

Explicit phoneme training combined with phonic reading instruction helps young children at risk of reading failure

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Background: We evaluate the effectiveness of three theoretically motivated programmes for the teaching of reading to four-year-old children. **Method:** Four hundred and ten children, of pre-kindergarten age, in 20 UK Reception-year classrooms were divided into four matched groups and randomly assigned to one of three experimental teaching conditions, Reading with Rhyme, Reading with Phoneme, Reading with Rhyme and Phoneme, or to a taught control condition (Reading). In each condition the Reading element contained a strong phonic component. **Results:** There were no selective effects of the different experimental teaching programmes for normally developing children. However, for those children identified as being at risk of reading failure, training in phoneme skills resulted in selective gains in phoneme awareness and in reading skills. **Conclusions:** A reading programme that contains a highly structured phonic component is sufficient for most 4.5-year-old children to master the alphabetic principle and to learn to read effectively, without additional explicit phonological training. In contrast, for young children at risk of reading delay, additional training in phoneme awareness and linking phonemes with letters is beneficial. **Keywords:** Longitudinal intervention, normal, at risk, phonological awareness, phoneme, rime (rhyme), reading, phonics. **Abbreviations:** C: consonant; V: vowel.

The strong association between phonological skills and reading attainment (Blachman, 1997; Goswami & Bryant, 1990; Rack, Hulme, & Snowling, 1993; Wagner & Torgesen, 1987) suggests that training in phonological awareness should be an effective foundation for teaching children of all levels of ability to learn to read (Lundberg, 1994; Lundberg, Frost, & Petersen, 1988 but see Olson, Wise, Johnson, & Ring, 1997). In support of this view a recent meta-analysis of 52 studies found the overall effect size of phonological awareness instruction on reading to be moderate ($d = .53$) (Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh, & Shanahan, 2001; National Reading Panel, 2000). However, training in phonological awareness has generally been shown to be more effective when it is combined with the teaching of reading (Ball & Blachman, 1991; Bradley & Bryant, 1983, 1985; Byrne & Fielding-Barnsley, 1989; Cunningham, 1990; Hatcher, Hulme, & Ellis, 1994; Iverson & Tunmer, 1993). This view was also supported by the findings of the National Reading Panel, where the mean effect size on reading for training that made explicit links with letters ($d = .67$) exceeded that for phonological awareness training alone ($d = .38$).

So far the majority of studies have focused on intensive, individual, or small group phonological training programmes (e.g., Byrne & Fielding-Barnsley, 1993, 1995; Torgesen, Wagner, & Rashotte, 1997; Torgesen et al., 1999; Santa & Høien, 1999; Levy & Lysynchuk, 1997). There have been fewer studies (e.g., Blachman, Tangel, Ball, Black, & McGraw, 1999; Foorman, Francis, Shaywitz, Shay-

witz, & Fletcher, 1997; Lundberg et al., 1988; Whitehurst et al., 1999) where class teachers have undertaken the training and only one (Byrne & Fielding-Barnsley 1995) where teachers have worked with large groups (10–15) of children in a pre-school setting. The extent to which phonological training linked to letters, given by class teachers, will help to facilitate the progress of learning to read in very young children (4.5 years) in groups of 10–15 has therefore to be established.

Byrne and Fielding-Barnsley (1995) found that their *Sound Foundations* programme was effective in teaching phoneme identity to groups of 11 to 14 children when employed by pre-school teachers, and Foorman et al. (1997) found that class teachers could successfully accelerate phonological development in kindergarten children. However, in neither of these studies is it clear whether the training generalised to performance on a standardised measure of 'regular and irregular' word reading. More recently, Whitehurst et al. (1999) reported that, although teachers were able to improve the phonological skills of children at Headstart Centres, the gains did not generalise to reading on standardised tests in the first and second grades.

One study in which generalisation to reading occurred was conducted by Blachman et al. (1999). In this study class teachers taught groups of 4 to 5 low-income inner-city children of kindergarten age (5:06 on entry). After a programme of lessons involving phonological awareness training, the children were superior to an unseen control group on measures of phonological awareness and regular word reading,

but not on another word reading test (Woodcock Word Identification). Based on their level of reading and phonological awareness, the children were assigned to groups of between 6 and 9 children in first-grade classrooms. In place of the normal basal reading programme, the children received further daily 30-minute sessions of phonological awareness training, sound linkage work, reading and writing. At the end of first grade the children who received this training did better than an unseen control group on measures of phoneme segmentation, letter identification and spelling but still did not read significantly better on the Woodcock Word Identification test. The children were again regrouped and assigned to second-grade classrooms where the children who had not completed the programme, or were reading below grade level, received additional sessions until the middle of the second grade. At the end of the second grade the treated children outperformed the unseen control group on reading but not on spelling. This study points to the success of classroom teachers in delivering a structured programme involving phonological awareness, sound linkage, reading and writing to young children. The present study attempts to extend such findings in the context of large group teaching to children a year younger.

A second important practical consideration concerns the optimal strategy for training children to 'link' their emerging phonological awareness to print. In the opaque orthography of English, there is significantly more regularity at the level of the orthographic rime than at the level of grapheme-phoneme correspondences (Treiman, Mullenix, Bijeljac-Babic, & Richmond-Welty, 1995). Arguably, therefore, it may be better to teach children to focus on links between their explicit awareness of rhymes and print, rather than to emphasise the linkage between phonemes and letters (or letter strings), because at this level they will be faced with inconsistency in spelling-sound correspondences.

