness variables at each point in testing.

Variable	Time 1	Time 2		Time 3	
	Factor 1	Factor 1	Factor 2	Factor 1	Factor 2
Vocabulary	**.663**	**.733**	.168	**.649**	.334
Mispro.	-	**.831**	.008	.380	**.674**
Articulation	-	.005	**.891**	-.002	**.895**
Syllable	**.786**	**.762**	.255	-	-
Rime	**.807**	**.768**	.159	**.873**	.001
Initial phoneme	-	.322	**.737**	**.828**	.129
% variance explained	56.99%	48.9%	17.2%	47.0%	20.9%

(Factor loadings of greater than 0.600 are shown in bold.)

These exploratory analyses suggest that the relationships between the variables change across time. At Time 1, all of the variables load onto a single factor. However, when the two speech variables are included at Time 2, a two-factor solution is found. Mispronunciation detection and syllable and rime matching load with vocabulary on factor 1, while articulation and initial phoneme awareness load together on factor 2. At Time 3 the pattern changes. The two speech variables, articulation and mispronunciation detection load onto the same factor, while vocabulary loads with the phonological awareness variables. The different patterns at different time points may reflect different approaches to the mispronunciation detection task. It is possible that at Time 2, many of the words in the mispronunciation detection task are still relatively new words for the children, and so performance on the task will depend largely on how many of the words used are well known to the child, and would therefore be highly correlated with vocabulary development. However, at Time 3 nearly all of the words should be well known to the children, and performance will be more highly dependent on the accuracy of the phonological representations of these words, as is the articulation task. Initial phoneme matching loads with articulation at Time 2 and with rime matching at Time 3. It is likely to be closely related to both of these factors; it is a phonological awareness task of the same form as the syllable and rime matching task, but requires analysis of words at the level of the phoneme, which may well require accurate articulation of those phonemes. At each point in testing, vocabulary and syllable and rime matching load onto the same factor. This finding is in line with the hypothesis stated in the introduction, that vocabulary would be related to concurrent phonological awareness, as both tasks tap phonological resources.

Simultaneous Multiple Regressions

In order to determine how speech and language development influences the development of phonological awareness over time, a path analysis consisting of a series of simultaneous multiple regressions was carried out. Within each regression, age was entered at the first step, then each of the other variables at a particular time point was entered simultaneously to predict each of the variables at the following time point. Only the tasks given to the full sample of children were included and paths are drawn only from those variables that predicted significant unique variance in the dependent variable. Because of the close correlations between the syllable and rime matching tasks at each point in testing, they were added together to form a single measure for use in all of the multiple regression analyses. The regressions using Time 1 independent variables to predict Time 2 dependent variables are shown in Table 3.5, while the regressions from Time 2 to Time 3 variables are shown in Table 3.6. The results from these regressions are then presented in a Path Diagram in Figure 3.1.

Table 3.5: Multiple regressions predicting language and phonological awareness variables from Time 1 to Time 2

a) Dependent Variable: Vocabulary			b) Dependent Variable: Mispronunciation detection			c) Dependent Variable: Articulation		
Variable	β	p	Variable	β	p	Variable	β	p
Age	.180	ns	Age	.024	ns	Age	.127	ns
Vocabulary	.707	<0.01	Vocabulary	.513	<0.01	Vocabulary	.265	ns
Syllable/rime	.087	ns	Syllable/rime	.192	ns	Syllable/rime	.037	ns

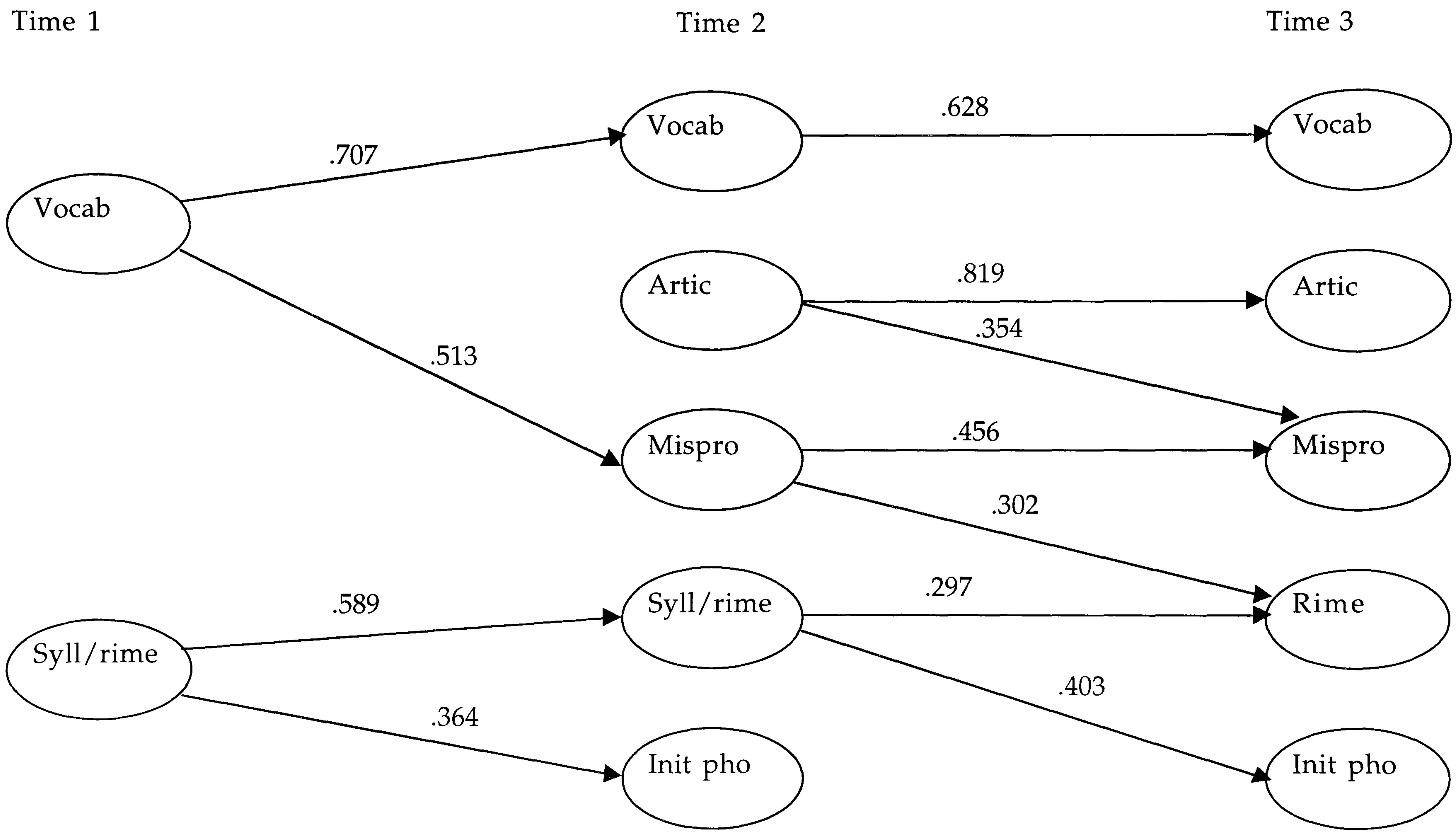
d) Dependent Variable: Syllable/rime			e) Dependent Variable: Initial phoneme		
Variable	β	p	Variable	β	p
Age	.232	ns	Age	.014	ns
Vocabulary	.168	ns	Vocabulary	.102	ns
Syllable/rime	.589	<0.01	Syllable/rime	.364	<0.05

Table 3.6: Multiple regressions predicting language and phonological awareness variables from Time 2 to Time 3

a) Dependent Variable: Vocabulary			b) Dependent Variable: Mispronunciation detection			c) Dependent Variable: Articulation		
Variable	β	p	Variable	β	p	Variable	β	p
Age	.010	ns	Age	.273	<0.05	Age	.032	ns
Vocabulary	.628	<0.001	Vocabulary	.070	ns	Vocabulary	-.089	ns
Syllable/rime	.145	ns	Syllable/rime	-.020	ns	Syllable/rime	.056	ns
Mispro. detection	.021	ns	Mispro. detection	.456	<0.01	Mispro. detection	.028	ns
Articulation	.117	ns	Articulation	.354	<0.01	Articulation	.819	<0.01
Initial phoneme	.011	ns	Initial phoneme	-.108	ns	Initial phoneme	.091	ns

d) Dependent Variable: Rime matching			e) Dependent Variable: Initial phoneme matching		
Variable	β	p	Variable	β	p
Age	.245	ns	Age	.250	ns
Vocabulary	.068	ns	Vocabulary	.243	ns
Syllable/rime	.297	<0.05	Syllable/rime	.403	<0.01
Mispro. detection	.302	<0.05	Mispro. detection	.124	ns
Articulation	-.099	ns	Articulation	.057	ns
Initial phoneme	.187	ns	Initial phoneme	-.019	ns

Figure 3.1: Path analysis showing the relationship between phonological awareness and language development over time



These regressions show a slightly different pattern to that shown by the principal component analyses. From Time 1 to Time 2 vocabulary influences mispronunciation detection ability, while syllable and rime matching influences initial phoneme matching. From Time 2 to Time 3, articulation has a significant influence on mispronunciation detection and syllable and rime matching ability again influences phoneme awareness. Mispronunciation detection at Time 2 also influences rime matching at Time 3. Overall, therefore, this Path Analysis does illustrate a pattern of development coherent with the hypotheses described in the introduction. Mispronunciation detection provides an index of how well specified phonological representations are. This is influenced early in development by vocabulary level, since the child will have to know the words used to do well on the task. However, by Time 3, when the children were all between 4;2 years old and 5;4 years old, most of the words used are well known, and so the main influence on mispronunciation detection is articulatory accuracy. As described in the introduction, accurate articulation of phonemes increases the likelihood that these phonemes will be accurately represented. Mispronunciation detection influences the development of rime matching ability in its capacity as a measure of the specification of phonological representations. Syllable and rime matching also influence the development of initial phoneme matching ability.

Predicting Performance on the Phoneme Completion and Phoneme Deletion Tasks at Time 3

Two parallel multiple regressions were carried out examining the influence of the language and phonological awareness variables at Time 2 on explicit phoneme awareness. In each regression, age was entered at the first step. For the first set of regressions the language variables were all entered together at the second step, and the phonological awareness variables were entered together at the third step. For the second set of regressions the phonological awareness variables were entered at the second step, followed by the language variables. These regressions are shown in Table 3.7.

Table 3.7: Multiple regressions examining the influence of language and phonological awareness variables at Time 2 on phoneme completion and deletion at Time 3.

Step	Variable	Phoneme Completion		Phoneme Deletion	
		β	P	β	P
1	Age	.219	ns	.369	<0.05
2	Vocabulary	-.144	ns	-.095	ns
	Mispro. detection	.362	<0.05	.176	ns
	Articulation	.254	<0.05	.259	<0.05
3	Syllable/rime matching	.196	ns	.272	0.07
	Initial phoneme matching	-.029	ns	.245	0.06
2	Syllable/rime matching	.323	<0.05	.237	0.06
	Initial phoneme matching	.023	ns	.263	<0.05
3	Vocabulary	-.165	ns	-.176	ns
	Mispro. detection	.275	ns	.015	ns
	Articulation	.241	0.06	.176	ns

For both phoneme completion and phoneme deletion, vocabulary level did not account for a significant proportion of the variance even when entered on the second step. However, articulation does account for significant variance in both dependent variables when entered on the second step. Mispronunciation detection also accounts for further variance in phoneme completion when entered on the second step. However, none of the language variables account for significant further variance when entered after the phonological awareness variables, though the contribution from articulation to phoneme completion approaches significance. Syllable and rime matching ability accounted for significant variance in phoneme completion ability when entered at the second step, while initial phoneme matching accounted for significant variance in phoneme deletion. However, after the language variables were included in the regression equations, the phonological awareness measures contributed only marginally to the development of phoneme deletion, and made no significant further contribution to phoneme completion.

A second set of regression equations was then carried out with composite variables formed from the language and phonological awareness variables. The composite phonological awareness variable was formed by adding scores on the three phonological awareness tasks together, while the 'speech' composite variable was formed by calculating z scores for the mispronunciation detection and articulation tasks and adding these together. Regressions predicting phoneme completion and deletion at Time 3 using these composite variables from Time 2 are shown in Table 3.8.

Table 3.8: Regressions predicting phonological completion and deletion at Time 3 using composite variables at Time 2.

Step	Variable	Phoneme Completion		Phoneme Deletion	
		β	p	β	p
1	Age	.218	ns	.345	<0.01
2	Vocabulary	-.153	ns	-.211	ns
	Phonological matching	.178	ns	.436	<0.01
	Speech	.386	<0.05	.154	ns

These regressions show a pattern of dissociation: while speech is the only unique predictor of phoneme completion ability, phonological awareness is the only unique predictor of phoneme deletion. The relationship between phoneme completion and speech probably reflects the fact that a child with clear articulation and accurate spoken word recognition is likely to have full specifications of the phonemes within a word. This will also allow detection of single phonemes within words, as measured by the phoneme completion task. In contrast, phoneme deletion is a task that requires further skills in addition to phoneme isolation. As described in Chapter 2, phoneme deletion requires greater metalinguistic capacities than phoneme completion; children must be able to mentally manipulate phonemes. It seems that an important precursor of this skill is phonological matching ability.

Discussion

This study examined the role of language in the growth of phonological awareness in pre-school children. A one-year longitudinal study was carried out, and children were tested three times over the course of this year. Walley (1993) suggested that vocabulary growth precipitates the development of phonological awareness. However, data from connectionist modelling (Harm and Seidenberg, 1999) suggested that in fact the quality of phonological representations might be the most important factor in the development of early sensitivity to phonological similarities. In order to compare these alternative hypotheses, the children were given two tasks measuring quality of phonological representations – articulation and mispronunciation detection – as well as receptive vocabulary and implicit and explicit phonological awareness tasks.

Receptive vocabulary showed good correlations with the phonological awareness tasks throughout development. These correlations were strongest with the syllable and rime matching tasks. When included in a principal components analysis, vocabulary always loaded onto the same factor as the syllable and rime matching tasks. However, vocabulary was not a significant unique predictor over time of any of the implicit or explicit phonological awareness tasks. While vocabulary and phonological awareness are related, vocabulary does not appear to be causally related to the onset of phonological awareness. These results cause problems for Walley's theory that vocabulary development is the major precipitator in the development of phonological awareness. Instead, the results suggest that the relationship between phonological awareness and vocabulary level is mediated by a third factor. This may be the quality of phonological representations, or some other unmeasured factor.

The mispronunciation detection task was included in the test battery as a measure of the detail and accuracy of phonological representations. This variable correlated with performance on the phonological awareness tasks at Times 2 and 3. It also correlated with vocabulary at Times 2 and 3 and with articulation at Time 3 only. This pattern of correlations was reflected in the behaviour of the mispronunciation detection task in the principal component analysis. At Time 2, mispronunciation detection loaded with vocabulary and the rime and syllable matching tasks. However, at Time 3 it loaded onto the second factor with articulatory accuracy. These patterns are reflected in the multiple regressions predicting mispronunciation detection: from Time 1 to Time 2, vocabulary is the only significant unique predictor of mispronunciation detection ability, while at Time 2 only articulation predicts growth in mispronunciation detection ability. There are at least two possible reasons why vocabulary may predict mispronunciation detection ability. The first is that, as Walley (1993) suggested, increasing vocabulary size may put pressure on the lexicon to encode words in a more detailed manner. An alternative reason relates to the nature of the mispronunciation detection task itself. A vital element of the mispronunciation detection task is that children know the words that are correctly or incorrectly articulated. However, at Time 2, many of the words used in the mispronunciation detection task may have been new or even unknown words for some of the children. Because of this, vocabulary level is likely to be an important factor in how well children do on this task. By Time 3 all of the words should be well known to the children. This may explain why at Time 3 the mispronunciation detection task is more closely correlated with articulatory accuracy. At this stage performance on the mispronunciation detection task will be more dependent on the quality of phonological representations of the words used. Articulatory accuracy will also be dependent on the quality of representations, and therefore these two tasks should be highly correlated.

Within the longitudinal multiple regressions, mispronunciation detection ability at Time 2 predicts growth in rime matching ability at Time 3. This finding is in line with the hypothesis stated in the introduction, that tasks measuring quality of phonological representations would be related to the development of phonological awareness.

Articulation was not closely related to vocabulary or mispronunciation detection in the correlational analysis, and neither of these variables predicted growth in articulatory accuracy over time. However, articulation at Time 2 did predict mispronunciation detection ability at Time 3. This finding is in line with the evidence discussed in the introduction suggesting that articulation of particular words can provide feedback to the phonological representations of these words.

Articulation at Times 2 and 3 was correlated with syllable and initial phoneme awareness at Time 2. However, it did not correlate with rime awareness at any stage of development. Articulation also did not show a close relationship with syllable and rime matching in the principal component analysis. It did load onto the same factor as initial phoneme matching at Time 2, but by Time 3 initial phoneme matching loaded onto the same factor as syllable and rime matching.

Articulation at Time 2 was also a marginally significant unique predictor of phoneme completion ability at Time 3.

These results suggest that the two measures of quality of phonological representations included in this study are differentially related to the two different types of phonological awareness described in the previous chapter. Mispronunciation detection ability is related to early global phonological sensitivity, as measured by performance on the rime task. In contrast, articulatory accuracy is more closely related to awareness of individual phonemes, such as initial phoneme matching ability and phoneme completion. It may be that good performance on each of these tasks is dependent on different aspects of phonological representations. In the articulation task, detailed representations of the sequence of gestures and their relative timings is required for accurate articulation of polysyllabic words. A child who can articulate many words accurately is likely to have full specifications of the phonemes within those words, and therefore this type of phonological processing is likely to be related to the development of phoneme awareness.

Mispronunciation detection ability is more closely related to global sound sensitivity. To be able to complete the syllable and rime matching tasks successfully, a child must be sensitive to sound similarities between words. To distinguish between correctly articulated words and words misarticulated by a single phoneme, a child must represent the gestures present within a word and detect that one or more of these gestures has been altered within the misarticulated word. However, the specific details and relative timings of these gestures may not be represented. In fact, many of the children were able to detect mispronunciations within words in the mispronunciation detection task when they produced the same words incorrectly in the articulation task. This less specific representation of gestures within a word may be all that is necessary for some global sound sensitivity to emerge.

The path analysis conducted in the study also showed that articulation was a significant unique predictor of growth in mispronunciation detection ability. It is likely that articulation of complex words provides some feedback to the phonological representations within the lexicon, to allow words to become more and more fully encoded. In this way, even though fully accurate articulation occurs after children are able to detect the mispronunciations in words used in the mispronunciation detection task, earlier, less accurate articulation pushes the lexicon into encoding representations in a more detailed and accurate way.

While language development is clearly important in the development of phonological awareness, an important factor in the development of awareness of individual phonemes remains global sound sensitivity, as measured by the syllable and rime matching tasks. Syllable and rime matching ability at Times 1 and 2 was a significant unique predictor of initial phoneme matching at Times 2 and 3, even after all the language variables had been included in the regression equation. Syllable and rime matching at Time 2 was also a significant unique predictor of phoneme deletion ability at Time 3, though it was not a significant unique predictor of phoneme completion ability. As discussed in the previous chapter, phoneme deletion is likely to be more closely related to the phonological matching tasks than phoneme completion, because phoneme completion requires only isolation of specific phonemes, while the phoneme deletion task requires mental manipulation of phonemes. A likely precursor of this skill is the ability to compare sounds across words.

These results therefore suggest that language development is an important factor in the development of phonological awareness. However, the quality of phonological representations seems to be more important than the quantity of them: mispronunciation detection and articulation were more closely related to phonological awareness than was vocabulary level. However, this is not to say that vocabulary level is not related to the development of well-specified representations; increasing vocabulary size is likely to force words to be encoded in a more detailed manner, which will in turn influence mispronunciation detection ability and therefore phonological awareness. Vocabulary level and phonological awareness also correlated at each point of testing; the relationship between these variables will be investigated further in the following chapter. Mispronunciation detection and articulation were also related to different types of phonological awareness; mispronunciation detection was related to global sound sensitivity, while articulation was related to phoneme awareness. It is suggested that this is because mispronunciation detection and articulation are each sensitive to different levels of detail in phonological representations.

4. The Relationship of New Word Learning Skill to Language and Phonological Awareness

Introduction

Data from the previous chapter suggest that vocabulary level and phonological awareness are closely correlated. However there was no evidence that the two were causally related: neither of these two variables predicted growth in the other variable over time. This chapter examines the relationships between vocabulary and phonological awareness in more detail.

One potential problem in distinguishing causal relationships in longitudinal studies of vocabulary and phonological awareness development is that both variables will be highly dependent on uncontrolled differences in children's language experience. Vocabulary levels vary with the socio-economic status and everyday experience of the child. Children who are read to daily and involved in conversations from an early age are likely to encounter a much wider range of words with a higher frequency than children who are not read to. This chapter investigates the relationships between vocabulary and phonological awareness by considering performance on a new word learning task. A new word learning paradigm allows a clearer examination of the relationship between these skills because it provides a pure measure of a child's ability to pick up new words. A child's exposure to a word can be held constant, and therefore his ability to learn new words can be measured directly.

As described in the introduction, Walley's lexical restructuring hypothesis predicts that vocabulary development precipitates the development of phonological awareness. The theory is silent as to the driver of vocabulary development. In contrast, Gathercole and colleagues (Gathercole & Baddeley, 1989; Gathercole & Baddeley , 1990) have suggested that phonological processing skills play a critical role in vocabulary development. Hence, to the extent that phonological awareness is dependent on phonological processing skills, it will predict vocabulary development. In fact, Bowey (1996) and Metsala (1999) have both found that the relationship between vocabulary level and measures of phonological memory, such as nonword repetition, can be accounted for by the relationship between vocabulary and phonological awareness.

Very few studies have examined the relationship between new word learning and phonological awareness. However, one study that addresses this relationship is that of de Jong et al. (2000). There were two parts to this study. The first examined the relationship between name and non-name learning, phonological awareness and vocabulary level. It was found that non-name learning was correlated with phonological awareness, while name learning was only correlated with vocabulary level. The second part of the study looked at the effects of training phonological awareness on non-name learning. It was found that those children who had undergone phonological awareness training had improved on the non-name learning task, both compared to pre-test scores and to a control group who had undergone semantic categorisation training. This suggests that phonological awareness levels have a direct effect on children's ability to learn novel phonological sequences. However, there are some difficulties with this study. The non-name learning task was administered in a single session, and performance on the task did not correlate with vocabulary level. This suggests that the task was not an accurate depiction of the process of transferring novel phonological sequences to long-term memory.

De Jong et al (2000) suggested that the relationship between phonological awareness and new word learning found in their study was due to the fact that training in phonological awareness increased children's sensitivity to the sounds within words. This would then allow children to encode phonologically novel words in a more detailed way. However, data from the previous chapter has shown that phonological awareness is at least partially dependent on the quality of underlying phonological representations. It may be, therefore, that the quality of existing phonological representations is in fact the strongest predictor of the speed of acquisition of new phonological representations, and that the relationship between phonological awareness and new word learning is in fact subsumed by the relationship between phonological representations and new word learning. The current study allows us to investigate this possibility, since measures of new word learning, phonological awareness and quality of phonological representations were all collected.

By the time children reach the age of six, they know around 14,000 words on average (Carey, 1978). For them to have learnt this number of words in the time since they were 18 months old, they must have learnt around 9 words a day. This suggests that children learn new words very quickly and easily. However, most nonword learning experiments find that children are not very good at learning new words, and require several trials. This may well be because of the artificiality of most of these tasks. Most measure word learning within a single session, and present the words to be learnt without much of the linguistic and environmental context that normally accompanies the acquisition of new words in everyday situations (Carey, 1978; Goodman, MacDonough, & Brown; 1998).

Markman (1994) suggests that young children use a range of logical and semantic constraints when learning new words. Infants assume that new words refer to whole objects; that they do not refer to objects that already have a known label; and that they can be generalised to similar objects. Most tasks used in previous new word learning studies involve learning names for toys and dolls. Names are likely to be applied only to specific objects within a known category (for instance, my dog is named Star, and that name belongs to her only, but she is also a dog, and that label can be extended to other similar animals). As such, names do not conform to two of these three constraints. Therefore they are likely to be more difficult to learn and may have an unusual pattern of acquisition.

Several researchers have found that while children may show recognition of a word after a single exposure, it is more difficult to make the child recall and reproduce a given word. Carey (1978) suggests that children make a 'fast mapping' of a new word after a single exposure, but that it takes several exposures in a variety of contexts before this word's form is well specified enough for accurate reproduction. She showed that if children were asked incidentally to 'pass the chromium chip, not the red one', that up to six weeks later they showed changes in responses on the basis of this exposure. When asked what colour the chip previously labelled as chromium was, most changed their original answer from 'green' to 'don't know', showing that, while they were not able to reproduce the word, they were aware that the chip had been associated with a novel word and that that word had been a colour name.

One way to avoid these difficulties is to present new words in the context of storybook reading. Most children are read storybooks regularly, and new words can be presented very naturally within this context. They can also be presented repeatedly without the task becoming unnatural, because this is the nature of the often repetitive structure of many children's storybooks. Elley (1989) used this paradigm to introduce a set of new words to a group of pre-schoolers. It was found that after the children had heard the book three times, they showed a significant increase (of 17%) in the number of the target words known. If the teacher explained the words as they were encountered, this increase rose to 40%. Very similar results were found by Robbins & Ehri (1994) and Senechal (1997).

The present study aims to investigate the relationship between new word learning and phonological awareness within the context of the longitudinal study described in previous chapters. The experiment used a more ecologically valid new word learning paradigm than has been previously employed. Measures of word recognition and word recall were used. This task was administered to a sub-group of the children involved in the main longitudinal study at Time 3 only.

It was expected that performance on the new word learning task would be related both to quality of phonological representations, as measured by the mispronunciation detection and articulation tasks, and to phonological awareness. Several researchers have suggested that phonological awareness is closely related to vocabulary growth (e.g. Bowey, 1996; de Jong et al., 2000). However, no previous studies have compared the relative predictive strength of phonological awareness and more basic spoken word processing. It may be, therefore, that the relationship between new word learning and phonological awareness is subsumed by the relationship between quality of phonological representations and new word learning.

It was also predicted that this task would be related to vocabulary level, because the task should provide an index of how easily a child acquires new vocabulary. It is predicted that receptive vocabulary level will be closely related to performance on both the recognition and the recall measures. However, it may be more closely related to word recognition, since this is a task measuring the acquisition of receptive vocabulary, while the recall task measures acquisition of expressive vocabulary.

Method

Participants

The children in this study were taken from the larger longitudinal study discussed in previous chapters. All of the children from group 1 and ten of the children from group 2 completed the new word learning task, given at Time 3 in the longitudinal study. Therefore, there were 48 children involved in this study, with a mean age of 4;1 years at Time 2 and 4;8 years at Time 3. The descriptive statistics for this group are shown in Table 4.1.

Table 4.1: Descriptive statistics for the children who took part in the new word learning study (standard deviations in parentheses)

Variable	Time 2	Time 3
Age	4;1 years (3.6 m)	4;8 years (3.5 m)
Male:Female ratio	19:29	19:29
Vocabulary (raw score)	40.98 (11.52)	49.83 (11.16)
Vocabulary (standard score)	106.48 (12.24)	108.98 (11.93)

The New Word Learning Task

The new word learning task was based around a storybook, 'The Gruffalo'. This story describes a monster called a gruffalo, and then follows a mouse as he searches for the gruffalo in the forest. Six words were selected from the description of the gruffalo to be the target words. Four of these were changed from the words in the published story into words not likely to be known by young children. The words consisted of three nouns and three adjectives; wart, talons, tusk, lilac, amber and gnarly. 'Tusk' and 'wart' were words present in the original story, but 'talons', 'lilac', 'amber' and 'gnarly' replaced 'claws', 'purple', 'orange' and 'knobbly', respectively.

The children were shown a picture of the gruffalo from the book. To begin with, they were asked to point to his ears and his tail as practice items to make sure that they understood the task. Then they were asked if they could point to each of the target parts of the picture in turn. For instance, they were asked 'Can you see his talons? Where do you think his talons are?' The children were given corrective feedback on their answers. Scores on this part of the test formed the pre-test score. Then the story was read to them, with the child looking at the pictures. To ensure that the children were concentrating on the story, they were given two informal comprehension questions during the course of the book reading, such as 'what animal is this?' and, 'Why is the fox running away?' Most children found these questions easy.

Each of the target words was included twice in the story, each time accompanying an illustration of that word. Immediately after the first reading of the story, the child was asked to point to the target areas on the picture of the gruffalo in the same way as they had in pre-testing. Again, corrective feedback was given. This score formed the 'mid-point' score.

In a second session that occurred between one and three days later, the children were asked to name each of the target areas of the picture that they had been taught in the previous session. For instance, the experimenter would point to the gruffalo's tusks and ask 'Can you remember what these were called?' Again, they were given corrective feedback on this task and this formed the 'recall' score. They were then read the story again, and finally given another recognition test using the picture of the gruffalo. This score formed the 'post-test' score.

Language Measures

The language measures from times 2 and 3 of the longitudinal study were also used in the following analyses. These were; receptive vocabulary, as measured by the British Picture Vocabulary Scales

(Dunn et al., 1982); mispronunciation detection, a task in which children had to listen to words and determine whether they were articulated correctly or not; and a confrontation naming task in which the correct responses were scored for articulatory accuracy. They are described fully in Chapter 3 (pg. 100).

Phonological Awareness

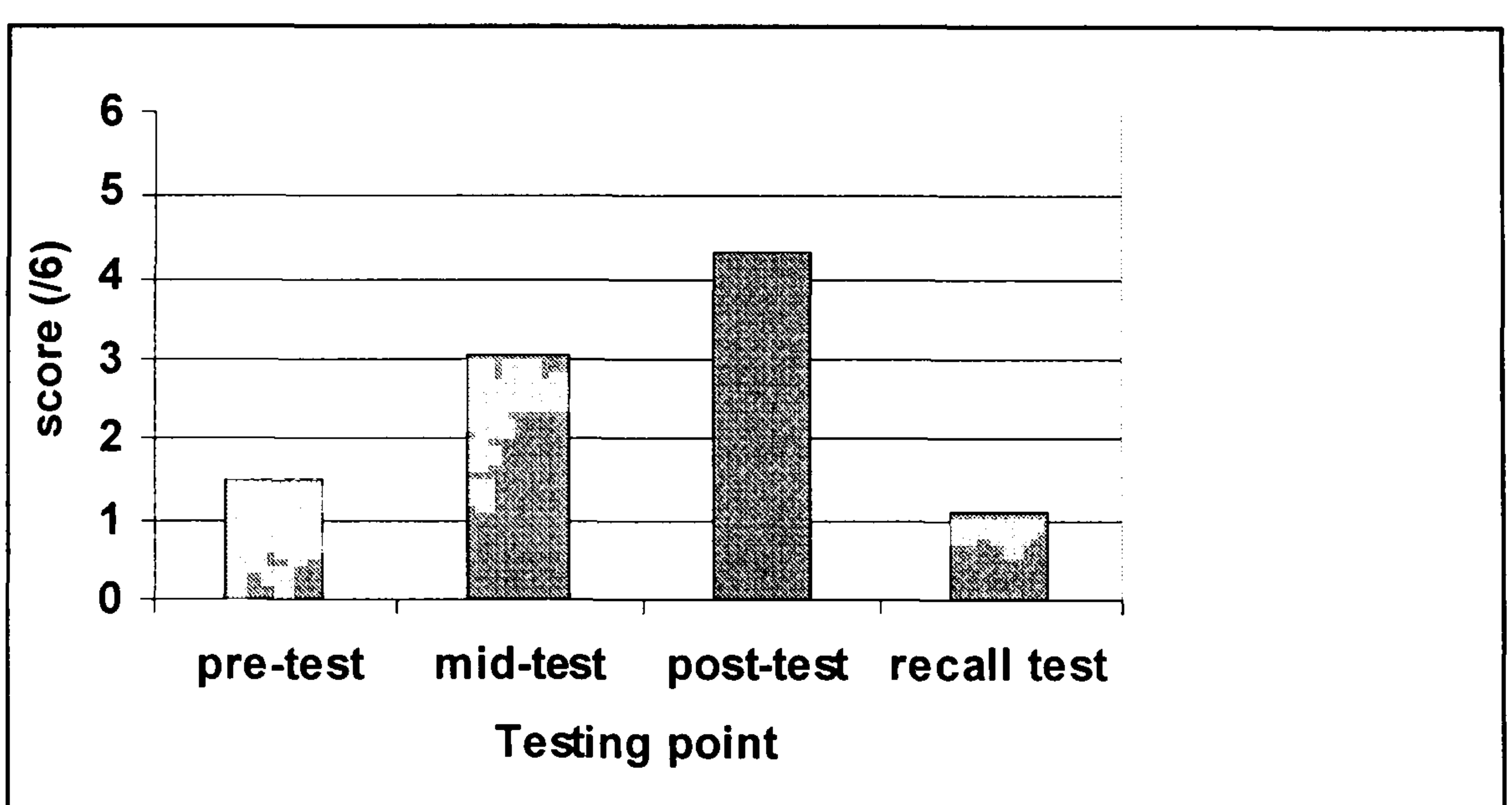
The phonological matching tasks from times 2 and 3 were also included in the analyses in this study. These were syllable, rime and initial phoneme matching at Time 2 and rime and initial phoneme matching at Time 3. These are fully described in Chapter 2 (pg. 68). For the purposes of this chapter the phonological matching tasks were combined into a composite variable at each point in testing by adding the scores on each of the phonological awareness tasks together.

Results

Summary Statistics

The mean scores across the new word learning task are displayed in Figure 4.1.

Figure 4.1: Mean scores on the new word learning task over time



A repeated measures ANOVA was carried out comparing pre-test performance with performance on the mid-test and post-test measures. The overall effect of Time of Testing was highly significant

(F(2,44)=109.7, p<0.001). Post-hoc difference contrasts showed that there was a significant increase between each point in testing. Performance on the recall measure was lower than performance on the recognition measures.

Correlations between New Word Learning and Other Tasks

A series of correlations examined the relationship between performance on the new word learning task and the language and phonological awareness measures. Both bivariate correlations and partial correlations (with age and pre-test performance on the new word learning task controlled) were carried out and are shown in Table 4.2. Bivariate correlations are shown above the diagonal and partial correlations are shown below the diagonal.

Table 4.2: Correlations between scores on the new word learning task and the other language and phonological awareness measures at Time 3

	vocab	artic	mispro.	phono	nwl mid-test (recog)	nwl post-test (recall)	nwl post-test (recog)
vocab	*	.223	**.474***	**.533***	.285	**.648***	**.563***
artic	.189	*	-.018	.147	-.063	**.305**	.294
mispro.	**.466***	-.049	*	**.516***	.146	**.297**	**.346**
phono	**.541***	.111	**.477***	*	.070	.193	**.362**
nwl mid-test (recog)	.245	-.083	.177	.136	*	**.476***	**.457***
nwl post-test (recall)	**.638***	.307	**.341**	.272	**.405***	*	**.615***
nwl post-test (recog)	**.506***	.275	**.362**	**.405***	**.395***	**.554***	*

(correlations in bold are significant at p<0.05, * indicates they are significant at p<0.01)

The mid-test learning measure does not correlate with any of the language measures. This may be because the mid-test measure is taken in the same session as the children are first introduced to the task, and may therefore not reflect long-term storage of new vocabulary. In contrast, the two post-test measures both correlate with vocabulary and mispronunciation detection. The recall measure also correlates with articulation. The recognition measure, but not the recall measure, correlates with phonological awareness.

Predicting New Word Learning over Time

As discussed in the introduction, there is some evidence that phonological awareness influences new word learning ability (e.g. de Jong et al., 2000). However, this relationship may be subsumed by the relationship between phonological representations and new word learning, as described in the introduction. In this section, these alternate hypotheses are investigated using a series of multiple regressions. New word recognition score at Time 3 is predicted using the variables at Time 2 in a hierarchical multiple regression. Pre-test score was entered on the first step to control for previous knowledge of the test words, then speech and phonological awareness were entered on successive steps. These regressions are shown in Table 4.3.

Table 4.3: Hierarchical multiple regression predicting new word learning performance on the post-test recognition measure from speech and phonological awareness scores at Time 2.

Step	Variable	β	% R^2 Change	p
1.	Pre-test new word learning	.382	14.6	<0.05
2	Phonological awareness	.415	17.2	<0.01
3	Articulation	.011	0.6	ns
	Mispro. detection	.096		ns
2	Articulation	.100	9.9	ns
	Mispro. detection	.275		0.06
3	Phonological awareness	.357	8.0	<0.05
	Total Variance Explained		32.5	

Phonological awareness and mispronunciation detection both account for a significant proportion of the variance when entered at the second step. However, articulation does not account for any further significant variance when entered at the second step with mispronunciation detection. Neither of the speech measures accounts for any significant further variance in new word recognition after phonological awareness was controlled. In contrast, phonological awareness does account for significant further variance when entered after speech. Next, vocabulary was included in the hierarchical multiple regressions in order to determine the relationship between vocabulary and new word recognition. These regressions are shown in Table 4.4.

Table 4.4: Hierarchical multiple regression examining the influence of vocabulary at Time 2 on new word learning performance on the post-test recognition measure.

Step	Variable	β	% R^2 Change	p
1.	Pre-test new word learning	.382	14.6	<0.05
2	Articulation	.100	9.9	ns
	Mispro. detection	.275		0.06
3	Phonological awareness	.370	8.0	<0.05
4	Vocabulary	.431	10.1	<0.05
2	Vocabulary	.497	23.5	<0.01
3	Articulation	.030	0.1	ns
	Mispro. detection	-.004		ns
4	Phonological awareness	.273	4.4	ns
	Total Variance Explained		42.6	

Vocabulary at Time 2 predicts a further 10% of the variance in new word recognition even when entered after both speech and phonological awareness. When vocabulary is entered on the second step of the regression after pre-test score, no other variables account for further significant variance in new word recognition. This was anticipated, since the new word learning measure aimed to measure a child's ability to acquire new vocabulary.

Parallel hierarchical multiple regressions predicting performance on the recall measure were carried out. Again, pre-test score was entered on the first step to control for previous word knowledge. Speech and phonological awareness were then entered on successive steps. These regressions are shown in Table 4.5.

Table 4.5: Hierarchical multiple regression predicting new word learning performance on the post-test recall measure from speech and phonological awareness scores at Time 2.

Step	Variable	β	% R^2 Change	p
1.	Pre-test new word learning	.346	12.0	<0.05
2	Articulation	.266	11.4	0.07
	Mispro. detection	.153		ns
3	Phonological awareness	.056	0.2	ns
2	Phonological awareness	.221	4.9	ns
3	Articulation	.253	6.8	ns
	Mispro. detection	.125		ns
	Total Variance Explained		23.6	

Articulation was a significant predictor of new word recall when entered with mispronunciation detection at the first step after pre-test score. Phonological awareness did not predict any significant variance in new word recall, even when entered on the first step after pre-test score. Speech did not account for significant further variance if entered after phonological awareness. Next, vocabulary was included in the hierarchical multiple regressions. The results of these regressions are shown in Table 4.6.

Table 4.6: Hierarchical multiple regression predicting performance on the new word learning recall measure

Step	Variable	β	% R^2 Change	p
1.	Pre-test new word learning	.346	12.0	<0.05
2	Vocabulary	.400	15.2	<0.01
3	Phonological awareness	.030	0.1	ns
4	Articulation	.014	4.1	ns
	Mispro. detection	.053		ns
2	Phonological awareness	.221	4.9	ns
3	Articulation	.253	6.8	ns
	Mispro. detection	.125		ns
4	Vocabulary	.378	7.8	<0.05
	Total Variance Explained		29.0	

In predicting the recall measure, vocabulary explained significant unique variance even when entered on the final step. Neither the speech measures nor phonological awareness accounted for significant unique variance when entered after vocabulary. Overall, language and phonological awareness explained less of the variance in the recall measure than in the recognition measure (29% and 42.6%, respectively).

Discussion

The results of this study confirmed that the new word learning paradigm provides an effective measure of children's ability to acquire new vocabulary. Both the recall and recognition measures correlated well with concurrent vocabulary level, and scores on the recognition measure were well distributed, with no floor or ceiling effects. Performance on the recognition measure also increased significantly at each point of testing. Performance on the recall measure was much lower. This is in line with previous findings measuring children's production of new words (e.g. Carey, 1978). However, on average the children produced at least one of the target words correctly, allowing enough variation for analysis of this variable.

Both quality of phonological representations, as indexed by performance on the mispronunciation detection task, and phonological awareness were significant predictors of new word recognition when entered on the first step after pre-test ability. The quality of existing phonological representations is likely to be important in the acquisition of new words. Well-specified phonological representations may make acquisition of new representations easier as new representations can build upon the patterns of activity already present for similar sounding words (c.f. Harm & Seidenberg, 1999; Snowling et al., 1991). Phonological representations in long-term memory boost the activation of familiar segments within phonological sequences by a process of redintegration (Hulme et al., 1997). It follows that the more detailed and accurate these representations within long-term memory, the more effective this process of redintegration will be.

However, once phonological awareness had been controlled, neither of the speech variables accounted for any significant further variance in new word recognition. Phonological awareness is dependent on the quality of phonological representations, as described in Chapter 3. The data presented in the current chapter suggests that phonological awareness also has an influence on how phonological representations are encoded. The phonological matching tasks used in this study required children to be able to compare sounds across words. Children who are successful on these tasks will therefore have started to represent the internal gestures within words and abstract these gestures across words. In this respect, the phonological awareness tasks provide a more stringent measure of the status of children's underlying phonological representations than the language tasks do: representation of the internal structure of words would be helpful in the speech processing tasks, but it is *necessary* for successful completion of the phonological awareness tasks. Children who are able to represent the internal structure of words will be able to learn words more efficiently, as new words can be represented in a similar way to similar sounding known words. This may be why the relationship between speech and new word learning is subsumed by the relationship between phonological awareness and new word learning.

A different pattern of results was found when predicting performance on the new word learning recall measure. Phonological awareness was not closely related to new word recall. Articulation did predict some variance in new word recall, but dropped out of significance once phonological awareness had been accounted for. These results could be interpreted as suggesting that new word recall is not highly dependent on phonological processing skills, which is surprising, especially given that new word recognition was closely related to phonological processing. However, a possible explanation for this finding may come from the fact that, as a whole, vocabulary, phonological awareness and speech accounted for a smaller proportion of the variance in the new word recall task than in the new word recognition task (29% and 42.6%, respectively).

It may be that generally the weaker relationships found between new word recall and the other variables was an artefact of the limited range in scores on this element of the new word learning task. Almost all of the children provided fewer than two correct answers on this part of the task, and scores as low as this are effectively at floor. Replication of this result would therefore be necessary before conclusions can be drawn.

Speech processing skills predicted significant variance in both the new word recognition and new word recall measures when entered at the second step. However, mispronunciation detection was most closely related to the recognition measure, while articulation was most closely related to the recall measure. This may be because the tasks used tap similar processes. In the mispronunciation detection task, children have to listen to words to determine whether they recognise them or not, while in the articulation task children have to recall words accurately.

Vocabulary at Time 2 accounted for a further 10% of the variance in new word recognition even when pre-test performance, speech and phonological awareness had been accounted for. It was also a significant unique predictor of new word recall. These results were anticipated. Since the new word learning measure aimed to mimic vocabulary acquisition, the two measures should be very closely related. It would not be expected, therefore, that other variables would account for significant further variance once vocabulary level had been controlled.

In summary, it seems that this new word learning task, with higher levels of linguistic and environmental context, was easier for young children than standard new word learning tasks used in previous studies. Phonological awareness was a significant predictor of the ability to recognise new words, and this relationship was not entirely due to the relationship between speech and new word learning. Arguably, phonological awareness was related to new word learning both because of its dependence on the quality of existing phonological representations and because it influences the development of phonological representations over time.

5. The Role of Letter Knowledge in the Development of Phoneme Awareness

Introduction

The research presented in Chapter 2 suggested that phonological awareness can be divided into two types: a global sensitivity to sound similarity that occurs early in development, and an explicit awareness of sound segments that develops later. Results described in Chapter 3 suggested that sensitivity to sound similarity develops as a result of general language development. This chapter considers the development of alphabet knowledge as a possible factor in the development of explicit awareness of individual phonemes.

Gombert (1992) suggested that learning to read forces children to move from epilinguistic awareness, or global sensitivity to sound similarity, to metalinguistic awareness, or explicit awareness of sound segments. There is a range of evidence in favour of this view. Studies examining the phonological awareness of pre-readers (Liberman et al., 1974) and illiterate adults (Morais et al., 1979) have shown that reading seems to play a role in the development of explicit phonemic awareness. A further study by Read et al. (1986) showed that in fact the development of explicit phonemic awareness was limited to languages with an alphabetic writing system. Thus the learning of letters must play a crucial role in the development of phonemic awareness.

Bowey (1994) compared phonological awareness in readers and non-readers with differing levels of letter knowledge. It was found that the readers performed better than the non-readers in all of the tasks, and that the children who had high levels of letter knowledge performed better than the children who had low levels of letter knowledge on the phonemic tasks. However, there was no difference between the non-reading groups on the onset – rime tasks. The authors suggested that letter knowledge aids the development of phonemic awareness.

Johnston et al. (1996) examined the relationship between letter knowledge and phonemic awareness in a group of pre-reading five year old children. She found only one child who had phonemic awareness without having some knowledge of letter sounds. In a series of multiple regressions, letter knowledge was a better predictor of phonemic awareness than a measure of rhyme production was. These data suggest a link between letter knowledge and phonemic awareness, but are only correlational and so do not imply causality. However, these findings are supported by data from longitudinal studies. For instance, Wagner et al. (1994) conducted a longitudinal study of a group of 244 children from kindergarten to second grade, in an effort to examine the reciprocal influences of phonological processing abilities, decoding and letter knowledge. It was found that phonological processing abilities influenced later development of reading and letter-name knowledge. There was no evidence from this study that reading development influenced the development of phonological processing abilities. However, letter knowledge did have a significant longitudinal effect on phonological analysis and synthesis abilities.

Burgess & Lonigan (1998) examined the relationship between phonological awareness and letter knowledge in a group of pre-reading four and five year old children. They found evidence of reciprocal relationships between the two abilities, with phonological awareness predicting growth in letter knowledge and letter knowledge predicting growth in phonological awareness once age and general language abilities had been taken into account.

However, the evidence from intervention studies is less clear. Gibson & Levin (1975) found no conclusive evidence that teaching letter names in pre-school accelerates reading development. Ball & Blachman (1991) found that children who had had letter knowledge training alone did not improve more than controls on a phoneme segmentation task. However, these children had an average age of 5;7 years and already knew around 10 letter sounds each. It is therefore likely that these children had already begun to develop some phoneme awareness. Moreover, Murray et al. (1996) found that training letters to pre-school children did improve performance on a phonemic awareness task.

This chapter contains two studies examining the relationships between letter knowledge and phonological awareness. The first describes the longitudinal study described in chapters 2 and 3. Letter knowledge was measured at each of the three points of testing in the longitudinal study, allowing its role in the development of phonological awareness to be assessed. The second is an intervention study in which a subgroup of the children from the longitudinal study was given training in letters over the course of four weeks. The influence of this training on the development of phoneme awareness was assessed.

Study 1

Previous research has suggested that learning letters precipitates the development of explicit phoneme awareness. The current study replicates and extends this research by measuring letter knowledge, implicit and explicit phonological awareness and general language development at three points in time in a one-year longitudinal study of a group of pre-school children in the earliest stages of learning letters. This study allows us to address several questions. Does letter learning influence the development of phonological awareness? If so, is this influence limited to the development of explicit phoneme awareness? Is some level of letter knowledge necessary for the development of explicit phoneme awareness? If this is the case, is it also sufficient for the development of this knowledge, or are other skills also needed? Finally, this study also allows us to address the issue of which skills in pre-school development are likely to aid the development of letter knowledge.

Letter knowledge itself is not a unitary phenomenon. It can be separated into knowledge of letter names and knowledge of letter sounds. There is some evidence suggesting that these two types of knowledge are differently related to reading and phonological awareness. McBride-Chang (1999) found that while letter-name knowledge and letter-sound knowledge both predicted independent variation in early reading development, letter-sound knowledge was more closely related to the development of phoneme awareness. For this reason, data on both letter-name knowledge and letter-sound knowledge were collected in this study.

This section considers the role of letter knowledge in the development of early phoneme awareness in a one-year longitudinal study. Letter knowledge and rime and phoneme matching are measured at each of the three points in time and syllable and phoneme completion and phoneme deletion are measured at Time 3 only.

Method

Participants

This chapter uses the data from the one-year longitudinal study of pre-school children described in the previous chapter. 67 children were tested three times over the course of a year. At the first time of testing they had a mean age of 3;10 years, at the second point of testing 4;2 years, and at the final point of testing 4;9 years. The descriptive statistics of these children can be seen in Table 3.4 (pg. 102).

Letter Knowledge

Letter knowledge was tested at each of the three points of testing. At the final point of testing, a task aiming to tap knowledge of the alphabetic principle was also included. The child was given a card with a single lower case letter on it and asked which letter it was. If they responded with the letter's name, they were asked if they knew its sound. At times one and two, the children were given an abbreviated set of 18 letters to name. These letters were selected as the earliest letters learnt according to Stuart & Coltheart (1988). At Time 3, they were given all 26 letters to name. At each time point, testing was discontinued if the child produced 10 incorrect responses or 8 non-letter responses (such as 'eight' or 'don't know').

Language and Speech Tasks

The children were given the three language and speech tasks described in Chapter 3 (pages100): receptive vocabulary, mispronunciation detection and articulation. The receptive vocabulary task was the British Picture Vocabulary Scale (Dunn et al., 1982). In this task, children heard a word and had to pick which picture out of a set of four it corresponded to. In the mispronunciation detection task, children heard words either pronounced correctly or slightly misarticulated by a 'naughty' puppet. They had to say whether the puppet had pronounced the word correctly or not. Finally, the children completed a confrontation naming task containing complex two- and three-syllable words. Their productions were then scored for articulatory accuracy.