Consistent with this view, Goswami and Bryant (1990) suggested that there may be two pathways to reading from phonological awareness; a direct route between awareness of rhyme and reading and an indirect route from rhyme to reading mediated by phoneme awareness. According to this model, the direct route operates from the outset of learning to read through the use of spelling/sound rime-analogies, whereas the indirect route operates a little later since it depends on the acquisition of phoneme awareness that is a consequence of reading. However, a problem for this view is that some children are able to identify or manipulate phonemes before starting to read (Bowey, 1994; Lundberg, 1994; Wimmer, Landerl, Linortner, & Hummer, 1991). Moreover, empirical research within this theoretical framework has tended to find that children use rime-analogies for reading later rather than earlier in acquisition (Duncan, Seymour, & Hill, 1997; Muter, Snowling, & Taylor, 1994; Savage & Stuart, 1998).

More generally, a number of studies have now shown that phonemic skill is a stronger predictor of early reading acquisition than onset-rime awareness (Duncan et al., 1997; Høien, Lundberg, Stanovich, & Bjaalid, 1995; Hulme et al., 2002; Muter, Hulme, Snowling, & Taylor, 1998). Training studies that compare the impact of training in onset-rime and phonemic skills on reading development may help to test alternative causal hypotheses about the relationships between phonological awareness and literacy development.

The evidence that has accumulated to date suggests that early readers learn words more quickly through onset-rime training than through phoneme, body-coda or post-vowel segmentation training. However, this might be at the expense of retention (Bruck & Treiman, 1992). Bruck and Treiman taught 39 Grade 1 children, who were at a very early stage of reading acquisition, to read 10 CVC clue words. The children then learned target words that shared the same rime (VC), body (CV) or peak (V). A day after the analogy training, the children were tested on the target words and were asked to read 20 nonwords that shared a body or rime unit with the clue words. The rime-analogy group learned the target words more quickly, but with the number of training-trials controlled, the rime-analogy group was the least successful of the three groups in remembering the target words a day later. It was the children taught using the peak (V) method who were the most successful in transferring their reading skills to nonwords. The need for further research concerning the effectiveness of large-unit phonic programmes is supported by the National Reading Panel (2000). In a meta-analysis of the data from 38 studies the panel found that the mean effect size for programmes that adopted a large unit approach ($d = .34$) was not significantly different from the synthetic small unit approach ($d = .45$). However, there were relatively few comparisons in the larger unit group and none involved children from kindergarten or pre-kindergarten.

The third issue addressed by the present study was whether it is possible to adapt teaching that has been shown to be effective in ameliorating reading delay (Hatcher, 2000a; Hatcher et al., 1994) for the prevention of reading difficulties. In this regard we were particularly interested in the progress of children judged to be at risk of reading delay on school entry. Although the National Reading Panel (2000) noted that children 'at risk' of reading delay are particularly advantaged by phonological awareness training, it remains to be established that children of 4.5 years who are judged to be at risk will also benefit.

At least three variables might be considered important in identifying children at risk of reading delay. The first is phonological awareness (Blachman, 1997; Goswami & Bryant, 1990; Rack et al., 1993; Wagner & Torgesen, 1987). In addition, letter-knowledge is a strong predictor of early reading

development (Gallagher, Frith, & Snowling, 2000; Stevenson & Newman, 1986), and its role appears to be independent of that played by phonological awareness (Muter et al., 1998; Share, Jorm, Maclean, & Matthews, 1984). Finally, vocabulary is predictive of both reading and phonological awareness (Bishop & Adams, 1990; Elbro, Borstrom, & Petersen, 1998; Lonigan, Burgess, & Anthony, 2000; Scarborough, 1989; Share et al., 1984), perhaps because vocabulary growth fosters the segmentalisation of phonological representations (Carroll & Snowling, in press; Fowler, 1991; Walley, 1993), and it is the distinctiveness of these which is responsible for individual differences in ease of reading acquisition (Elbro et al., 1998; Hulme & Snowling, 1992; Share et al., 1984; Swan & Goswami, 1997).

In summary, the present study addressed three main questions: 1. Does supplementing a structured approach to teaching reading (inclusive of phonics) with a package of phonological awareness training lead to gains in reading for children in Reception and Year-1 classes? 2. What is the optimal phonological unit to emphasise in oral phonological awareness training and linkage to print? 3. Are Reception and Year-1 children at risk of reading failure more likely to benefit from supplementary phonological awareness training than children judged to be not at risk of reading failure?

This longitudinal intervention study is an attempt to resolve an important theoretical issue (are small (phoneme) or large (onset-rime) phonological units more important for learning to read?) that has significant practical implications for how best to teach young children to read. This is a particularly important issue in the UK where children are encouraged to learn about rhyme, phonemes, rhyme-analogy and reading in their first year of education (Department for Education and Employment, 1998). The study was implemented in the context of classes of up to 30 children, where teachers delivered the phonological training to groups of between 10 and 15 children and where the children ranged in age from 4 to 5 years on school entry. The study involved 20 classes of children that received different modifications of the Reading Intervention with Sound Linkage programme employed by Hatcher et al. (1994) for children with reading difficulties.