Phonological Matching Tasks

The children were given the phonological matching tasks described in Chapter 2 (pg. 68). These were initial and final syllable matching, rime matching and initial phoneme matching. In each case, the children were given a cue word and then had to pick which of two alternative words matched the cue word. The syllable matching tasks were not given to the children at Time 3 because of anticipated ceiling effects.

Explicit Phonological Awareness Tasks

At Time 3, the children were also given three explicit phonological awareness tasks, which are described in Chapter 2 (pg. 75). These were syllable completion, phoneme completion and initial phoneme deletion, from the Phonological Abilities Test (Muter et al., 1997). In the syllable completion task, the child had to supply the final syllable of a two-syllable word. For instance, they were shown a picture of a cabbage, and told 'ca'. They had to supply the following syllable (bidge) to complete the word. Phoneme completion was very similar. Children had to supply the final phoneme of a single syllable word. For instance, they saw a picture of a gate and heard 'gay'. They had to supply /t/ to complete the word. In initial phoneme deletion, children had to remove the initial sound from a single syllable word. For instance, they would hear the word 'bus' and have to reply 'us'.

Results

The Development of Letter Knowledge

Table 5.1 shows the mean scores for the different types of letter knowledge over time.

Table 5.1: Mean scores (with standard deviations in parentheses) of each group on the letter knowledge task over time

	Group	Total Letter knowledge	Letter-sound knowledge	Letter-name knowledge
Time 1	Group 1	5.76 (6.00)	4.05 (5.32)	2.74 (5.13)
	Group 2	1.14 (1.77)	0.96 (1.32)	0.17 (0.60)
	Total	3.76 (5.18)	2.72 (4.36)	1.63 (4.07)
Time 2	Group 1	6.79 (6.14)	4.92 (5.93)	2.95 (5.17)
	Group 2	1.55 (2.76)	1.41 (2.43)	0.17 (0.61)
	Total	4.52 (5.59)	3.40 (5.03)	1.75 (4.13)
Time 3	Group 1	18.27 (7.35)	15.05 (6.93)	5.11 (5.59)
	Group 2	14.31 (8.25)	13.45 (7.36)	0.90 (0.77)
	Total	16.53 (7.95)	14.35 (7.89)	3.26 (4.69)

The children in group 2 knew substantially fewer letters than the children in group 1, probably due both to the fact that the children from group 1 were a more middle class sample and the fact that the group 2 nursery placed much less emphasis on the learning of letters in pre-school. However, floor effects were evident for each of the letter knowledge measures at Times 1 and 2, as shown by the high standard deviations for these variables. Transformation of the variables did not alter any of the results, and so raw scores were used throughout this chapter. Both groups of children knew substantially more letter-sounds than letter-names, and their letter-sound knowledge increased dramatically from Time 2 to Time 3, during which time most of the children entered formal schooling[1]. Because of the higher levels of letter-sound knowledge, and the likely links

[1] All of the children within this sample were receiving teaching according to the National Literacy Strategy (Department for Education and Employment, 1998). This prescribes that children should learn the role of letter sounds in nursery. Within the reception year, letter sounds are taught first, though letter names are also taught during this year. Children are expected to know all of the letter sounds and names by the end of the year.

between letter-sound knowledge and phonological awareness, letter-sound knowledge will be used in future analyses.

The Relationship between Letter Knowledge and Implicit Phonological Awareness

A series of multiple simultaneous regressions were carried out to determine the relationship between letter knowledge, language and the other phonological awareness variables. Since it can be assumed that learning letters does not influence language development, regressions including letter knowledge as an independent variable in the prediction of vocabulary and letter knowledge were not calculated. The regressions from Time 1 to Time 2 are shown in Table 5.2. Age in months was entered at the first step in each analysis, then all of the other variables were entered together at the next step.

Table 5.2: Multiple regressions (including letter knowledge) predicting Time 2 outcomes from Time 1 variables.

a) Dependent Variable: syllable and rime matching (Time 2)				b) Dependent variable: Letter-sound knowledge (Time 2)			
Step	Variable	β	p	Step	Variable	β	p
1	Age	.232	ns	1	Age	.236	ns
2	Vocabulary (t1)	.135	ns	2	Vocabulary (t1)	.016	ns
	Syllable/rime (t1)	.594	<0.01		Syllable/rime (t1)	.067	ns
	Letter-sound knowledge (t1)	.195	ns		Letter-sound knowledge (t1)	.903	<0.01

c) Dependent Variable: initial sound matching (Time 2)				d) Dependent Variable: Articulation (Time 2)			
Step	Variable	β	p	Step	Variable	β	p
1	Age	.014	ns	1	Age	.127	ns
2	Vocabulary (t1)	.031	ns	2	Vocabulary (t1)	.216	ns
	Syllable/rime (t1)	.374	<0.01		Syllable/rime (t1)	.045	ns
	Letter-sound knowledge (t1)	.417	<0.01		Letter-sound knowledge (t1)	.286	<0.05

The pattern of predictions across these regression equations differs somewhat from the patterns shown in Chapter 3, when letter knowledge was not included in the regressions. Syllable and rime matching ability at Time 1 was a significant unique predictor of syllable and rime matching ability at Time 2. Both syllable and rime matching and letter knowledge at Time 1 had significant independent influences on the development of initial sound matching at Time 2. Letter knowledge at Time 1 was also the only significant unique predictor of letter knowledge at Time 2. It also had a significant influence on articulation accuracy at Time 2.

Next a series of regressions predicting Time 3 outcomes from the Time 2 variables were carried out. As in the regressions calculating Time 2 outcomes from Time 1 independent variables, age was entered at the first step and all of the other variables were entered together at the second step. As before, regressions predicting vocabulary and mispronunciation detection ability were not calculated. The regressions are shown in Table 5.3.

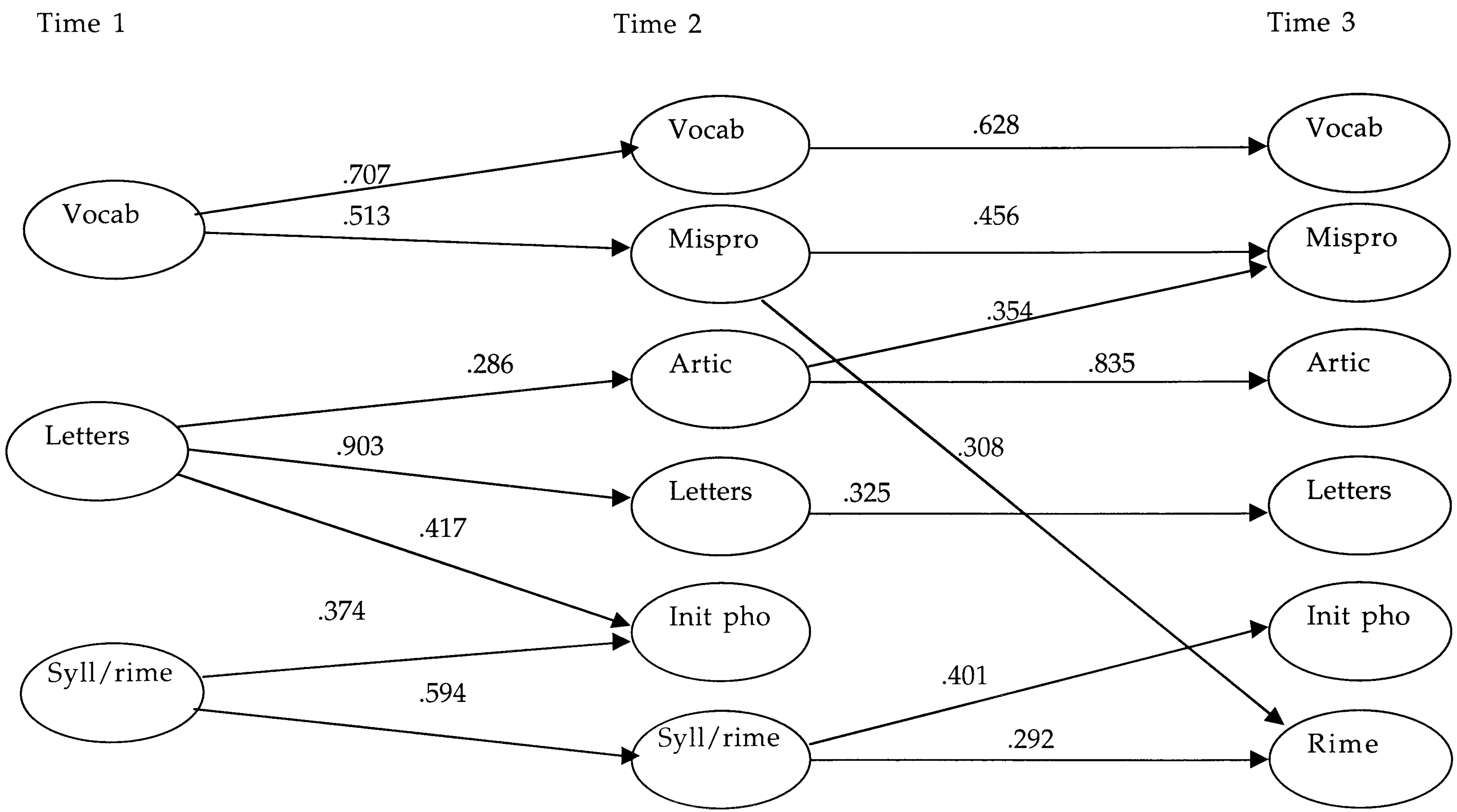
Table 5.3: Multiple regressions predicting Time 3 outcomes using Time 2 variables.

a) Dependent Variable: Rime Matching (Time 3)				b) Dependent Variable: Initial Sound Matching (Time 3)			
Step	Variable	β	p	Step	Variable	β	p
1	Age	.245	ns	1	Age	.250	0.068
2	Vocabulary (t2)	.062	ns	2	Vocabulary (t2)	.242	ns
	Syllable/rime (t2)	.292	<0.05		Syllable/rime (t2)	.401	<0.01
	Letter-sound knowledge (t2)	.037	ns		Letter-sound knowledge (t2)	.011	ns
	Initial sound matching (t2)	.174	ns		Initial sound matching (t2)	-.023	ns
	Articulation (t2)	-.107	ns		Articulation (t2)	.054	ns
	Mispro. detection (t2)	.308	<0.05		Mispro. detection (t2)	.126	ns

c) Dependent variable: Letter-sound Knowledge (Time 3)				d) Dependent Variable: Articulation (Time 3)			
Step	Variable	β	p	Step	Variable	β	p
1	Age	.517	<0.001	1	Age	.032	ns
2	Vocabulary (t2)	.159	ns	2	Vocabulary (t2)	-.079	ns
	Syllable/rime (t2)	.179	ns		Syllable/rime (t2)	.066	ns
	Letter-sound knowledge (t2)	.325	<0.05		Letter-sound knowledge (t2)	-.070	ns
	Initial sound matching (t2)	-.036	ns		Initial sound matching (t2)	.114	ns
	Articulation (t2)	.042	ns		Articulation (t2)	.835	<0.001
	Mispro. detection (t2)	-.092	ns		Mispro. detection (t2)	.018	ns

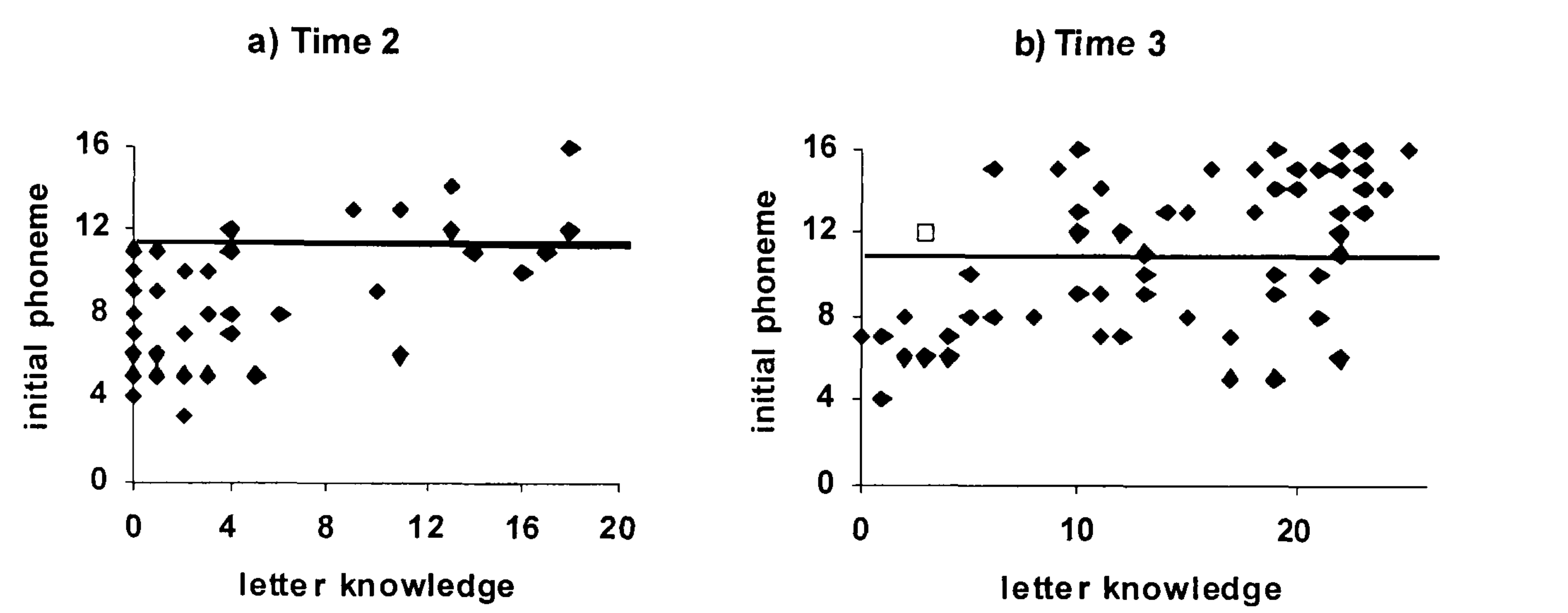
The regressions from Time 2 to Time 3 present a slightly different picture from the ones from Time 1 to Time 2. Both syllable and rime matching ability and mispronunciation detection at Time 2 predict rime matching ability at Time 3. However, only syllable and rime matching ability at Time 2 predicts initial phoneme matching ability at Time 3. In contrast to the first set of regressions, letter knowledge does not predict significant unique variance in the growth of articulation or initial phoneme matching ability. From Time 2 to Time 3, letter knowledge does not predict growth in any other skills. This may be because the large increase in letter knowledge shown by most of the children between times 2 and 3 masked potential individual differences between them. These regressions are shown in a path analysis in Figure 5.1.

Figure 5.1: Path analysis showing the relationships between phonological awareness, language and letter knowledge over time.



It was hypothesised that letter knowledge is a necessary precursor to the development of phoneme awareness. In order to examine this, a series of scatter graphs were plotted. Firstly, letter-sound knowledge was compared to initial phoneme matching ability concurrently at times 2 and 3. The relationship between letter knowledge and initial phoneme matching is shown in Figure 5.2.

Figure 5.2: Scatter diagrams showing the relationship between letter knowledge and initial phoneme matching at Times 2 and 3



(NB: the bold lines represent the level above which children are significantly above chance)

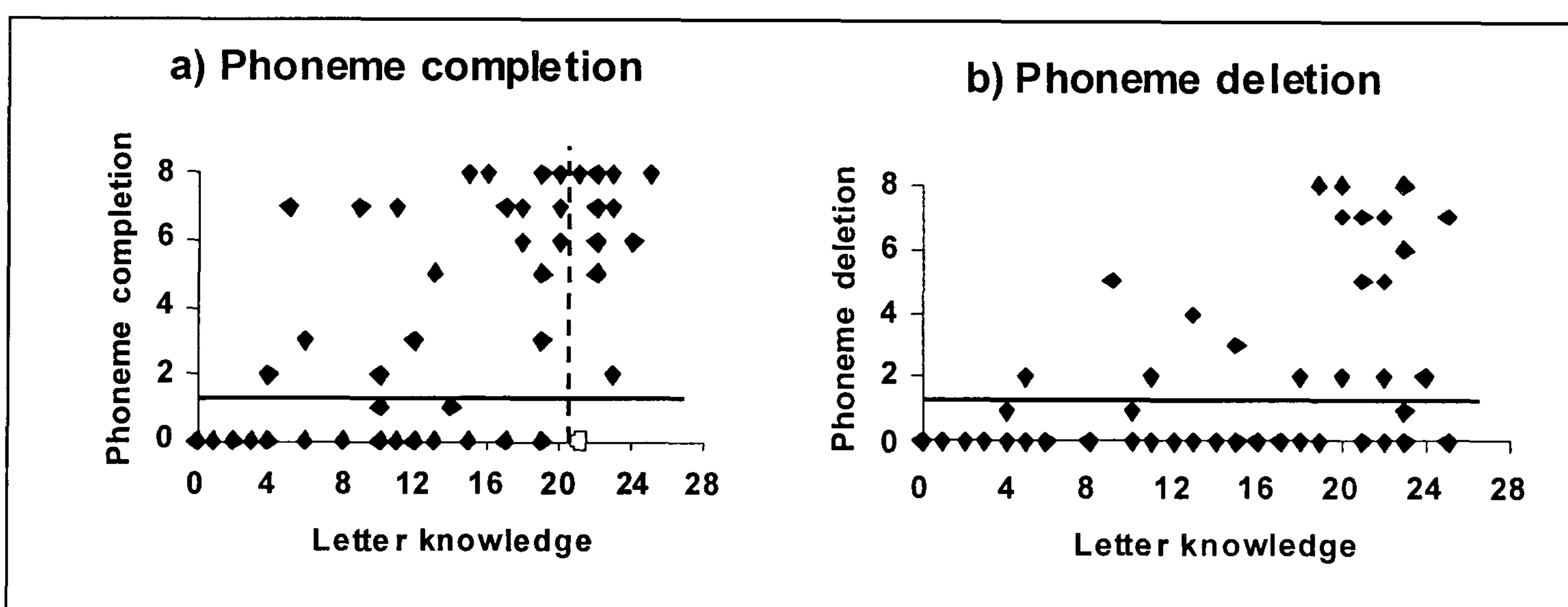
All of the children who were above chance (score >11) on the initial phoneme matching task at Time 2 or 3 knew at least one letter. Three of the eleven children at Time 2 who were above chance on the initial phoneme matching task knew fewer than four letter sounds. At this point in testing, 71% of the sample knew fewer than four letter sounds. At Time 3, all but one of the 34 children who were above chance on the initial phoneme matching measure knew at least four letters, and this child knew 3 letters.

However, it is possible that the relationship between letter knowledge and phoneme awareness is an artefact of general verbal development. To examine this, one-way ANOVAs for Time 2 and 3 were carried out comparing the letter knowledge of children who were and were not above chance on the initial phoneme matching measure. Both age and vocabulary were entered as co-variates. There remained a significant difference in letter knowledge between the two groups both at Time 2 ($F(1,63)=13.70$, $p<0.01$)and at Time 3 ($F(1,63)=13.18$, $p<0.01$). Performance on the initial phoneme matching task is significantly related to letter knowledge even when general verbal ability has been accounted for. In fact, these data suggest that letter knowledge is necessary for successful completion of the initial phoneme matching task.

The Relationship between Letter Knowledge and Phoneme Completion and Deletion

Scatter diagrams were then carried out to investigate whether letter knowledge was also crucial for the successful completion of the phoneme completion and phoneme deletion tasks at Time 3. The scatter diagram showing the relationship between phoneme completion and letter knowledge is shown in Figure 5.3.

Figure 5.3: Scatter diagrams showing the relationship between letter knowledge and phoneme completion and deletion at Time 3.



No child scored two or more correct on either the phoneme completion task or the phoneme deletion task unless they knew at least four letter sounds. It seems that knowing at least a few letter sounds is vital to the development of phoneme awareness. However, it is by no means the case that knowing a certain number of letters automatically confers phoneme awareness on children. In the graphs depicting the relationship between initial phoneme matching, phoneme deletion and letter knowledge, there are subgroups of children with good letter knowledge and poor phoneme awareness. The exception to this pattern is the phoneme completion task. The dashed line on Figure 5.3a separates the group of children who scored in the top third of the sample on the letter knowledge task. Only one of these 22 children scored zero on the phoneme completion task. All of the other children scored at least two correct. There appears to be a very close relationship between phoneme completion and letter knowledge. This task is the only one that only requires children to be able to isolate phonemes. The other two tasks require additional skills: the ability to match phonemes or the ability to manipulate phonemes, respectively. Perhaps learning letters teaches children how to isolate phonemes, while additional skills are required for successful completion of the phoneme matching and deletion tasks.

A series of regression analyses were carried out to examine which variables at Time 2 predicted success on the phoneme completion and deletion tasks in turn, beginning with the phoneme completion task. Initially, a simultaneous multiple regression was carried out, but none of the variables predicted unique variance within this model. Because it was likely that some of the variables shared common variance, a series of hierarchical regressions were carried out. All of the variables were significant at the second step (after age) apart from vocabulary knowledge and initial sound matching. Since it was hypothesised that letter knowledge and implicit phonological awareness would both be related to the development of explicit phoneme awareness ability even after accounting for general language development, age and vocabulary were entered on the first step. Letter knowledge and syllable and rime matching were then entered on steps two and three. The multiple regressions are shown in Table 5.4.

Table 5.4: Hierarchical multiple regressions predicting phoneme completion and phoneme deletion at Time 3 using Time 2 variables

Dependent Variable	Phoneme Completion			Phoneme Deletion		
Variable	β	% R^2 change	p	β	%R^2 change	p
1. Age 1. Vocabulary	.187 .170	7.6	ns ns	.312 .094	11.8	<0.05 ns
2. Syllable/rime matching 3. Letter-sound knowledge	.382 .186	11.0 2.7	<0.01 ns	.437 .340	14.4 9.0	<0.01 <0.01
2. Letter-sound knowledge 3. Syllable/rime matching	.277 .323	6.6 7.1	<0.05 <0.01	.432 .328	15.9 7.4	<0.01 <0.01

Both syllable and rime matching and letter knowledge accounted for additional variance in phoneme completion when entered at the second step. However, only syllable and rime matching predicted significant unique variance when entered on the final step. Further analyses showed that if syllable and rime matching and letter knowledge were entered on the first step, none of the language measures accounted for any further significant variance. These results are slightly different from the results of the scatter diagrams plotting the concurrent relationships. These suggested that letter knowledge was closely related to phoneme completion. In the longitudinal models, letter knowledge predicted unique variance in phoneme deletion but not in phoneme completion, where its effect was mediated by syllable and rime matching. Both letter knowledge and syllable and rime awareness were found to be significant independent predictors of later phoneme deletion ability. None of the language measures accounted for any significant further variance once entered after syllable and rime awareness and letter knowledge had been controlled.

Discussion

This study examined the role of letter knowledge in the development of phonological awareness within a longitudinal context. Some knowledge of letters was necessary for success on each of the phoneme awareness tasks, though in several cases children were successful while knowing only a few letters. Moreover, letter knowledge was not sufficient for the development of phoneme awareness.

Examination of the scatter diagrams for the concurrent relationship between letter knowledge and phoneme awareness revealed a clear picture. It was found that knowing at least one letter was crucial to the development of explicit phoneme awareness. No child who knew no letters at all was successful on any of the explicit phoneme awareness tasks. However, it was not the case that knowledge of several letters was vital to the development of explicit phoneme awareness. Many of the children who completed these tasks successfully knew around four or five letters, though it should be remembered that the letter knowledge task used here measured recall of letters, which is likely to be more difficult for young children than letter recognition. It is possible that many of these children knew several more letters, but were unable to retrieve their sounds at the time of testing.

In the case of phoneme completion, only one child who knew more than twenty letters was unable to complete the task. The task was the only one that required children only to be able to isolate phonemes – they did not have to manipulate them in any way. It may be, therefore, that the development of phoneme isolation ability is the skill involved in each of these tasks that is most closely related to letter knowledge. Initial phoneme matching and phoneme deletion are both tasks that require the isolation of single phonemes, but in both cases further operations are required after the phoneme has been isolated – either matching to another phoneme or deletion of this phoneme from the word in question.

Letter-sound knowledge was included in the path analyses described in Chapter 3. Letter knowledge at Time 1 was related to articulatory accuracy and initial sound matching at Time 2. The relationship between initial sound matching and letter knowledge was predicted, but the relationship between letter knowledge and articulatory accuracy was more unexpected. It may be that, at this early stage, letter knowledge is an index of how quickly children learn to reproduce new words and phonological sequences. Letter knowledge is not a significant predictor of any other variable from Time 2 to Time 3. This may be because of the fact that most of the children began formal schooling between times 2 and 3 and therefore made large leaps in their letter knowledge between these two points of testing. Tuition in letter knowledge may have swamped the individual differences that were present.