Method

In the present study we examine the effectiveness of three different structured methods of linking phonological awareness to reading for children at school entry. In Britain the school year begins in September and is divided into three terms, each having a mid-term break of a week, separated by a total of 10 weeks of holiday. For ease of interpretation, points of assessment and intervention are presented on a time line with units of months, beginning with Month 1 when the children entered school. As illustrated in Figure 1, the children

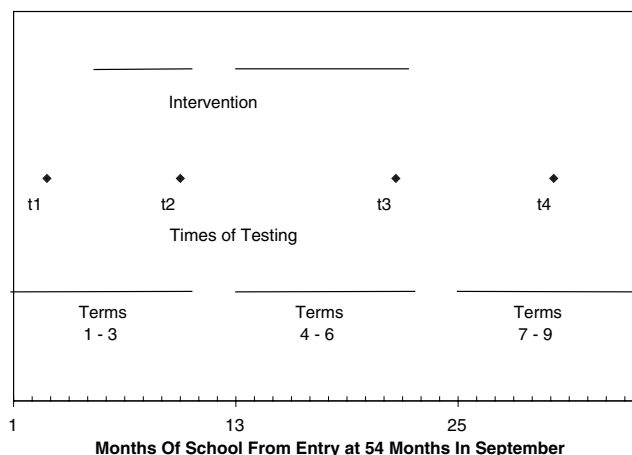


Figure 1 Timeline for period of intervention, times of testing and school terms

were assessed in months 2 and 3 (at the end of their first term, t1, mean age 4.65 years), in months 9 and 10 (at the end of their third term, t2, mean age 5.25 years) and in months 21 and 22 (at the end of their sixth term, t3, mean age 6.22 years). The intervention was conducted between months 5 and 22. To assess the durability of any effects on reading all children were reassessed in months 30 and 31 (mid-way through their eighth term in school, t4, mean age 6.93 years). We conducted two sets of analyses, one for the children judged to be developing normally and one for children considered to be at risk of reading failure (the poorest third of children based upon the average z-scores for vocabulary, letter identification, rhyme (detection and production) and phoneme skills (deletion of initial and final sounds)).

Participants

This longitudinal study began with 20 schools in the city of Carlisle, United Kingdom, who nominated a class of 4- to 5-year-old children to take part. The city of Carlisle is an urban area with an established service sector and a mixed economy. Its population is of mainly English extraction and is representative of the national profile for percentage of economically active semi- and unskilled people. It is over-representative of skilled manual and non-manual workers and under-representative of managerial and professional workers. After they had been in school for a month, the children (none of whom had clinically assessed Special Educational Needs) were assessed on a battery of cognitive measures. Based upon the age, general IQ, letter identification, phonological awareness and early word reading scores for these children ($N = 524$), and measures related to schools (percentage of rented housing, amount of classroom support and number of years since the teacher trained), the 20 classes (one per school) were assigned to one of four matched groups (five classes per group). The groups were then randomly assigned to one of three intervention conditions or to a taught control condition. During the period of intervention, 72 children were lost from the study, due to changes of school or to a move out of the area. Also, at the start of the

Table 1 Means (and standard deviations) for individual (age, general IQ, letter identification, phonological awareness, reading, $N = 410$) and school measures (rented housing, year of teacher training, classroom support, $N = 20$) used to assign schools to groups

	Group				
	Reading with Rhyme and Phoneme	Reading with Rhyme	Reading with Phoneme	Reading alone	
<i>Individual measures:</i>	($N = 102$)	($N = 106$)	($N = 113$)	($N = 89$)	$F(3,406)$ ratio
Age	4.69 (.28)	4.62 (.28)	4.66 (.30)	4.65 (.32)	<1.0
General IQ ¹	100.54 (13.07)	98.97 (13.56)	100.59 (11.02)	99.86 (12.03)	<1.0
Letter identification ²	3.06 (3.53)	3.42 (3.87)	3.19 (3.81)	3.28 (3.55)	<1.0
Phonological awareness ³	99.05 (13.96)	98.78 (13.68)	101.50 (16.30)	100.64 (15.96)	<1.0
Early word recognition ⁴	.95 (4.70)	1.24 (2.67)	1.66 (5.23)	2.36 (3.17)	2.08
<i>School measures</i>	($N = 5$)	($N = 5$)	($N = 5$)	($N = 5$)	$F(3,16)$ ratio
Rented housing ⁵	28.20 (17.36)	33.40 (24.59)	35.40 (12.76)	26.20 (27.62)	<1.0
Year teacher trained ⁶	11.40 (4.28)	16.20 (8.98)	17.40 (14.08)	19.40 (9.66)	<1.0
Hours classroom support ⁷	12.80 (7.23)	16.20 (5.25)	18.70 (2.77)	13.60 (9.39)	<1.0

Notes: ¹The standardised scores (Mean 100, SD 15) were derived from Receptive Vocabulary and Matrices.

²Maximum score = 12.

³The standardised scores (Mean 100, SD 15) were derived from a Principal Components Analysis ($N = 410$) of the Rhyme production and detection scores and the initial and final phoneme deletion scores.

⁴Maximum score = 42.

⁵Percentage of homes that were rented.

⁶Number of years since the class-teacher was trained to be a teacher.

⁷Maximum number of additional hours of classroom support per week = 22.5.

children's second year in school (aged 5.5 years), some classes were split and 42 children who transferred to mixed year-group classes were lost because the majority of their new classmates were not participants in the study. This left 410 children for whom there were complete data between t1 and t4. Descriptive statistics for the individual and school grouping measures for these children are shown in Table 1.

Assessment battery

At the beginning of the project, all children received a large battery of tests measuring receptive vocabulary and non-verbal ability, letter identification, reading, spelling, arithmetic, language, memory span, speech rate and phonological skills. These tests were administered in a fixed order in three sessions. At the subsequent times of testing, the battery of tests, apart from matrices, was repeated. We describe here the subset of 12 measures discussed in the present paper.

General cognitive ability. General ability was estimated using measures of receptive vocabulary and matrices.

Vocabulary: The *English Picture Vocabulary Test* (Brimer & Dunn, 1973) was used to provide a measure of receptive vocabulary. The test requires the child to match spoken words to one of four pictures.

Matrices: A matrices test was constructed to provide a measure of children's non-verbal ability. The test consisted of 20 graded items. For the first 12 items, children were expected to select one of ten 2.5 cm squares containing a shape such as a circle or a triangle to complete a 4-, 6- or 9-block pattern. The remaining 8 items required children to draw the missing shape on their record sheet. Two practice items were provided and the test was discontinued after five consecutive

errors. The score was the number of patterns completed correctly. At t3, the *Naglieri Nonverbal Ability Test A* (Naglieri, 1996) was used to provide a standardised (group administered) measure of non-verbal ability. In this test, children are required to identify one of five shapes to complete a set of patterns. There are 38 items and the test was administered to groups of up to 10 children at a time.

Literacy skills. Letter identification: Ability to identify letters was assessed at t1 using 8 obstruent (c, d, f, h, j, p, s, t) and 2 non-obstruent (m, r) consonants and two vowels (e, u). The full set of 26 letters was used at the later times of testing. Scoring was based upon the total number of letters identified, whether by name or by sound. There was a maximum of 12 points at t1 and 26 at each other time of testing.

Reading: Progress in reading was assessed by tests of word and nonword pronunciation. The *Early Word Recognition Test* (Hatcher, 1992) was used to differentiate the progress of children at an early stage of acquiring a 'sight vocabulary'. It consists of 42 words found at the first book stage of seven different reading schemes used in the schools participating in the study. Scoring was based upon the total number of words read aloud correctly. The *British Ability Scales (BAS) Word Reading Test A* (Elliot, Murray, & Pearson, 1983) was used as a standardised measure of context-free word-recognition. The test consists of a graded list of 90 regular and exception words and is discontinued after 10 consecutive errors. The *Graded Nonword Reading Test* (Snowling, Stothard, & McLean, 1996) was used to provide a relatively pure measure of phonic decoding skill. The 20-item test is graded in difficulty from items containing four phonemes such as 'hast' to phonically complex items such as 'sloskon'. There are five 'CVC' practice words, and testing only took place where children

obtained a score on the practice items. Testing was discontinued after four consecutive failures. The score was the number of nonwords read aloud correctly.

Arithmetic. The *BAS Basic Number Skills Test: Test C* (Elliot et al., 1983) was used to measure arithmetical skills. The test consists of 34 paper and pencil problems of graded difficulty. To avoid floor effects, these were supplemented by 15 graded items that required children to count (objects and pictorial items), to write number symbols and to complete 'simple' addition tasks using symbols (e.g., $4 + 0 =$). The test was discontinued after six consecutive failures but with the first three BAS items always being administered. The score was the number of items correct.

Phonological skills. Phonological skills were measured using two measures of rhyme awareness (detection and production) and two measures of phoneme awareness (initial and final phoneme deletion).

Rhyme detection: The 10-item rhyme detection sub-test from the *Phonological Abilities Test* (Muter, Hulme, & Snowling, 1997) and 22 other more difficult items that were presented without pictures (after Snowling, Hulme, Smith, & Thomas, 1994) were used to measure children's ability to detect rhyme in spoken words. There were two practice items and corrective feedback was provided for the first four test items. Two additional practice items were provided before the non-pictorial items. For the first ten items (with pictures) children were required to indicate which of three words rhymed with a named stimulus word. For the remaining items they were required to select two of three words that sounded the same at the end (e.g., job and rob, from job, knock, rob). The test was discontinued after four consecutive errors and the score was the total number of items responded to correctly.

Rhyme production: The rhyme production test from the *Phonological Abilities Test* (Muter et al., 1997) was used to measure the ability to produce rhyming words. It was supplemented by two items, 'pet' and 'note', in which children were also given 30 seconds in which to articulate words that rhymed with the stimulus word. The score was the total number of words (including nonwords) that rhymed with the stimulus words.

Phoneme deletion: The phoneme deletion sub-tests (initial and final sounds) from the *Phonological Abilities Test* (Muter et al., 1997) were used to measure phoneme awareness. Children are required to pronounce words without the beginning or end sound, for example to 'say the word "tin" without the /t/'. The 8-item tests (with pictures for each stimulus) were supplemented by 16 items (without pictures), making a total of 24 items for each sub-test. In each sub-test, the first 15 words contained three phonemes. The rest of the words contained consonant clusters, with the phoneme to be deleted being the first or last of two consonants (e.g., /s/ from stop, and /d/ from wind). For each sub-test there were four practice items and corrective feedback was given to the first four test items. Testing was discontinued after four consecutive failures. Where children failed to achieve a score on the first sub-test (initial sounds) and they did not understand the practice items for the second sub-test, testing was also discontinued. The scores were the total of correct responses for each subtest.

Teaching procedures

Our aim was to contrast the effectiveness, in teaching young children to read, of a structured reading programme that included phonics with programmes that in addition included a package of explicit phonological awareness and linkage training (rhyme, phoneme or

Table 2 Content of the four teaching programmes

	Reading alone	Reading with Rhyme	Reading with Phoneme	Reading with Rhyme and Phoneme
Reading				
Concepts about print	✓	✓	✓	✓
Letter identification	✓	✓	✓	✓
Word reading	✓	✓	✓	✓
Phonics	✓	✓	✓	✓
Writing	✓	✓	✓	✓
Spelling	✓	✓	✓	✓
Text reading	✓	✓	✓	✓
Sound linkage (synthetic, spelling and embedded phonics)	✓	✓	✓	✓
Explicit training in phonological awareness and linkage				
Word identification		✓	✓	✓
Syllable identification		✓	✓	✓
Rhyme supply		✓		✓
Onset-rime linkage ¹		✓		✓
Phoneme blending and linkage ²			✓	✓
Phoneme discrimination			✓	✓
Phoneme segmentation and linkage ²			✓	✓
Phoneme deletion and linkage ²			✓	✓
Phoneme substitution and linkage ²			✓	✓
Phoneme transposition and linkage ²			✓	✓

Notes: ¹There were 18 explicit rhyme linkage activities in the structured phonological training programme.