Hierarchical multiple regressions were carried out using syllable and rime matching ability and letter-sound knowledge to predict the development of phoneme completion and phoneme deletion ability. It was found that once vocabulary had been controlled, only syllable and rime awareness accounted for further unique variance in the development of phoneme completion. In contrast, both letter-sound knowledge and syllable and rime matching accounted for significant independent variance in the development of phoneme deletion ability.

Given the close relationship between letter knowledge and phoneme completion in the scatter diagram shown in Figure 5.3a, it is surprising that letter knowledge at Time 2 does not predict phoneme completion ability at Time 3. However, the distributions of each of the variables involved may provide an explanation for this finding. Letter knowledge at Time 2 still showed a significant floor effect, while phoneme completion at Time 3 showed a bimodal pattern of distribution (illustrated in Figure 2.1, pg. 78). It is likely that many of the children who knew more than a few letters at Time 2 scored close to ceiling on the phoneme completion task at Time 3. These difficulties with the distributions of the scores may mask the relationship between the variables.

Syllable and rime matching ability at Time 2 accounted for significant variance in all three of the phoneme awareness tasks at Time 3. There are several possible explanations for this relationship, and these explanations are not mutually exclusive. It may well be that children who show early sensitivity to sound similarity will also learn how to segment word sounds early. In addition, many of the task demands in the syllable and rime matching tasks and the initial phoneme matching task are similar. Both require children to hold two or three words in working memory and compare sounds across them. This skill may also be a precursor to the mental manipulation of word sounds required in the phoneme deletion task.

In conclusion, letter knowledge appears to be an important precursor for the development of explicit phoneme awareness, in that this awareness does not develop in children who know no letters at all. However, letter knowledge is not in general a sufficient skill for the development of phoneme awareness. Several children knew many letters and were still unable to complete the phoneme awareness tasks. A possible exception to this pattern comes from the phoneme completion task. All but one of the children who knew more than twenty letters were able to complete this task successfully. This may be because this is the task that requires the least manipulation of phonemes. The children do not have to delete phonemes or match them across words, but merely to isolate them.

This study has suggested that both letter knowledge and implicit phonological awareness play a role in the development of explicit phoneme awareness. However, the study is limited in two respects. Firstly, concurrent and longitudinal data were used to determine the relationship between letter knowledge and the explicit phoneme awareness tasks. It is therefore not possible to make inferences about the causal relationships between the variables. Secondly, many of the children made big jumps in letter knowledge between times 2 and 3; most of them started formal schooling within that period, and letters are taught intensively during the first year of schooling in Britain. An intervention study in which children were given training in letter knowledge and their phonological awareness was monitored would allow us to look more closely at the relationship between letter knowledge and phoneme awareness.

Study 2

This study extends the findings from study 1 using an intervention paradigm. Study 1 suggested that letter knowledge is closely related to the development of phoneme awareness, and that letter knowledge influences phoneme awareness more than phoneme awareness influences letter knowledge. In the present study, a group of pre-school children were taught letters and the development of their phoneme awareness during and following training was monitored.

As described in Chapter 2, phoneme matching tasks require children to have an understanding of both phoneme identity and phoneme invariance. However, one might expect that training in letter knowledge would increase children's ability to isolate and identify phonemes, but not necessarily their ability to compare or manipulate phonemes. This would explain the finding in study 1 that all but one of the children who knew at least 20 letters were also successful on the phoneme completion task, which requires only phoneme isolation. In order to investigate this hypothesis, the individual performance of the children on the phoneme completion and deletion tasks described in Chapter 2 (and study 1, this chapter) was examined with respect to the number of letters each child had learnt. The phoneme completion task requires children to isolate single phonemes, while the phoneme deletion task requires them also to manipulate phonemes.

A subgroup of children from the longitudinal sample was given daily letter knowledge training for a period of four weeks between Time 2 and Time 3 of testing. The children were also tested before and after the intervention for letter knowledge, rime and phoneme matching ability. At Time 3, two months after the end of training, they were compared to a no-intervention control group, also taken from the longitudinal sample. It was hypothesised that the letter knowledge training would improve their awareness of single phonemes. Phoneme awareness was measured by an initial phoneme matching task and by a phoneme completion and deletion task. It was expected that performance on each of these tasks would be improved by the training, but that the effect on the phoneme completion task would be largest. Since it was hypothesised that letter knowledge would improve phoneme awareness but not global sound sensitivity, no significant improvements were expected on a rime awareness task in which the targets and foils were not equated for global phonological similarity.

Method

Participants

The children who took part in this study were selected from a larger longitudinal study examining the development of phonological awareness in pre-school children. Ten children with a mean age of 4;3 years participated in the study, 2 males and 8 females. These children, with two exceptions, were in their final term of nursery before beginning formal schooling. The youngest two children were to begin school the term after that. One further child took part in training, but was removed from the sample as she had severe speech difficulties.

Matched Controls

The trained children in the experimental group were compared to a set of ten controls, who were matched on the basis of their letter knowledge and age at Time 2 in the longitudinal study, when the children had a mean age of 3;8 years. They were also matched as far as possible on vocabulary level at Time 2 and the term in which they entered formal schooling.

Pre- and Post-Testing

The children in the experimental group were given a set of tests immediately before and after training. These consisted of letter knowledge, as measured by the letter knowledge sub-test of the Phonological Abilities Test (Muter et al., 1997), and two phonological awareness tasks. The first was a rime matching task, where children had to pick out the word that rhymed with a cue word from two alternatives (e.g. cue word pill, alternatives duck and hill). The words used for this task were taken from the rhyme oddity test used by MacLean et al. (1987). The second phonological awareness task was an initial phoneme matching task with global similarity of the incorrect foils matched to the target word (e.g. cue word pig, alternatives beak and pool). This task was taken from Byrne & Fielding-Barnsley (1993). Both of the tasks used picture cues for each of the words, and consisted of two practice trials with feedback, and ten test trials with no feedback.

Training

The children in the experimental group were given 20 minutes of training in groups of three or four, five days a week for 18 sessions in total. During this time 8 letters were taught; s, m, k, t, p, r, a, and o. The children were introduced to each letter in the following manner: First, they were read the 'Letterland' storybook that corresponded to each letter. The Letterland series of books all feature letter shaped characters. For instance, 's' is represented by Sammy the snake. The letter's shape and distinctive features would be talked about. The children would then spend the rest of that session and the next session drawing that letter, colouring in pictures of that letter, finding that letter in a variety of contexts and finding pictures of things that began with that letter sound. The training therefore concentrated on linking the letter shape with the letter sound, though there was a little work on finding words that began with the corresponding sound. At the mid point and the end point of training, the children had a 'game day', where they played games involving the letters they learnt. These games were variations of twister and snap.

Follow-up Testing

The children in the experimental and control groups were then seen for the Time 3 testing in the longitudinal study. This was around 7 weeks after the end of training for the experimental group. Both groups of children were given the full battery of tasks from the longitudinal study, as described in experiment 1. However, this study concentrates on a subset of these tasks. These are: Receptive Vocabulary, as measured by the British Picture Vocabulary Scale (described in Chapter 3, pg. 100); rime and initial phoneme matching (described in Chapter 2, pg. 71); letter knowledge (described in this chapter, study 1, pg. 143); and the phoneme completion and deletion sub-tests from the Phonological Abilities Test (described in Chapter 2, pg. 75).

Results

Pre- and Post-Testing

First, the pre- and post-test scores were compared to determine whether the children in the experimental group had learnt a significant number of letter sounds during training. The results are shown in Table 5.5. The difference between pre- and post-test letter knowledge scores approached significance, with a probability of 0.06. However, there was not a significant difference between pre- and post-test scores on either of the phonological awareness measures.

Table 5.5: Mean pre- and post-test scores on letter knowledge, rime matching and initial sound matching (standard deviations in parentheses).

Variable	Pre- Test	Post-Test	ANOVA
Letter Knowledge	2.6 (4.72)	4.2 (4.61)	$F(1,9)= 4.397, p=0.06$
Rime Matching	7.2 (2.44)	7.9 (2.23)	$F(1,9)= 1.83$, p= ns
Initial Phoneme Matching	5.2 (1.75)	5.1 (1.29)	$F(1,9)<1$

Correlations between performance on the pre- and post-test tasks are shown in Table 5.6.

Table 5.6: Correlations between letter knowledge, rime and initial phoneme matching pre- and post-test scores.

	LK pre-	LK post-	Rime pre-	Rime post-	Initial pre-
LK post-	**.867**				
Rime pre-	.529	.470			
Rime post-	.439	.466	**.758**		
Initial pre-	**.710**	.572	.224	-.108	
Initial post-	.392	**.614**	.559	.468	.385

(correlations in bold are significant at p<0.05)

The pre- and post-test scores for letter knowledge and for the rime tasks inter-correlated significantly. However, the pre- and post-test scores for the initial phoneme matching task were not closely correlated, probably due to the fact that none of the children scored significantly above chance on the pre-test initial phoneme matching measure. The post-test initial phoneme matching measure correlated significantly with the post-test letter knowledge measure, suggesting perhaps that knowledge of individual phonemes is related to letter knowledge.

Time 3 Follow-up Testing

The children were re-tested two months after the end of training, to ascertain whether the letter knowledge training had significantly improved their phoneme awareness. The children who had undergone letter training were compared to the control group (taken from the group 1 longitudinal sample) matched in age and number of letters known at Time 2 of testing. The children were also matched as closely as possible on vocabulary level at Time 2 of testing. The children's scores at Time 2 are shown in Table 5.7.

Table 5.7: Mean scores of the experimental and control groups on the vocabulary, letter knowledge, rime and initial phoneme matching tasks at Time 2 (standard deviations in parentheses).

	Group 1 (control)	Group 2 (experimental)	ANOVA
Age	46.4 (2.17)	45.6 (1.26)	F(1,19) <1
Letter knowledge	1.1 (1.91)	0.70 (1.34)	F(1,20) <1
BPVS (raw score)	35.3 (8.46)	29.50 (7.76)	F(1,20)=2.551, ns
Rime	8.40 (3.50)	9.60 (3.72)	F(1,19) <1
Initial phoneme matching	8.00 (2.05)	7.40 (1.51)	F(1,19) <1

The children's scores were compared on the rime, initial phoneme matching and explicit phoneme awareness tasks at Time 3. These are shown in Table 5.8.

Table 5.8: Mean scores of the experimental and the control groups on the vocabulary, letter knowledge and phonological awareness tasks at Time 3 (standard deviations in parentheses).

	Group 1 (control)	Group 2 (experimental)	ANOVA
BPVS (raw score)	47.9 (7.58)	36.80 (7.48)	$F(1,20) = 10.87$, $p<0.01$
Letter knowledge	10.45 (7.57)	7.36 (5.43)	$F(1,20) = 1.48$, ns
Rime	11.1 (3.14)	10.4 (3.53)	$F(1,19) <1$
Initial phoneme matching	9.90 (4.07)	8.70 (3.09)	$F(1,20) <1$
Phoneme completion	2.09 (2.95)	3.18 (3.37)	$F(1,20) <1$
Phoneme deletion	0.36 (0.93)	0.55 (1.51)	$F(1,20) <1$

As can be seen, there were no significant differences between the two groups on letter knowledge or on the phonological variables. However, at Time 3 there was a significant difference between the groups in vocabulary that had not been present at Time 2, and this difference was in favour of the control group. As vocabulary was known to correlate with rime, initial phoneme matching and letter knowledge, a series of ANCOVAs was performed entering vocabulary level at Time 3 as a co-variate, but still no significant differences were found between the groups.

Thus, it appears that the children who were given training in letter knowledge did not show increased phonological awareness compared to a group of control children. However, these null results should be interpreted cautiously as the numbers involved were quite small and the two groups came from separate nurseries which differed somewhat in their ethos and in the amount of letter training incorporated into everyday nursery activities.

Notwithstanding these limitations, the study provided an opportunity to examine the early development of letter knowledge and the emergence of phoneme awareness. The letter knowledge of the experimental group was measured at Time 2, immediately prior to training, immediately after training, and at Time 3. There was also an informal measure taken of the children's understanding of letters at the middle and final training session. Rime and phoneme awareness were also measured immediately before and after training. This range of measures allows us to look closely at whether phonological awareness predicts responsiveness to letter training or whether ability to learn letters predicts how quickly phonological awareness will develop. Performance of the individual children on each of these tasks is shown in Table 5.9.

Table 5.9: Individual performances of the children during and following letter training in letter knowledge and phonological skills

	Pre-test	Intervention		Outcome (Time 3)		
Name	Rime pre-test (√= above chance)	No. Letters learnt (√=>2)	Letters known post-test (√= > 3, √√=>8)	Phoneme Completion (√=>2)	Phoneme deletion (√=>2)	Initial sound matching (√= above chance)
DD2	√	√	√√	√	√	√
EW2	√	X	√√	√	X	√
SP2	√	X	√	√	X	X
RM2	√	√	X	√	X	X
ZD2	X	√	√	√	X	X
OC2	X	√	√	√	X	X
LJ2	√	X	X	X	X	X
RN2	X	X	X	X	X	X
KF2	X	X	X	X	X	X
LC2	X	X	X	X	X	X

Table 5.9 shows that those children who were successful on the phoneme completion task at the follow-up testing point were those children who learned at least two letters during training or who had a solid base of three or more letters known at post-testing. However, whether or not these children showed an awareness of rime seems less important. The two children who were above chance on the initial sound matching task at follow-up testing both showed an understanding of rime at pre-test and a solid base of more than eight known letters at post-testing. One of these two children was also above chance on the phoneme deletion task. It seems likely that successful completion of these tasks requires both an ability to recognise similar sounds across words and an understanding of the role of letter sounds.

While learning letters does appear to help in the development of explicit phoneme awareness, it also seems likely that some global sound sensitivity helps children to learn letter sounds. Of the six children who showed explicit phoneme awareness at follow up, four of them showed rime awareness at pre-test. Only one child showed rime awareness at pre-test and did not go on to develop explicit phoneme awareness, and this child showed some difficulties in remembering letters.

Discussion

Unfortunately, the predictions of this study were not substantiated by the statistical analyses. There was not a significant increase in letter knowledge after training, though the value did approach significance. In addition, the children did not show improved phonological skills immediately after training. The group also did not learn significantly more letters than a matched control group, though uncontrolled differences in the socio-economic status of the two groups of children may have contributed to the failure to demonstrate group differences. This was illustrated by the fact that the control group children had significantly higher levels of vocabulary knowledge than the experimental group children did at Time 3.

Nonetheless, scrutiny of data from individual children suggests that the learning of letters may be related to the development of phoneme awareness. Performance on the rime pre-test task and the number of letters known at post-test were both significantly related to the initial phoneme matching post-test score. Thus, both of these skills seem to be important for the development of phoneme awareness. This idea is further substantiated by the fact that the only children who went on to score above chance on the initial phoneme matching task at follow-up testing were those children who were significantly above chance on the rime pre-test and knew eight or more letters immediately after letter training.

Performance on the phoneme completion measure was not closely related to earlier rime awareness. The children who succeeded at this task at follow-up were those children who had either learnt at least two letters during training or who knew at least three letters immediately following letter training. This task is more closely related to letter knowledge than to performance on the other phonological tasks.

In summary, the study was not successful in increasing letter knowledge in the group of children tested, and therefore the effects of training in letter knowledge could not be assessed. In addition, there were no significant differences in letter knowledge or phonological awareness between the groups, even when differences in language ability between the groups were controlled. However, the training did allow an investigation of the development of phoneme awareness in the earliest stages of letter learning. This showed that letter knowledge was important in the development of phoneme completion skill, and that both letter knowledge and global sound sensitivity were important in the development of initial phoneme matching ability.

General Discussion

The influence of letter knowledge on the development of phoneme awareness was investigated in two studies: a longitudinal study and a letter training intervention study. In both cases, letter knowledge was related to the development of phoneme awareness. Both studies also suggested that letter knowledge was the main predictor of performance on the phoneme completion task, while letter knowledge and global sound sensitivity were important in the development of the ability to match initial phonemes and for phoneme deletion.

There was a range of evidence suggesting that letter knowledge is crucial to the development of phoneme completion ability. In the longitudinal study, no child was able to complete this task unless they knew at least three letters. In addition, only one of the twenty-two children who knew more than 20 letters was unsuccessful on this task. In the intervention study, all of the children who learnt more than two letters during training, or who showed a post-test knowledge of more than three letters, were able to complete the phoneme completion task successfully two months later. It appears that phoneme completion ability is an almost automatic consequence of learning letters. This task required children to isolate and reproduce the final phoneme of a single syllable word, and therefore it seems reasonable to conclude that letter knowledge is important in the development of phoneme isolation ability.

It is likely that learning letters helps children to begin to isolate phonemes in two ways. Firstly, it teaches children a series of individual sounds, and links them with visual symbols. These are likely to aid children as they search for sounds within words. If they already know several individual sounds, they can mentally search through a word to see if they can equate the sounds they hear with any letter sounds that they already know. However, letter learning is also likely to help children isolate sounds in a more fundamental way than this. In several cases, children were able to isolate sounds in the phoneme completion task even when they did not know the letters that these sounds corresponded to in the letter knowledge task. It is probably true that learning letters and learning how letter sounds fit into words encourages children to consider word sounds explicitly, and this in itself has a role in teaching children to segment words into phonemes.

However, the ability to isolate phonemes within words does not constitute full phoneme awareness. As Byrne & Fielding-Barnsley (1989) suggested, children must also realise that sounds within different words can be different instances of the same phoneme. This skill was required for successful completion of the initial phoneme matching task. As with the phoneme completion task, it was true that no child was successful on this task without knowing at least three letters. However, several children who did know many letters were still unsuccessful on this task. It appears therefore that this skill does not arise from letter learning alone. In the regressions carried out on data from the longitudinal study, both letter knowledge and global sound sensitivity (as measured by rime and syllable matching tasks) predicted unique variance in the development of phoneme matching ability. Moreover, in the intervention study, only those children who had learnt several letters and were successful on the rime matching task went on to be successful on the initial phoneme matching task at Time 3 follow-up testing.

Both letter knowledge and global sound sensitivity also seemed to be necessary precursors to the development of phoneme deletion ability. No child who knew no letters at all was successful on this task. As with the initial phoneme matching task, both letter knowledge and syllable and rime matching were significant independent predictors of this ability in the longitudinal study. It was also true that the only child in the intervention study who was successful on this task at Time 3 had a good knowledge of global sound sensitivity prior to letter knowledge training and had learnt letters quickly during training. Phoneme deletion requires children to isolate single phonemes and to mentally manipulate them. This skill also seems to develop out of a combination of letter knowledge and global sound sensitivity.

Both letter knowledge and global sound sensitivity are therefore important precursors to the development of explicit phoneme awareness. As Gombert (1992) suggested, letter knowledge is a catalyst to the move from epilinguistic awareness to metalinguistic awareness. More specifically, once children have become sensitive to similarities between word sounds, learning letters seems to teach them how to isolate individual phonemes within words.

6. The Development of Language Skills and Phonological Awareness in Children At Risk of Reading Difficulties

Introduction

Previous chapters have suggested that language skills are related to the development of phonological awareness. Vocabulary level and phonological awareness are well correlated, but vocabulary is not a good longitudinal predictor of phonological awareness. In contrast, measures of speech production and perception such as mispronunciation detection and articulation do predict the development of phonological awareness over time. This is suggested to be because the development of phonological awareness and vocabulary are highly dependent on the detail and accuracy of phonological representations. This chapter investigates these relationships further by considering the problem from two further angles. If we can find children who are likely to develop difficulties in phonological awareness in the school years, we could determine whether these children show deficits in speech processing skills in the pre-school years. Conversely, children who have speech difficulties in the pre-school years should show resultant difficulties with phonological awareness tasks.

This chapter therefore compares the early phonological awareness and language skills of three groups of children. Children with a family history of dyslexia are compared to children with pre-school speech difficulties and to normally developing controls. There is strong evidence of a substantial genetic component in the development of dyslexia (e.g. Fisher, Stein, & Monaco, 1999). It is likely therefore that around half of our sample of children will go on to have significant difficulties in reading and phonological awareness in the school years.

Several researchers have found that children with a family history of dyslexia show language deficits in the pre-school years. For instance, Scarborough (1990) found that children who went on to become dyslexic showed less good articulation at two years old. They also showed lower vocabulary levels at 3;6 years, but not at 2;6 years. It is suggested that these vocabulary deficits are therefore a consequence of earlier phonological difficulties. Locke (1997) compared a group of children with family history of dyslexia with a group of normally developing controls between the ages of birth and 5 years. He also found that the potential dyslexics had poorer articulation at around eighteen months and that they scored lower than controls on an auditory discrimination task in which the children had to say whether two spoken words (such as 'dog' and 'door') were the same or different. Elbro et al. (1998) found that a variable that differentiated future dyslexics from normal controls effectively in kindergarten was articulatory accuracy. In contrast to the findings of Locke (1997) they found that performance on an auditory discrimination task did not differ between the two groups. Gallagher et al. (2000) also found that children who went on to showed poor reading in the school years showed lower vocabulary, word and nonword repetition and letter knowledge at 3;9 years, though the groups did not differ on the Edinburgh Articulation Test.

Previous research looking at pre-school children with a family history of dyslexia who go on to be dyslexic therefore suggests that these children do show subtle deficits in language development in the pre-school years. The children show early difficulties in articulation in infancy (as shown by Locke (1997) and Scarborough (1990)). They may also show difficulties in the articulation of long or complex words later in development (as shown by Elbro et al, 1998). The evidence concerning spoken word identification is less clear, as no previous studies have investigated mispronunciation detection in children with a family history of dyslexia.

However, Locke (1997) found that these children do show less accurate discrimination of spoken words than normal children do. Children with a family history of dyslexia also show vocabulary deficits, though these are more time-limited. Scarborough found that they had normal vocabulary levels at two years old, but that they had dropped behind by the time they reached 3;6 years. However, vocabulary levels seem to improve again: most school aged dyslexic children have normal vocabularies (e.g. Aguiar & Brady, 1991), though this may be a function of diagnostic criteria, as dyslexia is often defined as a significant discrepancy between reading age and verbal mental age.

There is also some evidence that children with pre-school speech difficulties may go on to have difficulties in reading and phonological awareness in the school years. Bird et al. (1995) looked at the reading and phonological awareness development of a group of phonologically impaired pre-school children. They found that these children showed deficits in reading, spelling and phonological awareness. When compared to reading age matched controls, these children still showed significantly lower nonword reading and spelling scores, suggesting that their difficulties were due to difficulties in phonological re-coding skills. The authors suggest that this may be because they still represent words as undifferentiated global wholes, rather than as a series of segmented phonemes.

Stackhouse et al. (submitted) examined the phonological processing skills of children with specific speech difficulties. They found that these children had difficulties with phonological awareness, letter knowledge and nonword repetition. These children showed low levels of articulatory accuracy, but close to normal performance on word and nonword phonological discrimination tasks. This contrasted with a group of children with speech and language difficulties, who had difficulties on all of the phonological processing tasks. They concluded that children with specific speech difficulties have phonological processing difficulties that are more evident in phonological output tasks, while children with speech and language difficulties had difficulties in phonological input and output tasks.

Previous research therefore suggests that pre-school children with a family history of dyslexia and children with pre-school speech difficulties may show similar patterns of impairments on phonological awareness, speech and language tasks. However, no study has previously compared these two groups of children directly. It may be that these two patterns of impairment are more closely linked than was previously anticipated. Separate studies of each of the two groups of children suggest that both groups should show deficits in nonword repetition, phonological awareness tasks and letter knowledge. In addition, both should show impairments in articulation, though these will be more marked in children selected for their speech difficulties. Since previous chapters have suggested that articulation and mispronunciation detection both provide indices of the quality of phonological representations, it is also predicted that both of these groups of children will show commensurate low scores on the mispronunciation detection task. The children at familial risk of dyslexia may also show lower vocabulary levels in the pre-school years.

Each of the children was assessed on reading, letter knowledge and nonword repetition. Since the children with family history of dyslexia and speech difficulties were at risk of reading difficulties, it might be expected that these two groups would show lower reading scores even at this early stage of development. Since letter knowledge is one of the major precursors of reading development, it might be expected that this task would also be sensitive to the early difficulties in learning to read.

Finally, nonword repetition was included because it has been considered to be a task that consistently differentiates both dyslexic and speech impaired children from normally developing controls. They were also given the phonological awareness and language tasks included in the longitudinal study described in previous chapters.

Method

Participants

12 children with a parent or sibling with diagnosed dyslexia were individually matched to 12 children with speech difficulties and 12 normally developing controls. The children in each group ranged in age from 3;11 years to 6;6 years and were matched as far as possible on educational experience (whether they were in state or independent education, and whether they were in nursery, reception or year one). The children were not individually matched, however, on language development. Seven of the children in each group were from state schools or nurseries. Five of the family at-risk and normal controls were from independent schools, and they were matched to three speech impaired children in independent education and two speech impaired children who were in state education but having speech therapy from a private speech therapist. The children with a family history of dyslexia were largely younger siblings of children assessed for dyslexia at the Centre for Reading and Language at York. One of the children in this group was receiving regular speech therapy. The children with speech difficulties were recruited through local speech therapists and nurseries. They were selected by their speech therapists as having significantly delayed speech, but average language development. None of the children in this group had a family history of dyslexia. Most of the family at-risk and speech impaired children were tested in their homes or in the Centre for Reading and Language in York, though some were tested at their

schools or at their speech therapist's offices. Testing was generally carried out in one or two sessions. The control children were tested in their schools.