²There were 14 explicit phoneme linkage activities in the structured phonological training programme.

both rhyme and phoneme awareness and linkage training). Each programme (the main details for which are described below; see also Table 2) was implemented over 14.5 months (5.4 months during terms 2 and 3 of the first school year and 9.1 months during the second school year). For each class there was a change of teacher at the start of the second school year. The reading programme involved children being taught as a class, in groups and as individuals, while the phonological awareness programmes were taught to groups of 10 to 15 children for three 10-minute sessions per week. The same amount of teaching time was dedicated to the teaching of 'reading' in all four conditions. During the time that the experimental groups received work on phonological awareness, the control group spent additional time on reading.

For each of the two years of intervention, the 20 teachers in the four conditions (40 in total) were granted leave from teaching to receive three days of training prior to their period of intervention. They also received three half-day tutorials each year and were visited regularly by the principal investigator. Prior to these visits, they completed an outline diary indicating the weeks in which weekly records and running-records (after Clay, 1985) had been completed for each child. They also completed a teaching record that indicated the amount of time they had devoted to class, group and individual work and the activities they had undertaken during the previous four to six weeks. At the end of each year, teachers completed a questionnaire detailing the priority they had attached to aspects of their teaching, for example in teaching letter identification, sight words, phonics and sounds in words. They also completed a questionnaire detailing events that might have placed additional demands on them during the course of the school year. In the first year, classes were provided with a set of 160 graded books and in the second year with a further 128 graded books. They were also provided with a list of about 1500 graded books (Hatcher, 2000b), two sets of magnetic letters and a magnetic whiteboard.

Reading programme. The Reading programme, adapted from the approach of Hatcher et al. (1994), required teachers to organise class, group and individual reading for children into five areas. These were i) concepts about print, ii) letter identification (sounds and names), iii) word reading, iv) writing and spelling (including phonics) and v) text reading. The programme required teachers to maintain weekly records for individual children and to relate teaching goals to their attainments. For example, where appropriate, weekly records of text reading ability were required. The programme contained a range of teaching strategies for each of the five areas. For example, under 'sound linkage in reading and spelling', children were encouraged to make the link between sounds and the written form of words using text, plastic letters and a magnetic letter board, as well as in their writing. Phonic skills were taught in the sequence initial sounds and blends in CVC and CCVC words such as 'cat' and 'flat', final and medial sounds in CVC words, vowel digraphs in CVVC and CCVVC words (e.g., /ee/ in 'feet' and 'sleep'), final blends (e.g., 'ld' in 'hold') and the final 'e' rule. Using the National Reading Panel (2000) ter-

minology, the phonic approach combined synthetic phonics (conversion of letters to sounds, and blending sounds), phonics through spelling (segmenting words into phonemes and selecting letters) and embedded phonics (relating phonic skills to unknown words in text). Under text reading, teachers were encouraged to listen to children read appropriately graded text, or to share a book with them, once a week while taking a running record of their reading behaviour. Although the programme was highly structured, it left responsibility for the selection of teaching activities and goals to teachers and permitted teachers to delegate responsibility for some activities to their support assistants.

Each term, teachers were required to complete a comprehensive reading profile for each child. For example, for 'word reading', teachers were expected to record the number of words (to 50) that a child could identify without prompting. They also recorded their ability to use letter-sound relationships (initial, final, medial, initial blend, onset-rime, final blend, vowel digraphs, consonant digraphs) to read unknown words. In order to facilitate this summative assessment, the programme contained a battery of assessment procedures; e.g., for 'writing and spelling' there were assessment measures that covered written vocabulary, sounds in writing and level of written language.

Reading with Rhyme programme. The reading part of this programme was equivalent to that for the Reading programme but was supplemented by a structured and simultaneously administered package of rhyme and rime-linkage training. This included seven sections involving a graded sequence of word, syllable, rhyme awareness and rhyme production tasks based broadly on the activities referred to by Hatcher (2000c), Lewkowicz (1980), Lundberg et al. (1988), Rosner (1975), Stanovich, Cunningham, and Cramer (1984) and Yopp (1988). The sections covered the identification of words as units within sentences, the identification and manipulation of syllables, the discrimination of rhyming words, rhyme supply (with semantic clues) and, importantly for this programme, prescribed onset-rime linkage activities with plastic letters using words from known rhymes and poems. One of the activities (identification of two out of three words that shared a rhyme) was equivalent to that used to assess phonological awareness, in that it involved the same task but different stimuli. The rime correction and supply activities were linked to an anthology of 200 rhymes and poems that was compiled for the research. Within the anthology, the verses were graded for 'level of difficulty' by taking account of variables such as the number of lines of verse, the number of words per line and the pattern of rhyming words in each verse. An appendix included a list of 176 common single-syllable rimes that were phonically regular, the poems in which they could be found and similar sounding but differently spelt rimes. The incidence of these variables was given to enable teachers to select rimes according to frequency and regularity. By way of example, the first 18 rime-linkage activities involved rimes that were frequently found in poems and were less likely to be confused with rimes that shared a rhyme but were spelt differently. A table of double and triple letter onsets was

also provided to help teachers to construct additional activities.