The Tasks

Language Tasks

The children were given the four language tasks used in the longitudinal study: receptive vocabulary, mispronunciation detection, new word learning and articulation. Full descriptions of these tasks and their administration are provided in Chapter 3 (pg. 100). Receptive vocabulary was measured by the British Picture Vocabulary Scales (Dunn et al., 1982). The mispronunciation detection task was a task in which children had to determine whether a puppet had pronounced a word correctly or not (pg. 100). Articulation was measured by percentage consonants correct on a picture-naming task (pg. 101). New word learning was measured by the storybook task using The Gruffalo storybook, as before (pg. 127).

Phonological Tasks

The children were given the syllable, rime and initial phoneme matching tasks, as described in Chapter 2 (pg. 68). The different tasks were given on different days if possible, to prevent confusion between them. However, if this was not possible, they were separated by other language tasks.

Nonword Repetition

The children were also given a nonword repetition task. Nonword repetition is a task that in the school years consistently distinguishes normally developing children from children with reading difficulties (Snowling, 1981) or speech and language difficulties (Bishop et al., 1996). This task was included as a validation that the three groups of children were in fact significantly different in their phonological processing skills. The test consisted of 12 two- and three-syllable nonwords. Eight of these words had primary stress on the initial syllable, while four of them had primary stress on the second syllable. Two points were given for every word correctly repeated, and one point for each word with a single error (an inserted, deleted or substituted phoneme).

Early Reading Skills

The children were given two tests assessing their emerging reading skills. These were letter knowledge and a reading test. Letter knowledge was administered in exactly the same way as it was administered in the longitudinal study. Children were shown lower-case letters individually and asked if they knew what that letter was. If they gave the letter name, they were asked if they knew the letter sound. Letter-sound knowledge was used in these analyses. The reading test was the Hatcher Early Word Recognition test (Hatcher, 2000). This test consists of 42 of the words children learn first when starting to read. Children were shown the words in groups of six and encouraged to read them. The test was discontinued if the child did not know any of the words from the first three groups.

Results

Group Characteristics

The group characteristics for each group are shown in Table 6.1. The groups did not differ significantly in age.

Table 6.1: Age characteristics and gender ratio for each group

	Controls	Family at-risk	Speech difficulties	ANOVA
Age (months) Range:	61.00 (10.41) 47 – 76 m	61.42 (9.59) 47 – 75 m	63.36 (9.63) 49 – 78 m	F(2,20) = 2.64, ns
Male: Female ratio	7:5	9:3	8:4	

Articulation and nonword repetition were included in the test battery to allow validation that the three groups were in fact significantly different from one another on key defining variables. Group means for these two tasks are shown in Table 6.2. For each task, within subjects ANOVAs were carried out to examine differences between the groups.

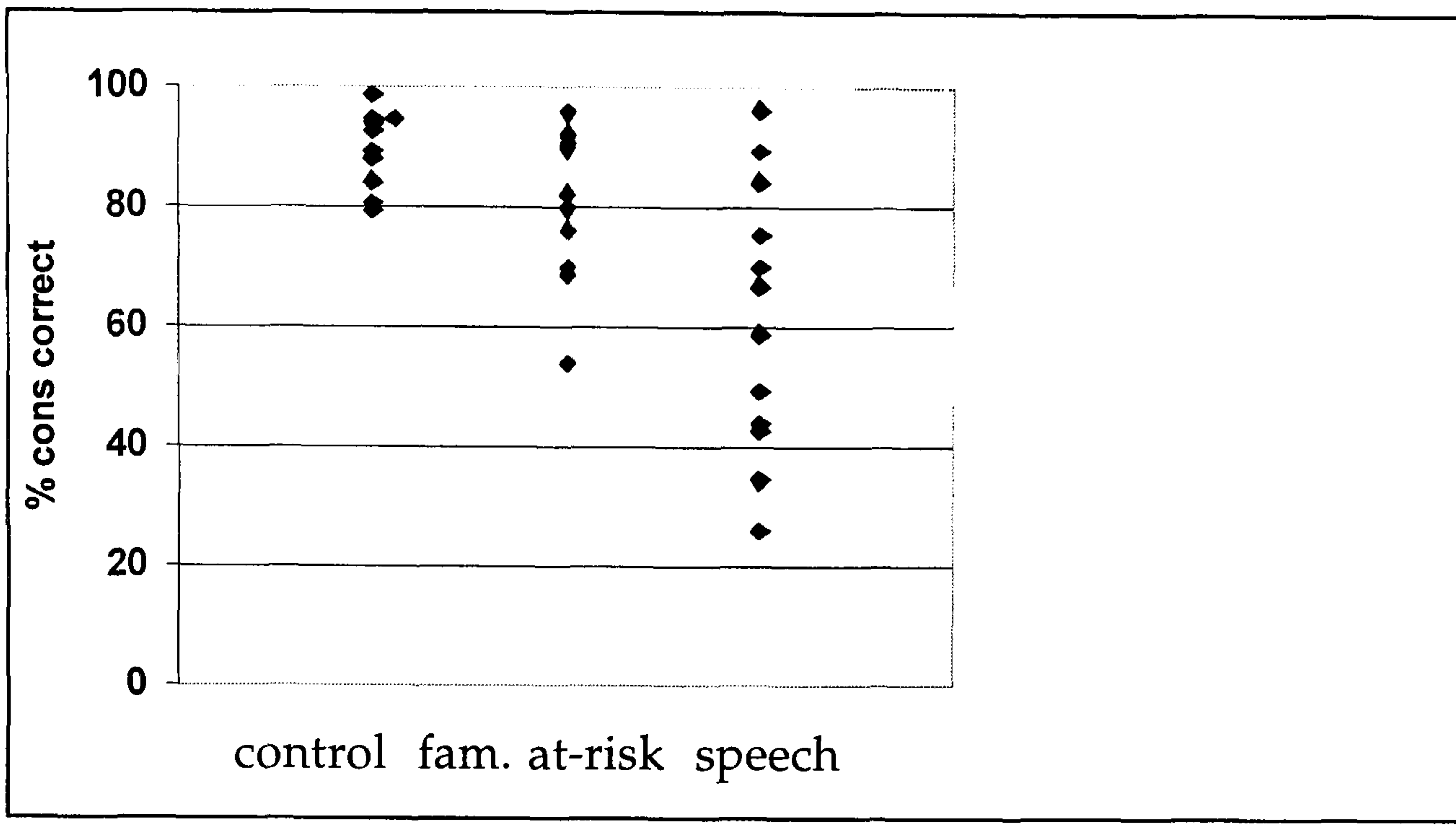
Table 6.2: Group means and standard deviations on the articulation and nonword repetition tasks

	Controls	Family at-risk	Speech difficulties	ANOVA
Articulation (% consonants correct)	90.72 (6.13)	80.90 (12.42)	63.13 (22.99)	F(2,20) = 14.39, p<0.01
Nonword repetition (/24)	16.67 (4.89)	12.5 (4.50)	6.45 (4.72)	F(2,20) = 32.49, p<0.01

The three groups differed significantly in both articulatory accuracy and nonword repetition ability. Post-hoc difference contrasts in each case showed that each of the three groups differed significantly from each other ($p<0.05$). As expected, the children with speech difficulties performed worse than the other two groups. However, it was also found that the family at-risk group performed significantly worse than the control group, though not as badly as the group with speech difficulties.

Performance of the different groups on the articulation task is shown in Figure 6.1.

Figure 6.1: Individual scores on the articulation task by group



All of the children in the control group scored at least 80% consonants correct. The children with speech difficulties show a much wider range, from 96% consonants correct to 25% consonants correct. The children in the family at-risk group show an intermediate range, with five of the eleven children scoring below the lowest scoring control child. These results suggest that the children with a family history of dyslexia and with speech difficulties do in fact come from different populations from the control children.

Performance on the Language Tasks

Next, the three groups were compared on the speech and language tasks described in Chapters 3 and 4. These were vocabulary, mispronunciation detection and new word learning. Mean scores for each of these tasks are shown in Table 6.3. Both raw scores and proportions correct (corrected for guessing) for the mispronunciation detection task are provided.

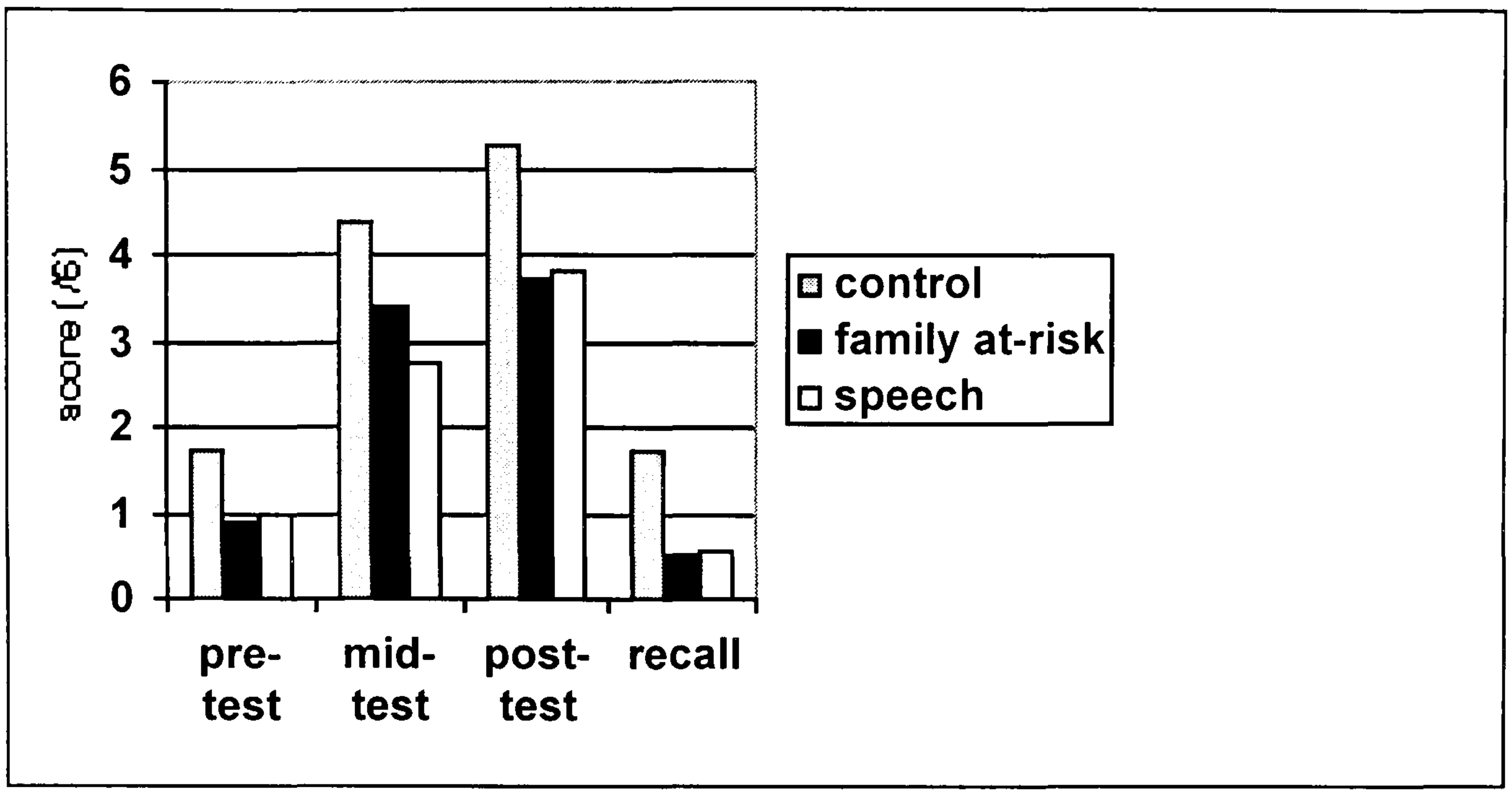
Table 6.3: Group means and standard deviations on each of the language tasks

	Controls	Family at-risk	Speech difficulties	ANOVA
Vocabulary *(standard score)*	104.33 (9.43)	102.58 (12.13)	100.91 (13.83)	F(2,20) <1
Mispro. detection:				
raw score (/23)	19.25 (3.19)	17.33 (4.23)	16.18 (4.81)	F(2,20) = 1.622, ns
corrected proportion	0.794 (0.21)	0.618 (0.29)	0.528 (0.38)	F(2,20) = 2.159, ns
New Word Learning – recog	5.08 (1.16)	3.45 (1.57)	3.67 (1.44)	F(2,20) = 3.014, p<0.05
New Word Learning- recall	1.58 (1.31)	0.55 (0.52)	0.58 (0.67)	F(2,20) = 6.57, p<0.01

The three groups did not differ in receptive vocabulary. In contrast, the groups did differ on both the recognition and recall elements of the new word learning task. In both cases, post-hoc difference contrasts showed that the control group outperformed the other two groups, who did not differ significantly from one another.

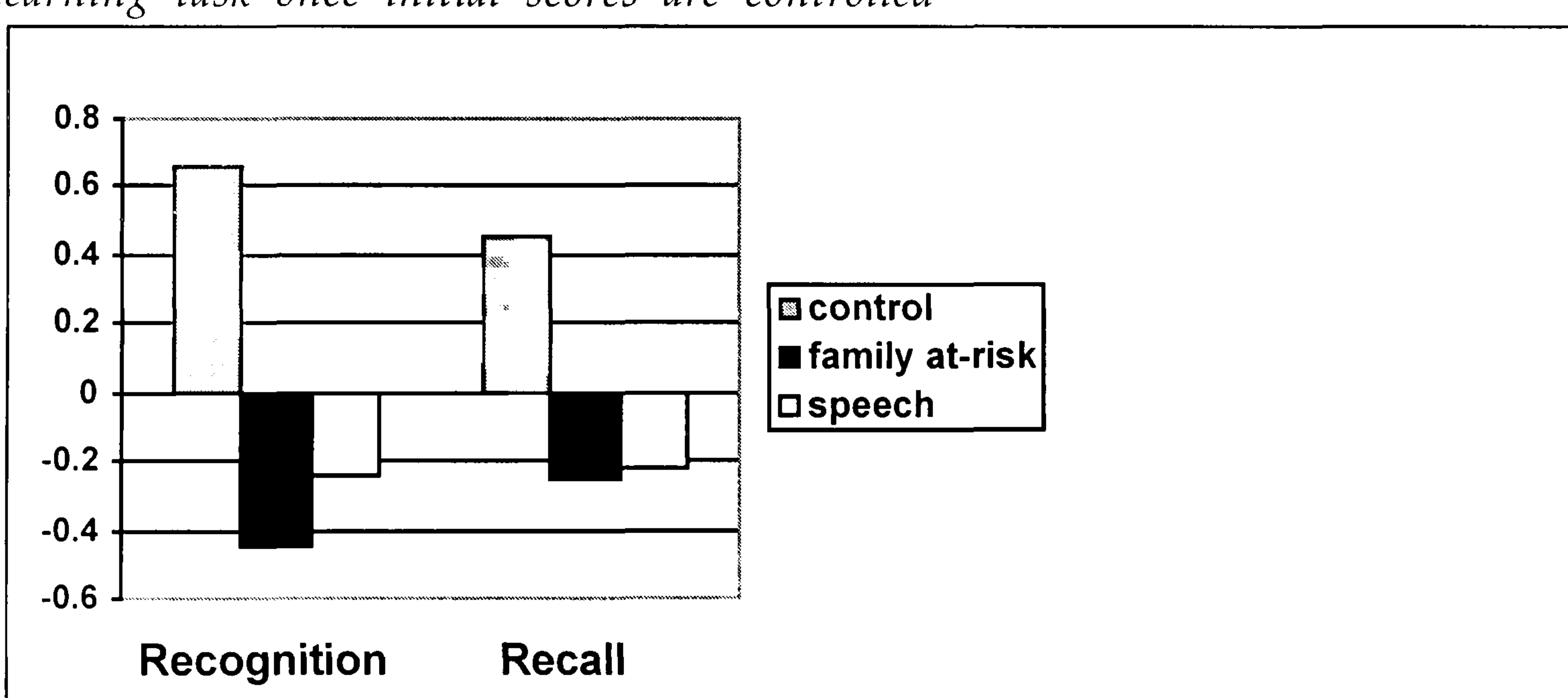
Performance on the new word learning task by group over the trials is shown in Figure 6.2. While all of the groups showed evidence of learning the words, the control group outperformed the two at-risk groups on each of the measures. In addition, the at-risk groups did not show improvements in scores from mid-test to post-test.

Figure 6.2: Mean scores on the new word learning task by group



When a between subjects ANCOVA was performed with pre-test score controlled, differences between groups remained significant only for new word recall ($F(2,20)=4.007$, $p<0.05$), not for new word recognition ($F(2,20)=1.580$, ns). Standardised residual scores after pre-test performance had been controlled are shown in Figure 6.3.

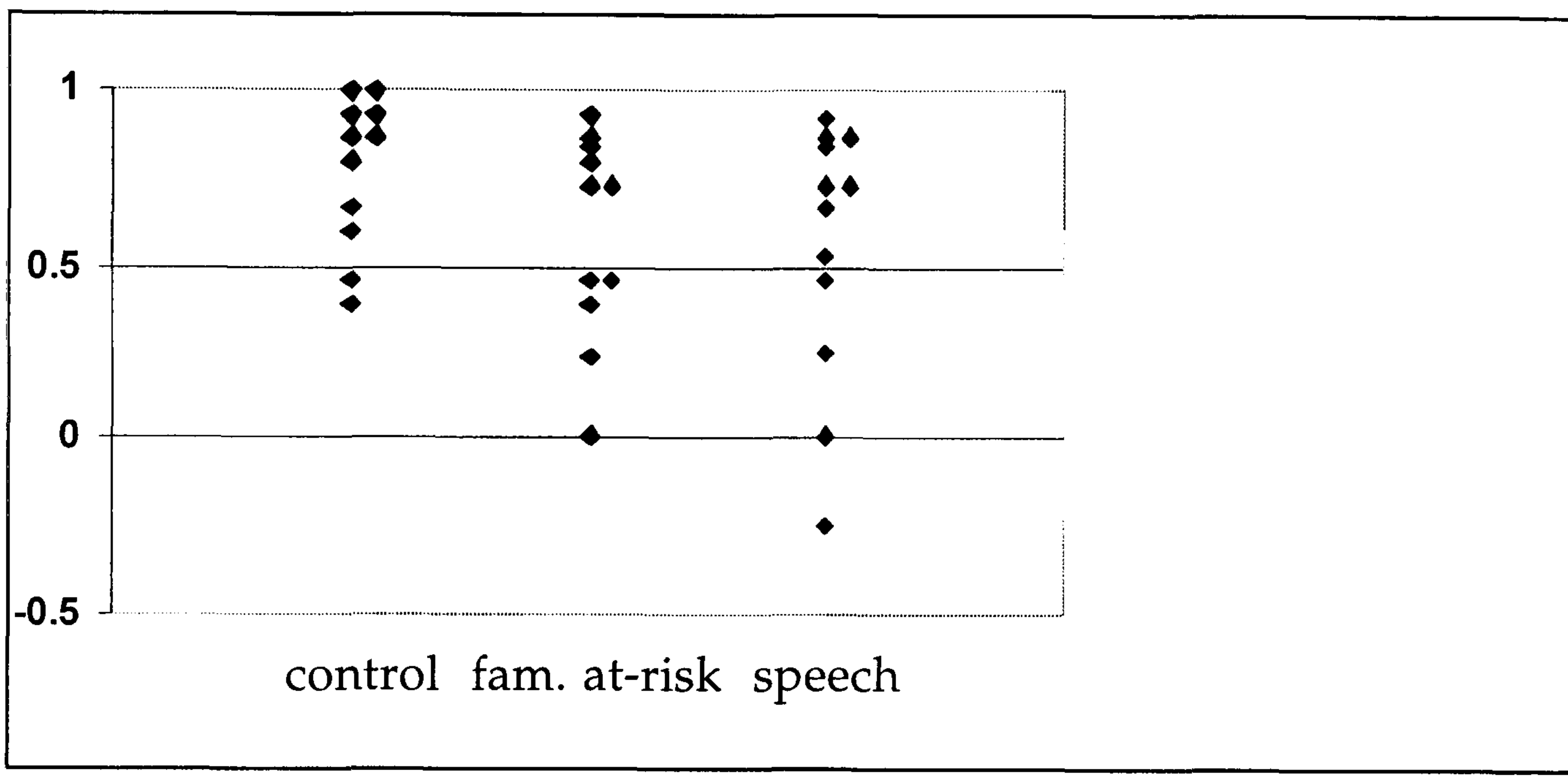
Figure 6.3: Mean standardised scores (by group) on the new word learning task once initial scores are controlled



The control group showed better performance than expected, given their pre-test scores, while the two at-risk groups showed less good performance than would be predicted given their pre-test scores. The children with a family history of dyslexia also showed slightly less good learning than the children with speech difficulties.

Given that the groups differed significantly on the articulation task, it was anticipated that they would also differ on the mispronunciation detection task. However, the differences between groups did not reach significance. The proportion of mispronounced words correctly detected, when guessing is controlled, is shown for each individual in Figure 6.4.

Figure 6.4: Proportion of correct detections on the mispronunciation detection task by group

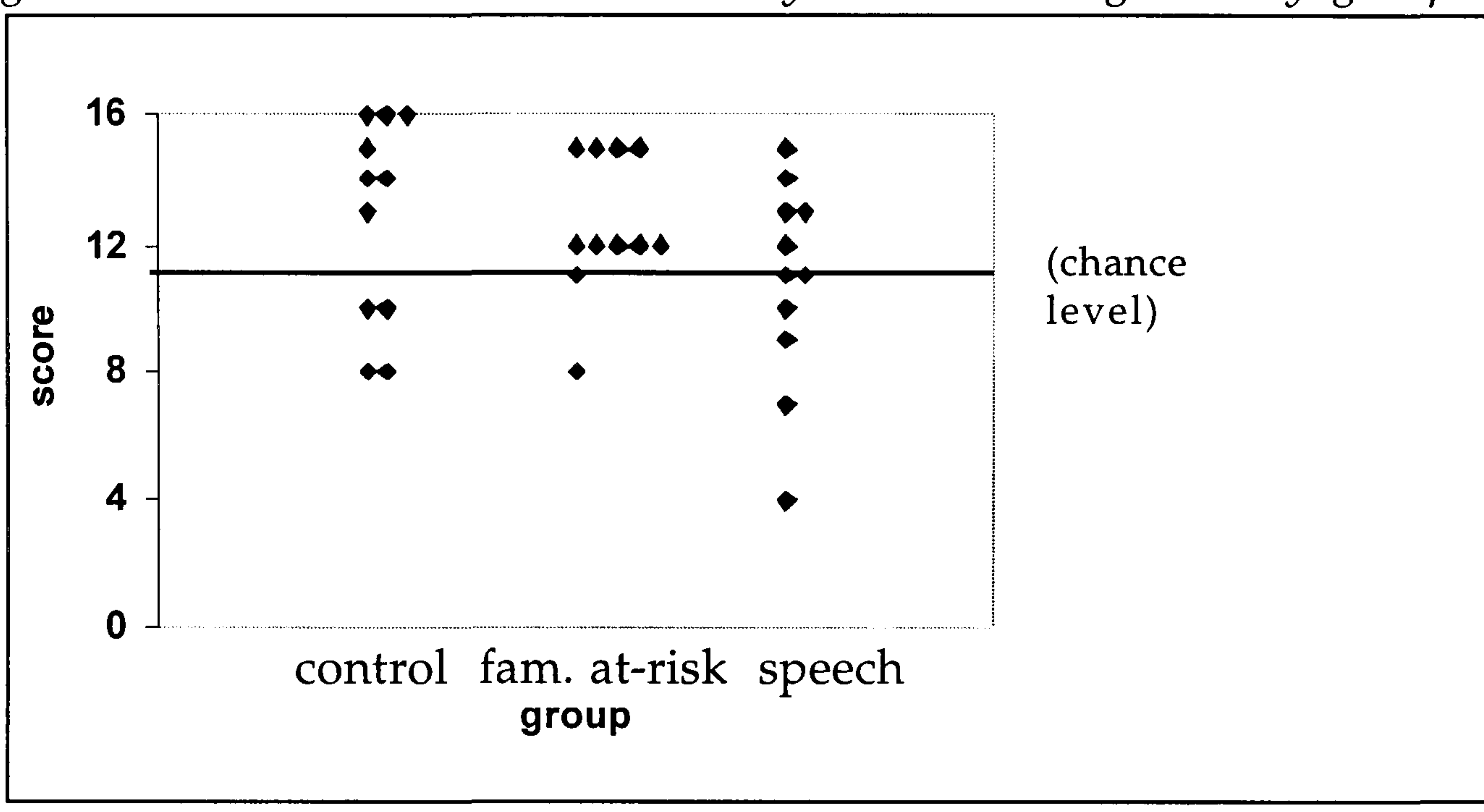


As with the articulation task, the children in the two at-risk groups show a wider range of scores than the control children. The control children show no scores of lower than 0.4, while the scores in the at-risk groups range down to less than zero. Scores close to zero indicate that a child is not sensitive to the difference between correctly and incorrectly articulated words. This suggests that a subset of children in the at-risk groups is not sensitive to single phoneme alterations when recognising spoken words.