Progress through the activities, as sequenced in the package, was determined by 75% of the items in an activity being completed accurately (one item per child) by children who were representative of the group. Progression through the sections was based upon 75% of the activities within a section being completed with success. Teachers maintained a weekly record of the number of teaching sessions per group and of the activities covered.

Reading with Phoneme programme. The reading part of this programme was equivalent to that for the Reading programme but was supplemented by a structured and simultaneously administered package of phoneme and phoneme-linkage training. This included eight sections comprising a graded sequence of word, syllable and phoneme tasks that were broadly based on the activities referred to by Hatcher (2000c), Lewkowicz (1980), Lundberg et al. (1988), Rosner (1975), Stanovich et al. (1984) and Yopp (1988). The sections covered the identification of words as units within sentences, the identification and manipulation of syllables, phoneme blending, the identification and discrimination of phonemes and phoneme segmentation, deletion, substitution and transposition. Each section contained a number of activities that varied in terms of teaching mode and level of stimulus difficulty. After work that was purely phonological, each of the phoneme manipulation sections (blending, segmentation, deletion, substitution and transposition) concluded with phoneme-linkage activities using plastic letters. These activities differed from the teacher-initiated phonic-linkage activities in being part of a graded sequence of phonological awareness training. Two of the phonological activities (initial and final phoneme deletion) were equivalent to those used to assess phonological awareness, in that they involved the same task but different stimuli. Additional activities were provided for each section in order that the programme could continue after completion of the prescribed activities.

Progress through the activities, and through the sections, was effected in an equivalent manner to the Rhyme programme, and teachers maintained equivalent records.

Reading with Rhyme and Phoneme programme. This programme included the Reading programme and a structured and simultaneously administered programme of rhyme and phoneme awareness with linkage training. For this programme, the sections from the Rhyme and Phoneme programmes were interleaved. They followed the sequence: identification of words as units within sentences, identification and manipulation of syllables, discrimination of rhyming words, phoneme blending, identification and discrimination of phonemes, rhyme correction and supply (with semantic clues), phoneme segmentation, rhyme linkage, phoneme deletion, rhyme linkage, phoneme substitution, rhyme linkage, phoneme transposition.

Progress through the activities, and through the sections, was effected in an equivalent manner to the Rhyme and Phoneme programmes and teachers maintained equivalent records to those programmes.

Fidelity of intervention

The fidelity of the intervention was monitored by using a diary of qualitative observations made during visits to schools and through teacher questionnaires and records. During the five terms of intervention, the comments of teachers and other qualitative observations about their delivery of the teaching programmes were recorded in a diary maintained by the principal investigator.

Data from the teaching records and the annual teacher questionnaire (see Table 3) suggest that there was no significant difference between groups in the amount of literacy teaching undertaken. Teachers devoted approximately 36 minutes per day to class teaching, 27 minutes to group teaching and 16.6 minutes to hearing individuals read. Over the five terms, approximately 8.25 minutes per day were spent on letter identification (both letter sounds and letter names).

Tukey HSD tests, with alpha set at .05, indicated that, in line with their programme of phonological awareness training, the teachers in the Rhyme group attached greater priority to teaching rhyme (moderate to high priority) than the teachers in the groups where rhyme was not taught (Phoneme and Reading, low to moderate priority). Otherwise (see Table 3) there were no significant differences between groups in the priority (moderate to high) that teachers attached to different aspects of teaching (concepts of initial and final phonemes, phonics, sight words and reading comprehension).

The records for the administration of the programmes of phonological awareness training (see Table 3) indicate that on average teachers worked with 2.48 groups of children and provided them with three 10-minute sessions (30 minutes) of training per week for 40.92 weeks over the period of intervention. This amounts to 20.46 hours, or 73% of the suggested time. The Reading with Phoneme group received the equivalent of 8.5 weeks more training in phonological awareness than the Reading with Rhyme group, and 5.9 weeks more training than the Reading with Rhyme and Phoneme group, but the ANOVA revealed no significant difference between groups for the amount of time spent on phonological skills training. Since the ANOVA, with a low *N* per group, may have lacked sufficient power to detect a difference, correlations were calculated between the number of weeks of training for each school (*N* = 20) and the outcome measures of nonword and word reading. These revealed a significant association between time spent on phonological skills training and nonword reading ($r = .54$) but not for word reading ($r = .26$) in the children at risk of reading delay. The corresponding correlations in the normal children (.37 nonword, .36 word) were not significant.

Results

For the normally developing children, descriptive statistics for all measures in the study at each time of testing are presented in Table 4 together with reliabilities for the measures. Cronbach's alpha coefficient is above .90 for 7 of the measures and

Table 3 Means (and standard deviations) for teacher rating of time spent teaching (class, groups, individuals, letter identification), priority attached to teaching strategies (rhyme, phonemes, phonics, sight words, comprehension) and arrangements for phonological training