Performance on the Phonological Awareness Tasks

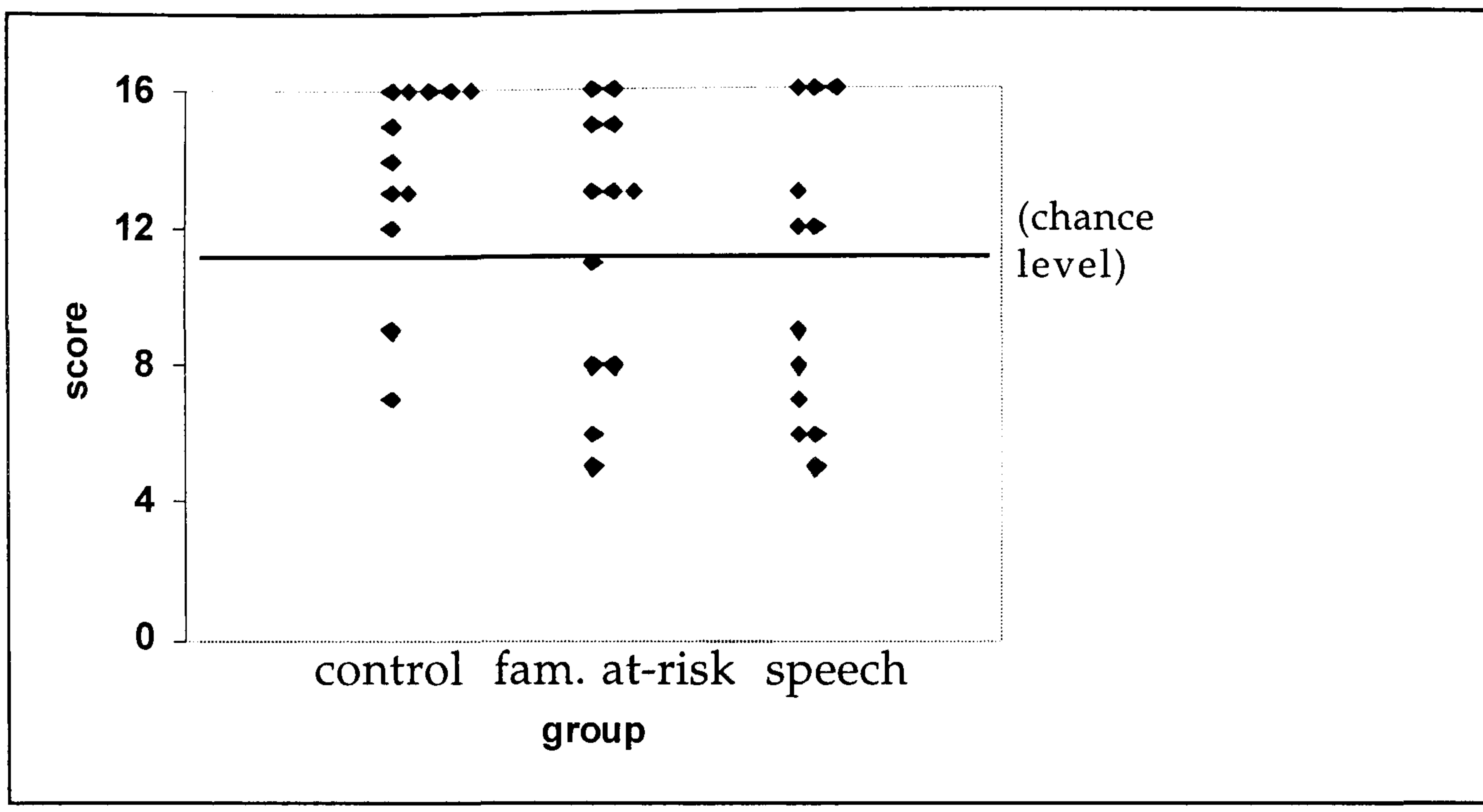
The scores of each of the children on the phonological awareness tasks are shown in the scatter diagrams. Figure 6.5 shows the performance of the groups on the syllable matching task.

Figure 6.5: Individual scores on the syllable matching task by group



Because performance on this task was not normally distributed, the Friedman non-parametric test was carried out to test for differences between the groups. While there are no significant differences on this task (χ^2=1.087, df=2, ns), the children with speech difficulties showed more variation, and fewer of them were above chance. However, different patterns of performance were not observed between groups. The second phonological awareness task administered was the rime-matching task. Scores on this task are shown in Figure 6.6.

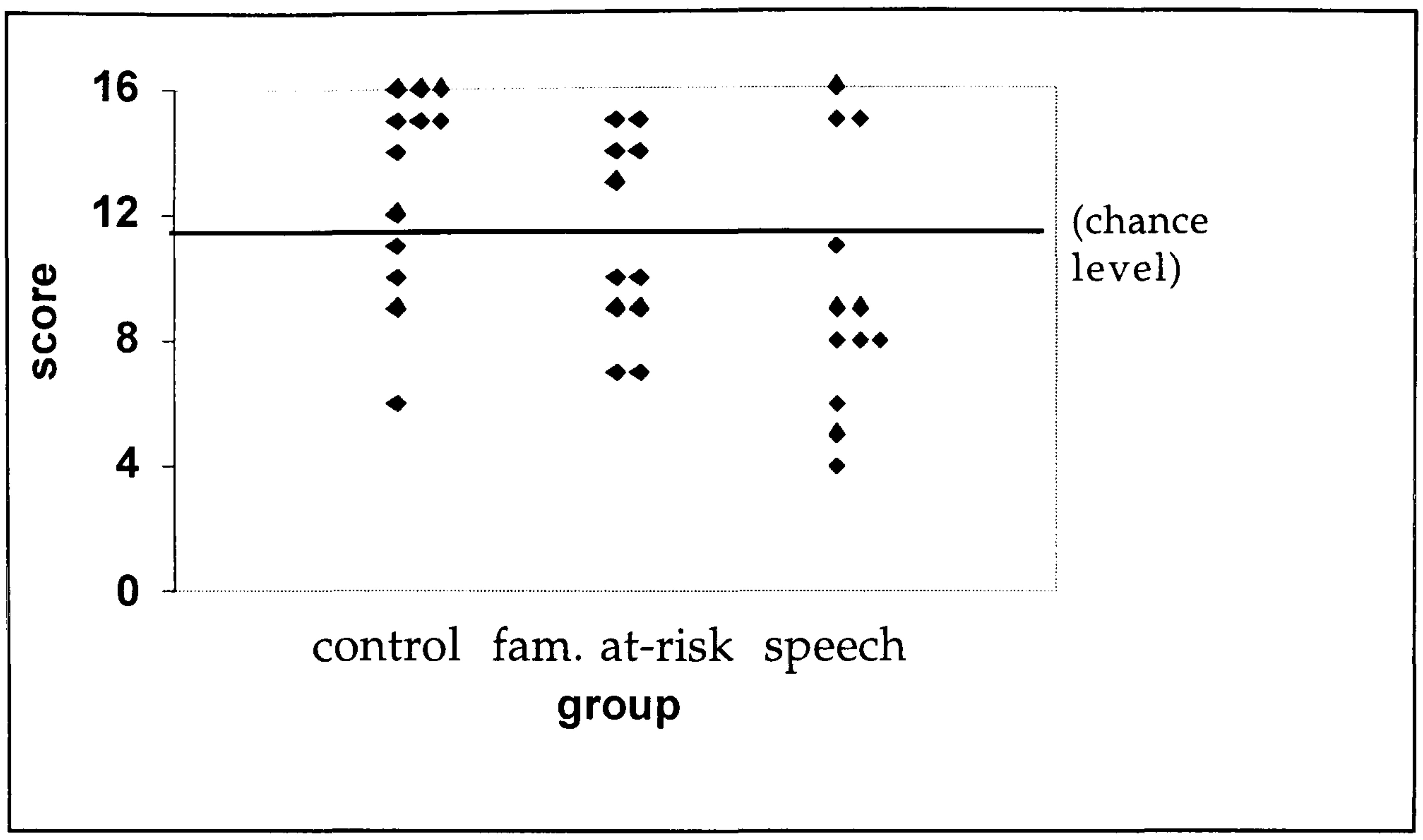
Figure 6.6: Individual scores on the rime matching task by group



Again, a non-parametric Friedman test was carried out. In this case, there was a significant difference between the three groups ($\chi2=7.302$, df=2, $p<0.05$). Ceiling effects are evident in the control group, while these are less pronounced in the other two groups. Only two children in the control group do not score significantly above chance (more than 11 correct) on this task, compared to five and six in the family at-risk and speech impaired groups respectively. The possible association between group and above-chance responding on the test was examined using a Chi-square analysis. Since the sample sizes were too small to conduct Pearson Chi-square analyses, the family at-risk and speech difficulties groups were collapsed together to create a combined 'at-risk' group, and Fisher's Exact Test was computed. The association between group and chance status on the rime task was marginally significant (p=0.086).

Performance on the initial sound matching task is shown in Figure 6.7.

Figure 6.7: Individual scores on the initial sound matching task by group



On this task, the differences between the groups were only marginally significant ($\chi 2$=4.850, df=2, p=0.08). Eight of the control children were above chance on this task, compared to five and three of the family at-risk and speech impaired children, respectively. Again, the data from the two at-risk groups were collapsed to test for an association between group and above chance performance on the task. Again, the Fisher's exact test statistic was marginally significant (p=0.062).

There is therefore some evidence that the children at risk of reading difficulties are impaired on the phonological awareness tasks. While only the rime matching task was sensitive enough to show statistically significant differences, performance on the initial phoneme matching task also seems to be impaired, at least for a subset of children at risk of reading difficulties.

Performance on the Reading Outcome Tasks

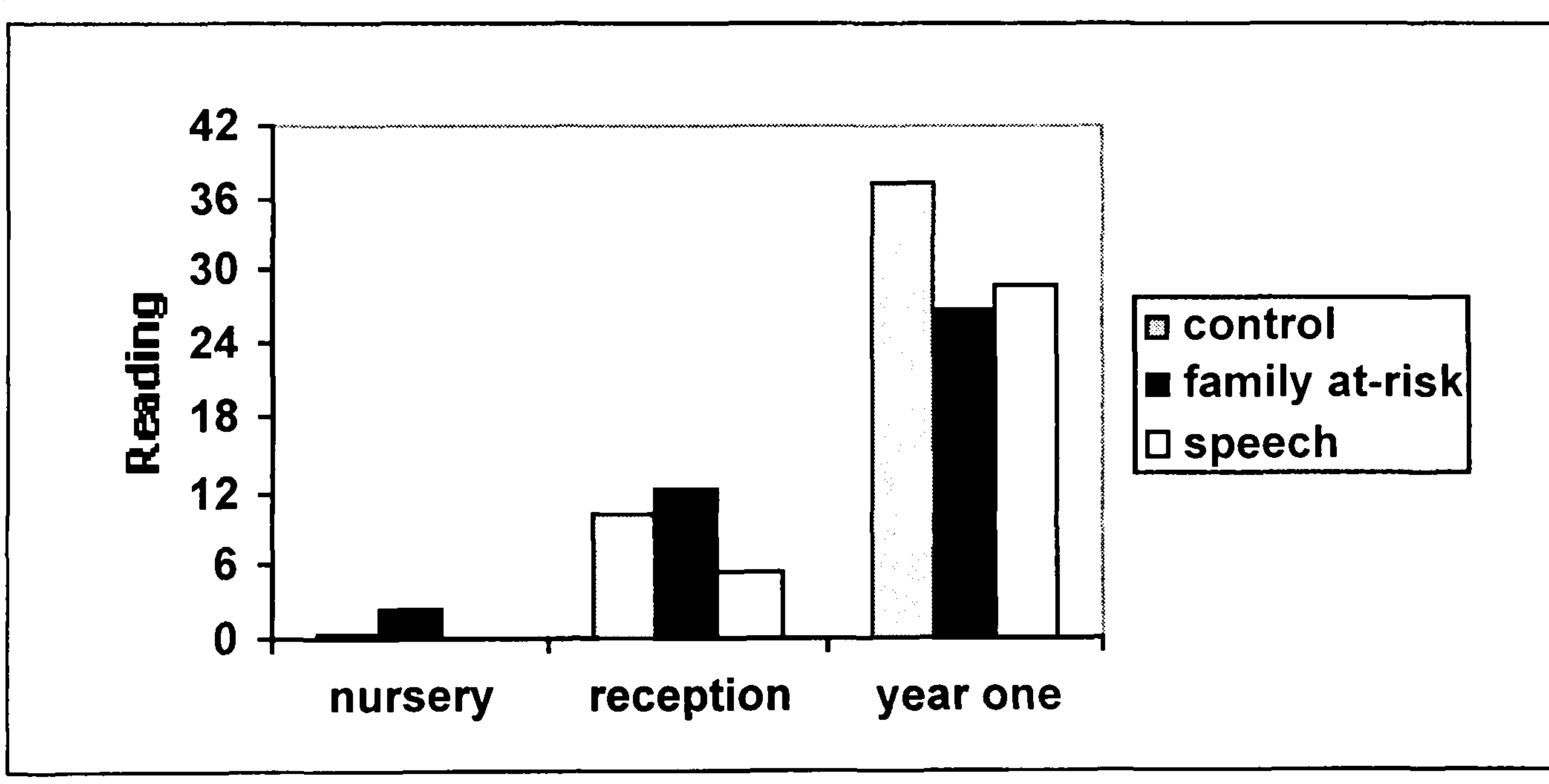
Performance on the reading outcome tasks, letter knowledge and word recognition is shown in Table 6.4.

Table 6.4: Group means and standard deviations for the word recognition and letter knowledge tasks

	Controls	Family at-risk	Speech difficulties	ANOVA
Letter-sound knowledge (/26)	16.5 (7.83)	18.58 (7.38)	13.64 (9.56)	F(2,20) = 2.794, p=0.08
Word recognition (/42)	15.92 (16.74)	13.75 (13.29)	12.91 (15.42)	F(2,20) <1

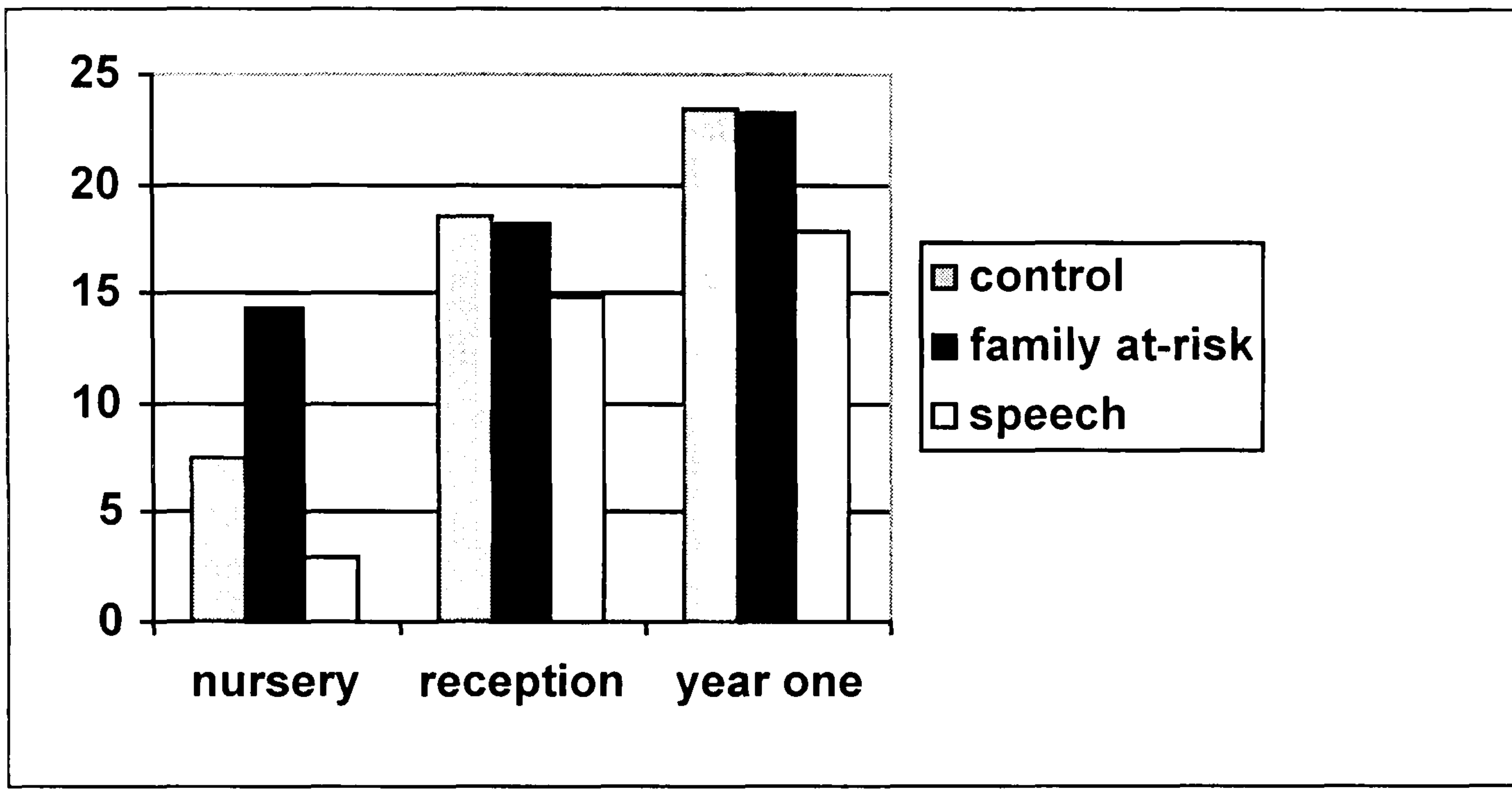
There are no significant differences between the groups on reading or letter knowledge, though there is a trend for the control group to outperform the other two groups on reading, and for children in the speech impaired group to know fewer letter sounds than the other two groups. Though mean reading scores look quite similar, all of the scores have large standard deviations, indicating that several of the children could read no words at all. Figure 6.8 shows reading scores of each group according to whether the children were in nursery, reception or year 1.

Figure 6.8: Mean reading score of the three groups by year



For children from the three groups in nursery and reception classes, reading scores were similar. However, for the controls in year one performance was better than that of the other two groups. This suggests that the lack of a significant difference in reading scores may be due to the fact that the majority of the children in this sample are in the earliest stages of reading acquisition. To assess group differences in letter knowledge over time a similar procedure was followed (see Figure 6.9).

Figure 6.9: Mean letter-sound knowledge of the three groups by year



For those in reception class and year one, the family at-risk group shows similar scores to the control group, while the speech impaired group shows slightly lower scores. However, the family at-risk children in nursery substantially out-performed the other two groups. Since these children are not yet in formal schooling, this suggests that the parents of the family at-risk children place more emphasis on letter learning than the parents of the children in the other two groups. Gallagher et al. (2000) found that parents of children with a family history of dyslexia spent more time teaching letters to their pre-school children than parents of control children did. It may be that the extra tuition the groups of at-risk children receive in letter knowledge, either from parents or speech therapists, masks possible difficulties these children may have in learning letters.

Comparison of the 'At-Risk' Group to Normal Controls

The results described so far suggest that children with a family history of dyslexia and children with speech difficulties in the pre-school years show a similar patterns of impairment. However, the small numbers of children in the sample has limited the statistical power of the analyses. Because of this, a second set of ANOVAs was carried out combining the children with family history of dyslexia and the children with speech difficulties into a single group and comparing this combined 'at-risk' group to the control group. Because of the poor distributions of the phonological awareness tasks, one-tailed Mann-Whitney U tests were carried out. The results of this analysis are shown in Table 6.5.

Table 6.5: Comparisons between the control group and the combined at-risk group on each of the language, phonological awareness and reading outcome variables

Variable	Controls	At-risks	ANOVA
Nonword repetition	16.67 (4.87)	9.43 (5.61)	$F(1,33)=14.26$, $p<0.01$
Articulation	90.72 (6.13)	71.22 (20.40)	$F(1,34)=10.36$, $p<0.01$
Vocabulary	49.83 (11.33)	48.33 (12.84)	$F(1,34)<1$
Mispro. detection (controlled)	0.794 (0.213)	0.587 (0.332)	$F(1,34)=3.84$, $p=0.06$
New word learning (recog)	5.08 (1.16)	3.57 (1.47)	$F(1,33)=9.59$, $p<0.01$
New word learning (recall)	1.58 (1.31)	0.57 (0.59)	$F(1,33)=10.15$, $p<0.01$
Syllable	12.42 (3.20)	11.54 (2.89)	$Z=-0.88$, $n_1=12$, $n_2=24$, ns
Rime	13.58 (3.00)	11.04 (4.00)	$Z=-1.89$, $n_1=12$, $n_2=24$, $p<0.05$
Initial phoneme	12.92 (3.29)	10.52 (3.71)	$Z=-1.94$, $n_1=12$, $n_2=23$, $p<0.05$
Letter-sound knowledge	18.42 (8.24)	16.43 (9.46)	$F(1,34)<1$
Reading	15.92 (16.74)	12.79 (13.98)	$F(1,34)<1$

When the two at-risk groups were combined, results confirmed and clarified the results described in earlier sections. There were large differences between the groups in articulation and nonword repetition, though the groups were well matched on receptive vocabulary. The at-risk group showed lower performance than controls on new word learning and on mispronunciation detection, though the differences between the groups on the mispronunciation detection task were only marginally significant. The two groups showed similar performance on the syllable matching task, but the at-risk group was significantly impaired on the rime and initial phoneme matching tasks. However, these important group differences did not yet seem to have impacted on early reading skills in this study: the two groups did not differ on letter knowledge or early word recognition.

Discussion

This study compared the performance of children with a family history of dyslexia and children with speech difficulties with controls matched on age and educational experience. Taken together, the two groups at risk of reading difficulties showed similar patterns of impairments. Both groups showed significantly lower levels of articulation and nonword repetition than the control children did. They also showed deficits in new word learning and to a lesser extent in mispronunciation detection. These difficulties in phonological processing skills were also evident in the phonological awareness tasks: as a single group, children at-risk of reading difficulties showed lower performance on the rime and initial sound matching tasks. However, these difficulties did not have a clear impact on early reading skills in this study, perhaps due to the fact that reading was measured at a very early stage, before phonological skills can be expected to have an impact on reading progress.

While the at-risk groups showed average receptive language skills, they showed difficulties in tasks tapping output phonology. Of course, this is expected in the case of the children with speech difficulties, as they were selected on the basis of their difficulties in articulation. However, the children with a family history of dyslexia showed a level of articulation in between that of the children with speech difficulties and the normal controls. A similar pattern was found on the nonword repetition task:

each of the groups was significantly different from the other two. Examination of the individual scores on the articulation task showed that around half of the children in this group had articulatory accuracy that was below the average range, though only one of these children was in regular speech therapy.

The two at-risk groups also showed less sensitivity to misarticulated words in the mispronunciation detection task, though the difference between the groups was only marginally significant. This suggests that the difficulties these children show in phonological processing are not limited to output processes. A possible explanation for the smaller deficits in the mispronunciation detection task is that this task is less sensitive to poorly specified representations than the articulation task: no control is made for whether the words used are in the children's vocabulary, and only one phoneme within each word is tested, rather than each phoneme within the word as in the articulation task.

The groups also differed on the new word learning task. The control group outperformed the other two groups at each stage of testing, including the pre-test, and also seem to show more of an increase in performance from the mid-test to the post-test. The evidence discussed in Chapter 4 suggested that new word learning is a skill that is highly dependent on the status of phonological representations, as measured by articulation, mispronunciation detection and phonological awareness. Given that the children in this study have shown deficits in all of these tasks, it is not surprising that they also show deficits in new word learning ability. It could be considered surprising that the groups differ on new word learning ability, yet do not differ on receptive vocabulary level. New word learning should provide a measure of how easily new vocabulary can be acquired. However, the two tasks measure different aspects of word knowledge, as described in Chapter 4. Since receptive vocabulary requires children to determine which of four pictures a spoken word refers to, it may not require well specified phonological representations, while in the earliest stages of word learning, the quality of encoding of phonological structures may determine whether the word is recognised in another presentation.

The combined 'at-risk' group showed lower performance than the controls on the rime and initial phoneme matching tasks, though they did not differ on the syllable matching task. Given that overall scores on the syllable and rime tasks were similar, both in the longitudinal study described in Chapter 2 and in the present study, this was a surprising result, and cannot be explained purely as a function of task difficulty. Instead, it seems likely that the two tasks involve slightly different skills. One possible explanation for the fact that the groups differed significantly on rime and initial phoneme, but not syllable, matching tasks is that the rime and initial phoneme tasks were the two tasks in which some of the trials contained distractor items matched for global similarity to the cue words. It may be that children at risk of reading difficulties have more difficulties on phonological awareness tasks that are best solved using segmental strategies.