	Group				<i>F</i> (3,36) ratio
	Reading with Rhyme and Phoneme	Reading with Rhyme	Reading with Phoneme	Reading alone	
<i>Time teaching:</i>	(<i>N</i> = 10)	(<i>N</i> = 10)	(<i>N</i> = 10)	(<i>N</i> = 10)	
Class ¹	2.30 (.48)	2.40 (.70)	2.20 (.42)	2.30 (.67)	<1.0
Groups ¹	2.20 (.42)	1.70 (.48)	1.90 (.74)	1.60 (.52)	2.29
Individuals ¹	1.3 (.42)	2.68 (.41)	2.46 (.50)	2.48 (.51)	1.81
Letter-identification ²	2.00 (.47)	2.10 (.74)	2.50 (.53)	2.00 (.47)	1.79
<i>Priority for teaching:</i>					
Concept of rhyme ³	2.20 (.79)	2.70 (.67)	1.60 (.70)	1.60 (.70)	5.50**
Concept of initial and final phonemes ³	2.70 (.48)	2.50 (.53)	2.70 (.67)	2.30 (1.06)	<1.0
Phonics ³	2.75 (.42)	2.50 (.53)	2.65 (.67)	2.30 (.67)	1.13
Sight words ³	2.20 (.42)	2.30 (.67)	2.55 (.69)	2.20 (.63)	<1.0
Comprehension ³	2.30 (.48)	2.50 (.71)	2.20 (.42)	2.40 (.52)	<1.0
<i>Structured phonological training:</i>					<i>F</i> (2,12) ratio
Number of groups	2.30 (.83)	2.73 (.34)	2.40 (.90)	–	<1.0
Number of weeks ⁴	39.79 (7.26)	37.23 (2.67)	45.73 (6.48)	–	2.80

Notes: ¹Scores (1 to 3) assigned to ratings 1 to 20 minutes, 21 to 40 minutes, 41 to 60 minutes per day.

²Scores (1 to 3) assigned to ratings <5 minutes, 5 to 10 minutes, 10 to 15 minutes per day.

³Scores (1 to 3) assigned to ratings low, moderate, high priority per year.

⁴Weeks over the five terms of training that children received 3 × 10 minutes of structured phonological (oral), and sound linkage, training.

***p* < .01.

close to or above .70 for the other 3. The equivalent statistics for the at-risk children are presented in Table 5.

From these tables it is apparent that between groups at t1 the normally developing children differed on Receptive vocabulary and Matrices and the at-risk children differed in reading. These differences were controlled for statistically in subsequent analyses. It is also evident that among the normally developing children there were outliers for reading, phoneme skill and rhyme skill. Following the recommendation of Tabachnick and Fidell (1989), outliers were recoded to have *z*-values of 3.49 in preference to discarding them. All analyses were conducted twice, with the outliers recoded and without recoding. As the pattern of results was identical, only the analyses of the raw data (including outliers) are reported.

The primary purpose of the study was to determine whether programmes that differed in the trained unit of phonological analysis varied in their benefits for early reading. However, a preliminary issue was to determine whether the phonological training programmes themselves were successful. For three of the intervention groups (Reading with Rhyme, Reading with Phoneme, Reading with Rhyme and Phoneme) an integral part of the teaching programme was training in phonological awareness. For the normal (*N* = 273) and at-risk children (*N* = 137) we compared the post-training attainments of these three groups in rhyme and phoneme skills to those for the group that had received the reading programme alone (Reading). It might be expected that

the two groups that had received training in phoneme skills would exhibit better phoneme skills than the Reading alone group and that the two groups that had received training in rhyme skills would exhibit better rhyme skills than the Reading alone group. Additionally, we might expect training in rhyme to influence phoneme skills, because rhyme training by definition involves the segmentation of onset and rime units, and in English, onsets are often phonemes. Conversely, it was considered to be less likely that training with phonemes would influence rhyme.

In order to reduce the number of variables involved in the analyses, Factor scores, based on the full sample of children (*N* = 410), were computed for the t1, t2 and t3 measures of rhyme (production and detection) and phoneme (initial and final deletion) ability. Six Principal Components Analyses indicated that the rhyme factors accounted for 72%, 80.3% and 78.3% of the variance at t1, t2 and t3 respectively, and the corresponding figures for the phoneme factors were 70.5%, 75.9% and 80.7%. For each group of normally developing children, the means (and standard deviations) for the two measures are shown in Table 6. The equivalent data for the at-risk children are shown in Table 7. All scores for the normally developing children are above 100 and those for the at-risk children are less than 100. For both the normally developing and at-risk groups, changes in standardised scores over time reflect change relative to the other children in the full sample (*N* = 410).

Table 4 Means (and standard deviations)¹ for age, receptive vocabulary, matrices, general ability, letter identification, reading, arithmetic, rhyme and phoneme in the four groups of normally developing children ($N = 273$)