The children at risk of reading difficulties did not differ from normal controls on the reading or letter knowledge tasks. This was a surprising result, given that these tasks were the most direct measures of early reading development. However, examination of the reading scores of these children divided into year groups gives a possible explanation of this result. On the reading task, the children in nursery and reception had very low scores on this task, as one would expect, and it seems not to be sensitive for children of this age. However, in year one it does appear that the control children are outperforming the other two groups of children, who show similar scores.

The finding that the groups did not differ significantly in letter knowledge was even more surprising given the fact that the groups did show significant differences on new word learning, a task that should be closely related to the development of letter knowledge. The new word learning task measures the acquisition of new phonological sequences. Since the letter knowledge requires the reproduction of meaningless phonological sequences, it is surprising that the at-risk group were able to learn letters normally in spite of their new word learning deficit. However, as before, examination of the children's scores by year group provides a potential explanation of these deficits. In reception and year one, the children in the two at-risk groups show slightly lower levels of letter knowledge than the control children did. However, in nursery the children with a family history of dyslexia show much higher levels of letter knowledge than the other two groups. Since these children are not yet receiving formal tuition in letters, it is likely that these children are receiving more home tuition than the other two groups. Many of the parents of the children in this group were in fact worried about the potential reading difficulties of their child and may have been more concerned that he or she should receive a good start. Gallagher et al (2000) included a parental questionnaire in their study of children with a family history of dyslexia, and they found that parents of these did in fact spend more time teaching their children letters than parents of normal controls.

It is also interesting to note that despite the close relationship between letter knowledge and initial sound matching skill described in Chapter 5, the lower performance of the at-risk groups on the initial sound matching task cannot be due to differences in letter knowledge between the groups, as there were none. This suggests that even children at risk of reading difficulties who are given thorough tuition in letter knowledge may be less likely to use this knowledge to solve phonological segmentation and categorisation tasks.

Though the two groups of children at risk of reading difficulties showed similar patterns of impairments, they also exhibited some differences. In the phonological awareness, mispronunciation detection and new word learning tasks, performance of the at-risk groups were very similar. However, the children with speech difficulties showed significantly worse performance overall on the articulation and nonword repetition tasks. One possible explanation for these differences is that, on the basis of earlier longitudinal studies (e.g. Gallagher et al., 2000; Scarborough, 1990) only around half of the children with a family history of dyslexia are likely to go on to show significant reading difficulties in the school years. Perhaps, therefore, only half of the present group was significantly impaired, and the others show normal performance on each of these tasks. However, examination of the distributions in nonword repetition and articulation suggest that this was not the case. Scores on nonword repetition for the normal group range from 22 to 7 out of a possible 24, while the scores for the family history of dyslexia group range from 19 to 5. Scores for the speech impaired children range from 14 to 0. This suggests that the entire range of scores in the family at-risk group was depressed, rather than the group containing two separable subgroups.

These results suggest that, rather than the family at-risk group containing two specific subgroups of impaired and unimpaired children, the children are instead on a continuum of impairment, from mild to moderate phonological processing difficulties. In most cases, these are too mild to require speech therapy in the pre-school years, but will cause varying degrees of difficulty when reading instruction begins. Most of the children with speech difficulties show moderate phonological processing difficulties. These are severe enough to warrant specific speech therapy, and are likely to impact upon reading. There are two possible reasons why the speech impaired children do not show worse performance than the children with a family history of dyslexia. The most parsimonious explanation is that since these tasks (with the exception of the new word recall task) do not require phonological output, they are less sensitive to differences in the quality of phonological representations between the children. A possible alternative explanation is that the group of children with speech difficulties is a heterogeneous group, containing some children with good phonological representations who have difficulties only in articulatory output processes. This would explain why the children with speech difficulties show poorer speech than the children with a family history of dyslexia. Unfortunately, the present data does not allow us to choose between these alternatives.

As a whole, these results are in line with the findings from Chapters 3 and 4. In Chapter 3, it was found that tasks that measure quality of phonological representations, such as articulation and mispronunciation detection, are related to the development of phonological awareness. This chapter showed that these skills are impaired in children at risk of reading and phonological awareness difficulties. In Chapter 4, it was found that new word learning is closely related to speech processing tasks such as articulation and mispronunciation detection. This study also showed that children with difficulties in phonological processing had difficulties on a new word learning task, despite the fact that these children had normal vocabulary levels. Children who show poor performance in these phonological processing tasks also show poor performance on phonological awareness tasks. This study therefore provides further evidence that phonological awareness is dependent on the quality of phonological representations.

7. General Discussion

The research presented in this thesis concerned the nature of phonological awareness in the pre-school years. The development of phonological awareness itself was considered, together with the relationship between phonological awareness, language skills and letter knowledge. It was found that phonological awareness could be usefully measured in the pre-school years, and that it was reciprocally related to vocabulary development. Letter knowledge was also causally related to the development of phoneme awareness.

Overview of Findings

The data presented in Chapter 2 examined the developmental progress of children on a set of phonological awareness tasks. At three points in time over one year, a group of pre-school children were given phonological matching tasks at the level of the syllable, rime and initial phoneme. At the final point of testing, two explicit phoneme awareness tasks (phoneme completion and phoneme deletion) were also included in the test battery. Children showed a tendency to use overall global similarity to solve the rime and initial phoneme matching tasks. Similar levels of performance were found on the syllable and rime matching tasks, with lower levels of performance on the initial phoneme matching task. Children generally did not score above chance on the phoneme matching task unless they also scored above chance on the rime matching task. In contrast, it was not the case that all of the children who showed above chance performance on the phoneme completion and deletion tasks also showed above chance performance on the initial phoneme matching task.

Chapter 3 investigated the relationship between phonological awareness and language development. Receptive vocabulary and two measures of phonological processing (articulation and mispronunciation detection) were included in the one-year longitudinal study described in Chapter 2, and the relationship of these variables to the phonological awareness tasks was assessed. Within the simultaneous multiple regressions, vocabulary was not a significant unique predictor of performance on any of the phonological awareness tasks. Articulation at Time 2 predicted mispronunciation detection ability at Time 3, mispronunciation detection ability at Time 2 predicted rime matching at Time 3 and syllable and rime matching at Time 2 predicted phoneme matching at Time 3. Overall, these results suggested a pattern of progression from good quality phonological representations to awareness of first large and then small phonological segments in the phonological matching tasks. Articulation at Time 2 was also a significant unique predictor of phoneme completion ability at Time 3, while syllable and rime matching at Time 2 was the only unique predictor of phoneme deletion at Time 3.

Chapter 4 considered the relationship between phonological awareness and the acquisition of new words. A subset of the children who took part in the longitudinal study was given a new word learning task at the final time of testing. While the speech processing and phonological awareness tasks both accounted for variance in new word recognition when entered at the first step of the regression, the relationship between speech processing and new word recognition was subsumed by the relationship between phonological awareness and new word recognition.

The relationship between letter knowledge and phonological awareness was investigated in Chapter 5. In the first study, the role of letter knowledge in the development of phonological awareness was examined in the context of the one-year longitudinal study. No child scored significantly above chance on any of the phoneme awareness tasks unless they knew at least one letter. In addition, all but one of the children in the top third of the sample for letter knowledge at Time 3 showed above chance performance on the phoneme completion task. Letter knowledge at Time 2 was also a significant predictor of phoneme deletion at Time 3. The second study within this chapter examined the role of letter knowledge in the development of phoneme awareness by means of an intervention study. Children were taught 8 letters and their phonological awareness was tested before and after training, and at follow-up two months later. Only those children who had learnt several letters went on to be successful on the phoneme completion task at follow up. Only those children who knew several letters at the end of training and were successful on the pre-test rime task went on to be successful on the phoneme matching task at follow-up.

Chapter 6 explored the phonological awareness and language skills of children at risk of reading difficulties. Two groups of children were included, children with a family history of dyslexia and children with speech difficulties. Both groups scored significantly lower than normal controls on articulatory accuracy and nonword repetition, and their scores on the mispronunciation detection task were marginally lower than the control children, though the groups did not differ in receptive vocabulary. The two groups of children at risk of reading difficulties also showed normal syllable matching ability, though their scores on the rime and initial phoneme matching tasks were lower than those of the controls. These difficulties had not yet impacted upon early reading development: the three groups did not differ significantly on the single word recognition or letter knowledge tasks.

Overall, the findings suggested that pre-school children show some awareness of word sounds, but that this is generally limited to an implicit sensitivity to the overall similarity of words. This sensitivity is related to the quality of a child's phonological representations, as indexed by their speech processing skills. However, phonological awareness itself can influence the acquisition of novel phonological representations; phonological awareness predicted children's ability to complete a new word learning task. When children begin to learn letters, they begin to become aware of the phonemes that make up words. This awareness does not generally appear in English speaking pre-school children until they begin to learn letters. However, it is not solely dependent on letter knowledge: implicit phonological sensitivity and the nature of a child's phonological representations also play a role in the development of explicit phoneme awareness. Data from children at risk of reading difficulties backed up these conclusions: these children showed deficits in speech processing skills, which in turn led onto deficits in phonological awareness and in the acquisition of new words.

What is the Nature of Pre-school Phonological Awareness?

According to Goswami and Bryant (1990), children should progress from awareness of the syllable to awareness of sub-syllabic units such as the rime and the onset (or initial phoneme). In the present study, children showed similar performance on the syllable and rime matching tasks but poorer performance on the initial phoneme matching task. This finding suggests that phonological awareness progresses from awareness of large units to awareness of small units, rather than from awareness of syllables to awareness of onsets and rimes.

The second part of Chapter 2 compared performance on the implicit and explicit phoneme awareness tasks. There was not a clear progression from implicit to explicit phoneme awareness: several children who were at chance on the initial phoneme matching task showed above chance performance on the phoneme completion or deletion tasks. Children did not develop implicit phoneme awareness prior to developing explicit phoneme awareness. One possible explanation for this finding is that the progression from implicit to explicit awareness and the progression from sensitivity to gestures to sensitivity to phonemes are bound up with one another. As children become explicitly aware of word sounds, they develop sensitivity to phonemes, and vice versa.

How is Phonological Development Related to Implicit Phonological Awareness?

Early phonological awareness must have its roots in general language development – the tasks involve the analysis of the sounds in words, and should therefore be at least partially dependent upon how children represent these sounds. One possible explanation for the onset of implicit phonological awareness in the pre-school years is that it is a natural consequence of structuring the lexicon in terms of the sub-phonemic gestures within words. Studdert-Kennedy (1987) suggested that children begin to represent the articulatory gestures (or features) within words some time during the third year of life. This allows them to exploit similarities between words – words that contain the same articulatory gestures can be stored using similar sets of perceptual weights (Harm & Seidenberg, 1999). Since there are hundreds of different syllables in the English language, but a limited set of articulatory gestures that can be used in these syllables (c.f. Byrne & Liberman, 1999), this restructuring allows much more efficient storage of phonological sequences.

Chapter 3 examined the relationship between phonological awareness and word-level language skills. Two tasks measuring quality of lexical representations – articulation and mispronunciation detection – were included, as well as receptive vocabulary. While vocabulary correlated well with phonological awareness, it was not a significant unique longitudinal predictor of this skill. Mispronunciation detection, on the other hand, was a significant unique predictor of later rime matching ability. In addition, the children at risk of reading difficulties described in

Chapter 6 showed poor articulation and mispronunciation detection scores and correspondingly poor scores on the rime matching task, though they showed average vocabulary development. These results suggest that early phonological awareness is dependent on the quality, rather than the quantity, of phonological representations. Children who represent words in an accurate and detailed fashion are more likely to be able to match sounds across words.

The children in the longitudinal study also showed a tendency to use overall global similarity to solve the phonological matching tasks. Children found distractors equated for global phonological similarity to the cue word harder to reject than unrelated or semantically related distractors. Since in several cases the globally similar distractors did not share a phoneme with the target word, this suggests that when pre-school children solve phonological awareness tasks, they are not considering words as sequences of phonemes. Equally, since the children are sensitive to similar, but non-identical rimes, they must represent some of the sounds within these rimes. Children must be sensitive to word features that are common across words. These may be sub-phonemic similarities between phonemes, such as articulatory features or gestures, or supra-segmental features, such as overall word contour or stress.

Children's first approach to solving phonological awareness tasks therefore seems to involve phonetic cues at levels other than the level of the phoneme. For instance, Treiman & Breaux (1982) gave pre-literate children and literate adults a free classification task in which they had to say which of two nonsense syllables a cue syllable sounded most similar to. The two alternatives either sounded globally similar to, or shared a phoneme with the cue word. Adults were more likely to classify words according to a shared phoneme, while children were more likely to classify words according to global similarity.

This sensitivity is also shown in early reading and spelling behaviour. Read (1971) analysed the invented spelling of kindergarten children and concluded that the spelling patterns showed sensitivity to common phonetic features and similarities across vowels and consonants that adults find very difficult to detect. Rack, Hulme, Snowling, & Wightman (1994) taught children who were in the earliest stages of learning to read a set of three letter cues for words, such as WSL for whistle. The cues all contained two letters that matched phonemes in the target word and one letter that differed from the central consonant either in place or voicing. Children found cues that differed only in voicing from the target word easier to learn than cues that differed in place. These children must therefore make use of some sound similarities when learning to read sight words.

There are many possible cues that pre-school children may be sensitive to when judging sound similarities between words. The data presented within this thesis does not allow us to choose between these alternatives, and indeed different children may be responding to different cues. However, a sensitivity to articulatory gestures would allow the child to develop an awareness of phonemes more readily than the other types of sound sensitivity.

Since early phonological awareness is dependent upon the quality of a child's phonological representations, it is vital that children begin school with good phonological representations already in place. It is often assumed that pre-school children will develop adequate speech processing skills naturally, without any specific training being necessary, and in many cases this is true. However, the children with a family history of dyslexia described in Chapter 6 provide an example of a group of children for whom this is not the case. These children's speech skills were generally thought to be adequate by their parents and nurseries – only one of the twelve children was receiving regular speech therapy. However, the difficulties in phonological processing shown by this group have clearly affected their phonological awareness even before the onset of schooling. These results imply that early work on these children's speech processing skills would give them a greater chance of developing good reading skills in the school years.

How is Phonological Development Related to Explicit Phoneme Awareness?

The phonological processing tasks showed a close relationship to the development of explicit phoneme awareness. In the longitudinal multiple regressions in Chapter 3, articulation at Time 2 was found to be a significant predictor of phoneme completion ability at Time 3. Articulation and initial phoneme matching also loaded onto the same factor at Time 2 in the longitudinal study. These results suggest that good speech processing skills also play a role in the development of explicit phoneme awareness. Children who show accurate articulation of complex words are likely to have full and accurate representations of the articulatory gestures and their relative timings within words. This would allow children to isolate phonemes within words.

Both of the groups of children at risk of reading difficulties showed poor articulation of complex words and poor performance on the initial phoneme matching task. These results, as before, suggest that the children's less detailed and accurate representations of words resulted in difficulties on a task in which they had to match sounds across words.

While mispronunciation detection and articulation were both considered measures of the quality of phonological representations, the two variables showed slightly different relationships with the different phonological awareness tasks. Mispronunciation detection was a good predictor of rime matching ability, while articulation was more closely related to phoneme completion. These two variables seem to tap different elements within phonological representations. Perhaps children can determine whether words have been spoken correctly if they have a largely accurate, but not highly precise, phonological representation. For instance, they may represent all of the articulatory gestures within the word accurately, but not the relative timings of these gestures. A child with this type of representation would be able to detect if a gesture within the word was not articulated correctly, and they may also be able to compare relatively long sound segments within words, as they have started to represent internal gestures. However, accurate articulation of a complex word requires a more precise representation. Children must know when each of the constituent gestures occurs relative to others. This type of knowledge would also be necessary for detection of phonemes within words.

How does Phonological Awareness Influence Vocabulary Development?

The relationship between language development and phonological awareness is not, however, uni-directional. The development of phoneme awareness also seems to affect the way in which children learn new words. In Chapter 4, it was shown that phonological awareness is a better longitudinal predictor of new word learning ability than speech processing.

Children who are sensitive to the sounds (or gestures) within words may be able to use this sensitivity when storing new phonological sequences. This finding emphasises the close relationships between implicit phonological awareness and language development. The implicit sound sensitivity tapped by the rime matching task is not a skill that needs to be directly taught: it arises naturally out of language acquisition. Moreover, it is not merely an epiphenomenon in non-literate children: this sensitivity to the sounds within words seems to be an important factor in the vocabulary development of children in middle childhood. As described in Chapter 1, the rate of vocabulary acquisition increases throughout childhood until adolescence, and implicit sound sensitivity plays a part in this. This could be considered an example of the Matthew Effect (Stanovich, 1986). Children who begin word learning by representing words fully and accurately begin to make links between the sub-phonemic gestures within different words. This knowledge allows them to learn words more quickly and accurately, as they can be coded according to the regularities already coded within the lexicon, and so children who begin word learning well generally continue to learn well throughout childhood. In contrast, children who begin life with poorly specified representations may well continue to drop behind their peers over time (c.f. Stothard et al., 1998).

In support of this hypothesis, the children at risk of reading difficulties, who had poor phonological representations and poor phonological awareness, showed particular difficulties on the new word learning task. These children did however show average receptive vocabulary levels, and when their pre-test knowledge was controlled their difficulties in new word learning were significant only for the recall of new words. This finding suggests that these children can acquire phonological representations that are sufficient for recognition of words in some contexts – for instance with the limited choices of alternative pictures provided in the receptive vocabulary and new word recognition tasks. These representations are not, however, sufficiently well-specified to allow accurate reproduction of the phonological sequence. Taken together, these results imply that implicit phonological awareness interacts closely with phonological processing, and could be considered part of the natural process of language development.

What Roles could Phonological Awareness and Phonological Development play in Learning to Read?

The evidence presented so far suggests that there are at least two separable types of phonological awareness. Sensitivity to sound similarities develops when children begin to represent the articulatory gestures within syllables. Over time, however, children place less emphasis upon sub-phonemic features and more upon phonemes. As they learn to read, they start to consider words as series of phonemes rather than as sets of overlapping gestures. This type of awareness allows adults and children to make explicit links between letters and phonemes, which in turn allows them to read words quickly and accurately, and to decode unknown words effectively.

Sensitivity to sub-phonemic similarities may in some circumstances also be useful for young children learning to read words. For instance, Rack et al (1994) showed that children were able to use it to learn cues for words that sounded similar to, but not identical to, the phonetic structure of the target word. This type of skill might be useful for learning irregular words (such as 'have' or 'of') that contain letters that sound similar to phonemes within the target word, but do not exactly match them. For example, the word 'of' contains the final phoneme /v/. The phoneme /v/ differs from the phoneme /f/ only in voicing, and children who are sensitive to this similarity may be able to learn to read this irregular spelling more easily.

This sensitivity might also be used during learning to read. When children who are learning to read encounter an unknown word, they are encouraged to sound out the letters within that word. In the case of 'of' this would normally be decoded as 'off'. However, if that possibility were discounted, either because of the surrounding context or because of teacher feedback, they would continue to search their lexicon for a suitable candidate word. If words are stored according to their sub-phonemic features, then 'of' would have a very similar pattern of weights to 'off' and would therefore be the word most likely to be selected second. In contrast, if words were only stored as series of phonemes, there would be no reason (notwithstanding to the influence of context) why 'of' would be selected before other words such as 'on'.

Both types of awareness may therefore be useful when learning to read. Global sound sensitivity may be particularly useful in languages such as English that have a high number of irregularly spelt words. For this reason, early tuition in reading instruction may well be most effective if it involves a combination of explicit sounding out and linking of the orthography and phonology of words at a whole word level. While explicit phonics is the only strategy that allows children to decode unknown words out of context, implicit sound sensitivity does offer an alternative way of learning to link the orthography and phonology of irregular words.

What Role does Learning Letters play in the Development of Explicit Phoneme Awareness?

As described above, both language development and implicit phonological awareness are related to the development of explicit phoneme awareness. Another major factor in the development of this skill seems to be the learning of letters. Data presented in Chapter 5 showed that no child who knew no letters at all was successful on any of the phoneme awareness tasks. Learning letters was an essential precursor to phoneme awareness in this sample of children[2]. However, high levels of letter knowledge were not necessary. Several children were successful on the phoneme awareness tasks while being able to produce only four or five letters.

Researchers have proposed different explanations for the finding that learning letters is vital to the development of phoneme awareness. Walley (1993) suggested that learning letters forces a restructuring of the words within the lexicon, so that they come to be represented as a series of phonemes rather than as unanalysed syllables. Other researchers (e.g. Gombert, 1992) have suggested that learning letters is one of the factors that allows children to develop meta-phonological abilities – abilities that allow conscious manipulation of meaningless word segments.

There is a growing body of evidence suggesting that the differences between adults' and children's strategies in phonological awareness and phonological processing tasks are linked to learning letters. Treiman & Breaux (1982) showed that adults were more likely than children to use phoneme-based strategies in phonological awareness tasks. Nittrouer and colleagues (Nittrouer et al., 1989; Nittrouer & Studdert-Kennedy, 1987) showed that adults were also more likely than children to use phoneme based strategies in speech perception and production. Walley proposed that this data could be explained if one assumed that learning letters forces a child to restructure the words within his or her lexicon into series of phonemes.

---

[2] While learning letters was an essential precursor to phoneme awareness in this sample of pre-school children, this does not imply that learning letters is always essential to phoneme awareness. In particular, people given specific training in phoneme awareness, or other training such as awareness of articulatory movements, may well develop phoneme awareness in the absence of letter knowledge.

There are, however, some difficulties with this theory. If learning letters forces children to restructure their lexical representations, one might expect to find that children's ability to complete meta-phonological tasks would be restricted to words they already knew. In fact, children seem able to complete meta-phonological tasks with nonwords soon after they begin school (e.g. Hulme et al., in press).

Another problem with this theory is that it does not explain the fact that phoneme awareness seems to be so closely bound up with the development of explicit phonological awareness. Learning letters seems to precipitate the development of both of these skills. A possible explanation of this finding is that, rather than forcing a restructuring of the existing lexicon, learning letters allows a further level of representation to develop. Children learn letters and their associated phonemes and then begin to abstract these phonemes from words that they have learnt. This would allow children to mentally manipulate phonemes in both known words and nonwords.

This theory still leaves unresolved the specific way in which letter knowledge precipitates meta-phonological awareness. The research presented in this thesis suggests that letter knowledge allows children to begin to isolate phonemes within their speech. Almost all of the children who knew more than twenty letters were successful on the phoneme completion task. In addition, all of those children in the intervention study who knew three or more letters by the end of training were successful on the phoneme completion task when tested two months later. These results suggest that good letter knowledge is a sufficient condition for the development of phoneme completion ability. This phoneme completion requires that children isolate the final phoneme from a word and reproduce it. It seems, therefore, that learning letters teaches children how to isolate single phonemes within words.

Byrne & Liberman (1999) proposed that learning visual symbols for meaningless sound segments (i.e. phonemes) helps children to develop another level of representation; to develop representations for phonemes beyond the words containing these phonemes. Children begin to learn words by linking sounds with meanings, but in order to learn the way in which the alphabet works, they must learn how meaningful words can be broken up into a small number of meaningless segments.

This proposal does not, however, imply that children would only be able to isolate phonemes from words if they had been taught the associated letter for that phoneme. In fact, several of the children who completed the phoneme completion task presented in Chapter 2 were able to isolate phonemes that they would not have known the letters for (such as /ʃ/). It might be the case therefore that, once children began to abstract phonemes from words, the other phonemes can be abstracted almost automatically. If a child learns that the central sound in bat is /a/, then /b/ and /t/ will also be isolated from the other sounds within the word and could be labelled as phonemes themselves. In this way, phonological representations, phonological awareness and letter knowledge may interact to allow the development of meta-phonological awareness.

What is the Role of Implicit Sound Sensitivity in the Development of Meta-phonological Awareness?

Most researchers agree that both letter knowledge and implicit phonological awareness must play a role in the development of meta-phonological ability. The research presented in this thesis confirms this finding. In the intervention study, only those children who were successful on a pre-test rime matching task and who knew more than eight letters at the end of training were successful on either of these tasks at follow-up testing. In the longitudinal multiple regressions presented in Chapter 3, syllable and rime matching ability at Time 2 was a significant unique predictor of both initial phoneme matching and phoneme deletion at Time 3. Overall, these results suggest that sensitivity to sound similarities is a second vital skill in the development of initial phoneme matching and phoneme deletion ability. In the phoneme matching task, children must be able to isolate a phoneme from its phonetic context. However, they must also be able to match phonemes across differing phonetic contexts. The phoneme deletion task does not require children to compare sounds across words. However, it does require the mental manipulation of sounds within words, and it seems that an important precursor to this skill is successful completion of the phonological matching tasks. Letter knowledge helps children to isolate phonemes within words, but it does not teach children how to manipulate phonemes or how to compare similar sounds across words. Implicit phonological awareness appears to be the most important precursor of this skill.

Conclusions

The results of the research described within this thesis suggest that pre-school phonological awareness can be divided into an implicit sensitivity to sound similarity and an explicit awareness of phonemes. Implicit sensitivity is a skill that develops out of normal language development. In fact, it seems to interact closely with other language skills, such as vocabulary acquisition, and should therefore possibly be considered a part of language rather than of metalinguistic awareness. Children with poor quality phonological representations show poor implicit phonological sensitivity in the pre-school years. Explicit awareness of individual phonemes is a skill that develops with the learning of letters. Learning letters may allow the development of a further level of phonological representation. This influences both the articulation of complex words and the ability to isolate phonemes within speech. This skill allows children to move from implicit sound sensitivity to explicit phoneme awareness.

Arguably, these two types of phonological awareness are in fact fundamentally different processes. The change from one to the other is not just a change in the size of segment a child can process. Implicit sound sensitivity is an emergent property of the lexicon: it occurs because of the way that words are represented. Children do not have some subconscious awareness of sub-phonemic segments. Implicit phonological sensitivity is not another level of representation, but merely a result of similar patterns of weights across existing representations. Because of this, implicit sound sensitivity is bound to words within the lexicon. For this reason, this kind of sound sensitivity is not truly metalinguistic. However, explicit phoneme awareness allows children to move beyond this. When children are taught letters, this provides a catalyst to allow them to abstract phonemes within words. These phonemes are not limited to those phonemes represented by letters they have learnt; once children have learnt a few letters they can go on to abstract other phonemes within words[3]. This allows them to move beyond known words, and to develop a further level of representation, the level of phonemes. Once children have achieved this level of awareness, they have learnt a skill that they can use to operate on

[3] This does not mean that there are no differences with different types of word – children find it more difficult to segment phonemes from within clusters, for instance. However, this is likely to be a specific difficulty due to the high level of co-articulation between consonants within clusters and to the relative rarity of consonant clusters within our language (c.f. Caravolas & Bruck, 1993).

words in the lexicon and nonwords alike, and which will fuel their reading development by allowing them to decode unknown words.

References

Adams, M. J. (1990). *Beginning to Read.* Cambridge, MA: MIT Press.

Aguiar, L., & Brady, S. A. (1991). Lexical acquisition in good and poor readers. *Reading and Writing, 3,* 413-425.

Avons, S. E., Wragg, C. A., Cupples, L., & Lovegrove, W. J. (1998). Measures of phonological short term memory and their relationship to vocabulary development. *Applied Psycholinguistics, 19*(4), 583-603.

Ball, E. W., & Blachman, B. A. (1991). Does phoneme awareness training in kindergarten make a difference in early word recognition and developmental spelling? *Reading Research Quarterly, 26,* 49-66.

Bird, J., & Bishop, D. V. M. (1992). Perception and awareness of phonemes in phonologically impaired children. *European Disorders of Communication, 27,* 289-311.

Bird, J., Bishop, D. V. M., & Freeman, N. H. (1995). Phonological awareness and literacy development in children with expressive phonological impairment. *Journal of Speech and Hearing Research, 38,* 446-462.

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., North, T., & Donlan, C. (1996). Nonword repetition as a behavioural marker for inherited language impairment: evidence from a twin study. *Journal of Child Psychology and Psychiatry, 37*(4), 391-403.

Bloom, P. (2000). *How Children Learn the Meanings of Words.* (1st ed.). Cambridge, MA: MIT Press.

Bowey, J. A. (1994). Phonological sensitivity in novice readers and non-readers. *Journal of Experimental Child Psychology, 58,* 134-159.

Bowey, J. A. (1996). On the association between phonological memory and receptive vocabulary in five year olds. *Journal of Experimental Child Psychology, 63,* 44-78.

Bowey, J. A. (in press). Nonword repetition and children's vocabulary: a longitudinal study. *Applied Psycholinguistics.*

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

Bradley, L., & Bryant, P. (1983). Categorising sounds and learning to read - a causal connection. *Nature, 301,* 419-421.

Bruce, D. (1964). The analysis of word sounds. *British Journal of Educational Psychology, 34,* 158-170.

Bruck, M., Genesee, F., & Caravolas, M. (1997). A cross-linguistic study of early literacy acquisition. In B. Blachman (Ed.), *Foundations of Reading Acquisition and Dyslexia: Implications for Early Intervention* (pp. 145-162). Mahwah, NJ: Lawrence Erlbaum Associates.

Bryant, P. E., Maclean, M., & Bradley, L. (1990). Rhyme, language and children's reading. *Applied Psycholinguistics, 11,* 237-252.

Burgess, S. R., & Lonigan, C. J. (1998). Bi-directional relations of phonological sensitivity and pre-reading abilities: evidence from a pre-school sample. *Journal of Experimental Child Psychology, 70,* 117-141.

Byrne, B., & Fielding-Barnsley, R. (1989). Phonemic awareness and letter knowledge in the child's acquisition of the alphabetic principle. *Journal of Educational Psychology, 81,* 313-321.

Byrne, B., & Fielding-Barnsley, R. (1993). Global similarity effects in pre-school children. *Reading and Writing: an interdisciplinary journal, 5,* 315-324.

Byrne, B., & Liberman, A. M. (1999). Meaninglessness, productivity and reading: some observations about the relationship between the alphabet and speech. In J. Oakhill & R. Beard (Eds.), *Reading*

Development and the Teaching of Reading (pp. 157-174). Oxford: Blackwells Publishers.

Caravolas, M., & Bruck, M. (1993). The effect of oral and written language input on children's phonological awareness: a cross-linguistic study. *Journal of Experimental Child Psychology, 55,* 1-30.

Caravolas, M., Hulme, C., & Snowling, M. (in press). The foundations of spelling ability: evidence from a three year longitudinal study. *Journal of Memory and Language.*

Cardoso-Martins, C. (1994). Rhyme perception: global or analytic? *Journal of Experimental Child Psychology, 57,* 26-41.

Cardoso-Martins, C. (1995). Sensitivity to rhymes, syllables and phonemes in literacy acquisition in Portuguese. *Reading Research Quarterly, 30*(4), 808-828.

Carey, S. (1978). The child as a word learner. In M. Halle, J. Bresnan, & G. A. Miller (Eds.), *Linguistic Theory and Psychological Reality .* Cambridge, MA: MIT Press.

Carey, S., & Bartlett, E. (1978). Acquiring a single new word. *Papers and Reports on Child Language Development, 15,* 17-29.

Cataldo, S., & Ellis, N. (1988). Interactions in the development of spelling, reading and phonological skills. *Journal of Research in Reading, 11*(2), 86-109.

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

Chaney, C. (1989). I pledge a legiance tothe flag: three studies in word segmentation. *Applied Psycholinguistics, 10,* 261-281.

Chaney, C. (1992). Language development, metalinguistic skills and print awareness in 3 year old children. *Applied Psycholinguistics, 13,* 485-514.

Chaney, C. (1998). Pre-school language and metalinguistic skills are linked to reading success. *Applied Psycholinguistics, 19*(3), 433-447.

Charles-Luce, J., & Luce, P. A. (1990). Similarity neighbourhoods of words in young children's lexicons. *Journal of Child Language, 17,* 205-215.

Chukovsky, K. (1925, 1968). *From Two to Five.* (Vol. (translation 1968, first Russian edition 1925)). Berkeley: University of California Press.

Content, A., Kolinsky, R., Morais, J., & Bertelson, P. (1986). Phonetic segmentation in pre-readers: effect of corrective information. *Journal of Experimental Child Psychology, 42,* 49-72.

Cossu, G., Rossini, F., & Marshall, J. C. (1993). When reading is acquired but phonological awareness is not: a study of literacy in Down's syndrome. *Cognition, 46,* 129-138.

de Jong, P., Seveke, V., & van Veen, L. (2000). Phonological sensitivity and the acquisition of new words in children. *Journal of Experimental Child Psychology, 76*(4), 275-301.

Department for Education and Employment, (1998). The National Literacy Strategy; Framework for Teaching . Suffolk: Department for Education and Employment.

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

Dollaghan, C. (1998). Spoken word recognition in children with and without specific language impairment. *Applied Psycholinguistics, 19*(2), 193-207.

Dowker, A. (1989). Rhyme and alliteration in poems elicited from young children. *Journal of Child Language, 16,* 181-202.

Duncan, L. G., Seymour, P. H. K., & Hill, S. (1997). How important are rhyme and analogy in beginning reading? *Cognition.*

Dunn, L., Dunn, L., Whetton, C., & Pintilie, D. (1982). British Picture Vocabulary Scale . Windsor, England: Nfer-Nelson.

Eimas, P. D., Siqueland, E. R., Jusczyk, P., & Vigorito, J. (1971). Speech perception in infants. *Science, 171*, 303-306.

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.

Elkonin, D. (1973). USSR. In J. Downing (Ed.), *Comparative Reading* (pp. 551-580). New York: The Macmillan Company.

Elley, W. B. (1989). Vocabulary acquisition from listening to stories. *Reading Research Quarterly, 24*(2), 174-187.

Ferguson, C. A., & Farwell, C. B. (1975). Words and sounds in early language acquisition. *Language, 51*, 419-439.

Fisher, S. E., Stein, J. F., & Monaco, A. P. (1999). A genome-wide search for identifying quantitative trait loci involved in reading and spelling disability (developmental dyslexia). *European Child and Adolescent Psychiatry, 8*(3), III/47-III/51.

Fowler, C. A. (1991). How early phonological development might set the stage for phoneme awareness. In S. Brady & D. Shankweiler (Eds.), *Phonological Processes in Literacy* . Hillsdale, NJ: Lawrence Erlbaum Associates.

Fox, B., & Routh, D. K. (1974). Analysing spoken language into words, syllables and phonemes. *Journal of Psycholinguistic Research, 4*(3), 331-341.

Gallagher, A., Frith, U., & Snowling, M. (2000). Precursors of literacy delay among children at genetic risk of dyslexia. *Journal of Child Psychology and Psychiatry, 41*(2), 203-213.

Gathercole, S. E. (1995). Is nonword repetition a test of phonological memory or long term knowledge? It all depends on the nonwords. *Memory and Cognition, 23*, 89-94.

Gathercole, S. E., & Baddeley, A. D. (1989). Evaluation of the role of phonological STM in the development of vocabulary in children: a longitudinal study. *Journal of Memory and Language, 28,* 200-213.

Gathercole, S. E., & Baddeley, A. D. (1990). The role of phonological memory in vocabulary acquisition. *British Journal of Psychology, 81*(4), 415-558.

Gathercole, S. E., Hitch, G. J., Service, E., & Martin, A. J. (1997). Phonological short-term memory and new word learning in children. *Developmental Psychology, 33*(6), 966-979.

Gathercole, S. E., Willis, C. S., Emslie, H., & Baddeley, A. D. (1992). Phonological memory and vocabulary development during the early school years - a longitudinal study. *Developmental Psychology, 28,* 887-898.

Gerken, L. A., Murphy, W. D., & Aslin, R. N. (1995). Three- and four-year-olds' perceptual confusions for spoken words. *Perception and Psychophysics, 57*(4), 475-486.

Gibson, E. J., & Levin, H. (1975). *The Psychology of Reading.* Cambridge, MA: MIT Press.

Gombert, J. E. (1992). *Metalinguistic Development.* Chicago: Harvester Wheatsheaf.

Goodman, J. C., MacDonough, L., & Brown, N. B. (1998). The role of semantic context and memory in the acquisition of novel nouns. *Child Development, 69*(5), 1330-1344.

Goswami, U. (1999). Phonological development and reading by analogy: epilinguistic and metalinguistic issues. In J. Oakhill & R. Beard (Eds.), *Reading Development and the Teaching of Reading* (pp. 174-200). Oxford: Blackwells.

Goswami, U., & Bryant, P. E. (1990). *Phonological Skills and Learning to Read.* Hove, East Sussex: Psychology Press.

Halle, P. A., & De Boysson-Bardies, B. (1996). The format of representation of recognised words in infants' early receptive lexicon. *Infant Behavioural Development, 19,* 463-481.

Harm, M. W., & Seidenberg, M. S. (1999). Phonology, reading, and dyslexia: insights from connectionist models. *Psychological Review, 106*(3), 491-528.

Hatcher, P. J. (2000). Sound Linkage . London: Whurr Publishers.

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.

Heath, S. B. (1983). *Ways with words.* Cambridge: Cambridge University Press.

Heibeck, T. H., & Markman, E. M. (1987). Word learning in children: an examination of fast mapping. *Child Development, 58,* 1021-1034.

Hoien, T., Lundberg, I., Stanovich, K. E., & Bjaalid, I. K. (1995). Components of phonological awareness. *Reading and Writing, 7,* 171-188.

Huang, H. S., & Hanley, J. R. (1994). Phonological awareness and visual skills in learning to read Chinese and English. *Cognition, 54,* 73-98.

Hulme, C., Hatcher, P. J., Nation, K., Brown, A., Adams, J., & Stuart, G. (in press). Small but powerful: phoneme awareness is a better predictor of early reading skill than onset-rime awareness. *Journal of Experimental Child Psychology.*

Hulme, C., Roodenrys, S., Schweickert, R., & Brown, G. D. A. (1997). Word frequency effects on short-term memory tasks: evidence for a redintegration process in immediate serial recall. *Journal of Experimental Psychology: Learning, Memory and Cognition, 23*(5), 1217-1232.

Joffe, V. L. (1998). Rhyming and related skills in children with specific language impairment. *Current Psychology of Cognition, 17*(2), 479-512.

Johnston, R. S., Anderson, M. A., & Holligan, C. (1996). Knowledge of the alphabet and explicit awareness of phonemes in pre-readers: the nature of the relationship. *Reading and Writing, 8,* 217-234.

Jusczyk, P., & Aslin, R. N. (1995). Infants' detection of the sound patterns of words in fluent speech. *Cognitive Psychology, 29,* 1-23.

Kirtley, C., Bryant, P. E., MacLean, M., & Bradley, L. (1989). Rhyme, rime, and the onset of reading. *Journal of Experimental Child Psychology, 48,* 224-245.

Leitao, S., Hogben, J., & Fletcher, J. (1997). Phonological processing skills in speech and language impaired children. *European Journal of Disorders of Communication, 32*(2), 73-93.

Lenel, J. C., & Cantor, J. H. (1981). Rhyming ability in pre-school children. *Journal of Psycholinguistic Research, 10,* 57-67.

Levi, G., Capozzi, F., Fabrizi, A., & Sechi, E. (1982). Language disorders and prognosis for reading disabilities in developmental age. *Perceptual and Motor Skills, 54,* 1119-1122.

Liberman, I., Shankweiler, D., Fischer, F. W., & Carter, B. (1974). Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology, 18,* 201-212.

Locke, J. (1997). The development of disabilities in dyslexia. In Hulme & Snowling (Eds.), *Dyslexia: Biology, Cognition and Intervention* . London: Whurr Publishers Ltd.

Lundberg, I., Frost, J., & Peterson, O. (1988). Effects of an extensive program for stimulating phonological awareness in pre-school children. *Reading Research Quarterly, 23*(3).

Lyytinen, P., Poikkeus, A.-M., Laakso, M.-L., Eklund, K., & Lyytinen, H. (in press). Language development and symbolic play in children with and without familial risk for dyslexia. *Journal of Speech, Language and Hearing Research.*

MacLean, M., Bryant, P. E., & Bradley, L. (1987). Rhymes, nursery rhymes and reading in early childhood. *Merrill-Palmer Quarterly, 33,* 255-281.

Manis, F., McBride-Chang, C., Seidenberg, M. S., Keating, P., Doi, L. M., Munson, B., & Peterson, A. (1997). Are speech perception deficits associated with developmental dyslexia? *Journal of Experimental Child Psychology, 66,* 211-235.

Mann, V. (1986). Phonological awareness: the role of reading experience. *Cognition, 24,* 65-92.

Markman, E. (1994). Constraints on word meaning in early language acquisition. *Lingua, 92*(1), 199-227.

Mayo, C. (1999). Perceptual weighting and phonemic awareness in pre-reading and early reading children . Paper presented at the Child Phonology Conference, Bangor 1999.

McBride-Chang, C. (1996). Models of speech perception and phonological processing in reading. *Child Development, 67,* 1836-1856.

McBride-Chang, C. (1999). The ABCs of ABCs: the development of letter-name and letter-sound knowledge. *Merrill-Palmer Quarterly, 45*(2), 285-308.

McNicol, D. (1972). *A Primer of Signal Detection Theory.* Sydney, Australia: George Allen & Unwin Ltd.

Menyuk, P., Menn, L., & Silber, R. (1986). Early strategies for the perception and production of words and sounds. In P. Fletcher & M. Garman (Eds.), *Studies in Language Acquisition* (2nd ed., pp. 198-222). Cambridge, MA: Cambridge University Press.

Metsala, J. L. (1999). Young children's phonological awareness and nonword repetition as a function of vocabulary development. *Journal of Educational Psychology, 91*(1), 3-19.

Metsala, J. L., & Walley, A. C. (1998). Spoken vocabulary growth and the segmental restructuring of lexical representations: Precursors to phonemic awareness and early reading ability. In J. L. Metsala & L. C. Ehri (Eds.), *Word Recognition in Beginning Literacy* (pp. 89-120). Mahwah, NJ: Lawrence Erlbaum Associates.

Michas, I. C., & Henry, L. A. (1994). The link between phonological memory and vocabulary acquisition. *British Journal of Developmental Psychology, 12,* 147-164.

Moon, C., Cooper, R. P., & Fifer, W. P. (1993). Two-day old infants prefer native language. *Infant Behavioural Development, 16,* 495-500.

Morais, J. (1991). Phonological awareness: a bridge between language and literacy. In D. J. Sawyer & B. J. Fox (Eds.), *Phonological Awareness in Reading: the Evolution of Current Perspectives* (pp. 31-71). New York: Springer-Verlag.

Morais, J. (1993). Phonemic awareness, language and literacy. In R. M. Joshi & C. K. Leong (Eds.), *Reading Disabilities: Diagnosis and Component Processes* (pp. 175-184). Amsterdam: Kluver Academic Publishers.

Morais, J., Cary, L., Alegria, J., & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition, 7,* 323-331.

Morais, J., & Kolinsky, R. (1995). The consequences of phonemic awareness. In B. d. Gelder & J. Morais (Eds.), *Speech and Reading* . Hove, East Sussex: Erlbaum.

Morrison, C., Chappell, N., & Ellis, A. (1997). Age of acquisition norms for a large set of object names and their relation to adult estimates and other variables. *The Quarterly Journal of Experimental Psychology, 50A*(3), 528-560.

Moss, H. E., Hare, M. L., Day, P., & Tyler, L. K. (1994). A distributed memory model of the associative boost in semantic priming.

Connection Science: Journal of Neural Computing, Artificial Intelligence and Cognitive Research, 6(4), 413-427.

Murray, B. A., Stahl, S. A., & Ivey, M. G. (1996). Developing phoneme awareness through alphabet books. *Reading and Writing, 8*(4), 307-322.

Muter, V., Hulme, C., & Snowling, M. (1997). Phonological Abilities Test . London: Psychological Corporation.

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

Nittrouer, N., Studdert-Kennedy, M., & McGowan, R. S. (1989). The emergence of phonetic segments: evidence from the spectral structure of fricative-vowel syllables spoken by children and adults. *Journal of Speech and Hearing Research, 32,* 120-132.

Nittrouer, S., & Studdert-Kennedy, M. (1987). The role of coarticulatory effects in the perception of fricatives in children and adults. *Journal of Speech and Hearing Research, 30,* 319-329.

Olofsson, A., & Neidersoe, J. (1999). Early language development and kindergarten phonological awareness as predictors of reading problems. *Journal of Learning Disabilities, 32*(5), 464-472.

Orsolini, M., Sechit, E., Maronato, C., Bonvino, E., & Corcelli, A. (2001). Nature of phonological delay in children with specific language impairment. *International Journal of Language and Communication Disorders, 36*(1), 63-90.

Rack, J., Hulme, C., Snowling, M., & Wightman, J. (1994). the role of phonology in young children learning to read words: the direct mapping hypothesis. *Journal of Experimental Child Psychology, 57,* 42-71.

Read, C. (1971). Pre-school children's knowledge of English phonology. *Harvard Educational Review, 41*(1), 1-36.

Read, C., Zhang, Y., Nie, H., & Ding, B. (1986). The ability to manipulate speech sounds depends on knowing alphabetic spelling. *Cognition, 24,* 31-44.

Robbins, C., & Ehri, L. C. (1994). Reading storybooks to kindergarteners helps them learn new vocabulary words. *Journal of Educational Psychology, 86*(1), 54-64.

Scarborough, H. S. (1990). Very early language deficits in dyslexic children. *Child Development, 61,* 1728-1743.

Senechal, M. (1997). The differential effect of storybook reading on pre-schoolers' acquisition of expressive and receptive vocabulary. *Journal of Child Language, 24,* 123-138.

Seymour, P. H. K., & Evans, H. (1991). *Does awareness of onset-rime proceed awareness of phonemes?* Paper presented at the Cognitive section of the British Psychological Society, Oxford.

Seymour, P. H. K., & Evans, H. (1994). Levels of phonological awareness and learning to read. *Reading and Writing, 6,* 221-250.

Singh, S., & Woods, D. R. (1971). Perceptual structure of 12 American English Vowels. *Journal of the Acoustical Society of America, 49*(6), 1861-1866.

Singh, S., Woods, D. R., & Becker, G. M. (1972). Perceptual structure of 22 English vocalic consonants. *Journal of the Acoustical Society of America, 52*(6), 1698-1713.

Smith, C. L., & Tager-Flusberg, H. (1982). Metalinguistic awareness and language development. *Journal of Experimental Child Psychology, 34,* 449-468.

Snodgrass, J. G., & Vanderveldt, M. (1980). A standardised set of 260 pictures: norms for name agreement, image agreement, familiarity and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 174-215.

Snowling, M. (2000). *Dyslexia.* Oxford: Blackwells.

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

Snowling, M. J., Chiat, S., & Hulme, C. (1991). Words, nonwords and phonological processes. *Applied Psycholinguistics, 12*(3), 369-373.

Stackhouse, J., Nathan, L., & Goulandris, N. (submitted). Speech processing, language and emerging literacy skills in 4-5 year old children with specific speech difficulties. .

Stothard, S. E., Snowling, M. J., Bishop, D. V. M., Chipchase, B. B., & Kaplan, C. A. (1998). Language-impaired pre-schoolers: a follow-up into adolescence. *Journal of Speech, Language and Hearing Research, 41,* 407-418.

Stuart, M., & Coltheart, M. (1988). Does reading develop in a sequence of stages? *Cognition, 30*(2), 139-181.

Studdert-Kennedy, M. (1987). The phoneme as a perceptuomotor structure. In D. G. MacKay, A. Allport, W. Prinz, & E. Scheerer (Eds.), *Language Perception and Production: relationships between listening, speaking, reading and writing* (pp. 67-85). London: Academic Press Inc.

Studdert-Kennedy, M., & Goodell, E. W. (1995). Gestures, features and segments in early child speech. In B. De Gelder & J. Morais (Eds.), *Speech and Reading: a Comparative Approach* . Hove, East Sussex: Erlbaum (UK) Taylor and Francis.

Swan, D., & Goswami, U. (1997). Phonological awareness deficits in developmental dyslexia and the phonological representations hypothesis. *Journal of Experimental Child Psychology, 66,* 18-41.

Swingley, D., Pinto, J. P., & Fernald, A. (1999). Continuous processing in word recognition at 24 months. *Cognition, 71,* 73-108.

Thomas, E. M., & Senechal, M. (1998). Articulation and phoneme awareness of 3 year old children. *Applied Psycholinguistics, 19*(3), 363-433.

Thompson, G. B., Fletcher-Flinn, C. M., & Cotterell, D. S. (1999). Learning correspondences between letters and phonemes without explicit instruction. *Applied Psycholinguistics, 20,* 21-50.

Treiman, R. (1985). Onsets and Rimes as Units of Spoken Syllables: Evidence from Children. *Journal of Experimental Child Psychology, 39,* 161-181.

Treiman, R., & Breaux, A. M. (1982). Common phoneme and overall similarity relations among spoken syllables: their use by children and adults. *Journal of Psycholinguistic Research, 11*(6), 569-598.

Treiman, R., Tincoff, R., Rodriguez, K., Mouzaki, A., & Francis, D. J. (1998). The foundations of Literacy: Learning the sounds of letters. *Child Development, 69*(6), 1524-1540.

Velleman, S. L. (1988). The role of linguistic perception in later phonological development. *Applied Psycholinguistics, 9,* 221-236.

Wagner, R. K., Torgeson, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: new evidence of bi-directional causality from a latent variable longitudinal study. *Developmental Psychology, 30*(1), 73-87.

Walley, A. (1988). Young children's detections of word-initial and -final mispronunciations in constrained and unconstrained contexts. *Cognitive Development, 2,* 145-167.

Walley, A. (1993). The role of vocabulary development in children's spoken word recognition and segmentation ability. *Developmental Review, 13,* 286-350.

Webster, P. E., & Plante, A. S. (1995). Productive phonology and phonological awareness in pre-school children. *Applied Psycholinguistics, 16,* 43-57.

Werker, J. F., & Tees, R. C. (1984). Cross language speech perception: evidence for perceptual reorganisation during the first year of life. *Infant Behavioural Development, 7,* 49-63.

Werker, J. F., & Tees, R. C. (1999). Influences on infant speech processing: toward a new synthesis. *Annual Review of Psychology, 50,* 509-535.