		Group				$F(3,269)$ ratio
		Reading with Rhyme and Phoneme ($N = 60$)	Reading with Rhyme ($N = 70$)	Reading with Phoneme ($N = 82$)	Reading alone ($N = 61$)	
Age	t1	4.73 (.26)	4.66 (.29)	4.68 (.30)	4.68 (.30)	<1.0
Receptive vocabulary ($\alpha = .94$)	t1	105.53 (13.15)	107.54 (11.90)	103.72 (12.42)	110.51 (10.69)	4.16**
Matrices ($\alpha = .78$)	t1	107.96 (13.12)	107.54 (11.90)	103.72 (12.42)	110.51 (10.69)	5.428***
General ability	t1	106.49 (10.96)	105.31 (10.36)	104.10 (9.09)	104.53 (9.94)	<1.0
Letter	t1	4.70 (3.71)	4.83 (4.03)	4.18 (4.02)	4.34 (3.71)	<1.0
identification ²	t2	19.78 (5.00)	20.63 (5.49)	19.51 (6.62)	19.75 (6.72)	<1.0
($\alpha = .69$)	t3	24.17 (1.44)	23.49 (3.19)	23.89 (1.80)	23.85 (2.32)	<1.0
	t4	24.75 (1.42)	24.66 (1.83)	24.33 (1.88)	24.31 (1.91)	<1.0
Early word	t1	1.58 (6.07)	1.87 (3.10)	2.21 (6.05)	2.92 (3.48)	<1.0
recognition ³	t2	11.77 (10.99)	14.47 (9.17)	13.07 (11.24)	15.26 (12.30)	1.24
($\alpha = .96$)	t3	32.53 (8.78)	30.94 (11.66)	31.20 (10.56)	31.31 (13.37)	<1.0
	t4	38.32 (4.74)	36.97 (8.24)	36.76 (8.14)	37.18 (7.31)	<1.0
BAS word	t1	1.40 (8.07)	.54 (1.79)	1.30 (8.46)	.41 (1.05)	<1.0
reading ⁴	t2	6.91 (12.99)	6.57 (6.49)	8.34 (12.41)	8.51 (11.23)	<1.0
($\alpha = .98$)	t3	27.3 (19.26)	27.31 (18.20)	27.07 (20.03)	30.34 (22.89)	<1.0
	t4	45.07 (19.89)	43.40 (21.77)	41.63 (21.51)	45.57 (22.43)	<1.0
Nonword	t1	.20 (1.55)	.01 (.12)	.18 (1.55)	.03 (.26)	<1.0
Reading ⁵	t2	1.02 (2.59)	.51 (1.34)	1.49 (3.39)	1.31 (3.35)	1.67
($\alpha = .96$)	t3	5.23 (5.37)	5.00 (5.34)	5.46 (5.82)	5.43 (6.32)	<1.0
	t4	9.20 (6.63)	8.63 (6.56)	8.26 (6.64)	8.38 (6.76)	<1.0
BAS	t1	7.80 (2.86)	7.24 (2.42)	7.33 (2.60)	7.28 (2.72)	<1.0
arithmetic ⁶	t2	10.87 (2.67)	10.30 (2.22)	10.94 (2.92)	10.97 (3.09)	<1.0
($\alpha = .84$)	t3	15.93 (3.55)	15.99 (3.70)	14.90 (3.28)	16.11 (3.62)	1.92
	t4	19.63 (3.48)	17.91 (3.66)	18.62 (3.85)	18.49 (3.72)	2.38
Rhyme	t1	6.45 (4.53)	5.39 (4.48)	6.48 (4.96)	7.00 (4.91)	1.37
detection ⁷	t2	11.68 (4.59)	12.59 (5.80)	10.99 (5.83)	10.08 (5.99)	2.35
($\alpha = .94$)	t3	17.47 (7.37)	16.03 (7.49)	16.33 (8.65)	15.51 (8.29)	<1.0
	t4	19.87 (6.91)	19.23 (8.30)	19.15 (7.77)	19.44 (7.73)	<1.0
Rhyme	t1	1.53 (2.94)	2.06 (3.57)	2.59 (4.37)	1.93 (3.66)	<1.0
production	t2	8.68 (5.95)	9.49 (6.49)	6.50 (5.56)	5.41 (5.17)	6.98***
	t3	13.47 (6.66)	14.97 (6.59)	11.39 (5.80)	12.49 (7.61)	3.90**
	t4	17.77 (7.29)	16.69 (6.95)	13.95 (6.42)	17.48 (7.30)	4.66**
Sound	t1	1.00 (3.20)	.57 (2.18)	.61 (2.78)	.43 (2.12)	<1.0
deletion	t2	4.50 (5.83)	5.30 (6.21)	4.94 (6.41)	3.57 (5.71)	<1.0
(initial) ⁸	t3	11.85 (5.25)	11.69 (5.47)	12.40 (5.53)	10.38 (6.61)	1.51
($\alpha = .95$)	t4	16.52 (4.52)	14.89 (6.61)	15.63 (6.65)	14.38 (6.77)	1.37
Sound	t1	1.00 (2.79)	.83 (2.25)	.82 (2.80)	1.28 (3.59)	<1.0
deletion	t2	4.10 (5.89)	4.43 (6.10)	5.12 (6.44)	3.82 (5.90)	<1.0
(final) ⁸	t3	11.53 (6.68)	9.89 (6.53)	9.93 (7.06)	9.59 (7.32)	<1.0
($\alpha = .97$)	t4	17.78 (6.79)	15.17 (8.66)	15.99 (8.66)	15.87 (7.82)	1.19

Notes: ¹Raw scores are presented apart from those for listening vocabulary, matrices and general ability which are expressed as standardised scores with a mean of 100 and a SD of 15.

²Maximum score = 12 at t1 otherwise 26.

³Maximum score = 42.

⁴Maximum score = 90.

⁵Maximum score = 20.

⁶Maximum score = 49 (inclusive of 15 items added to the beginning of the test).

⁷Maximum score = 32.

⁸Maximum score = 24.

** $p < .01$; *** $p < .001$.

For the normally developing children (Table 6) there is a tendency for the groups that received training in rhyme to make gains relative to the groups that did not, while for phoneme skills, the normally developing Reading alone group (who did not receive any type of explicit phonological training) appeared to be disadvantaged compared to all of the other 3 groups. For the at-risk children (Table 7) there is a tendency for the group that

received training in 'Rhyme and Phoneme' manipulation to make gains in rhyme relative to the Reading alone group. In contrast, the Reading with Phoneme group appears to have made less progress in rhyme skills than the Reading alone group. For phoneme skills, all three groups that received training in phonological awareness appear to have made gains relative to the Reading alone group.

Table 5 Means (and standard deviations)¹ for age, receptive vocabulary, matrices, general ability, letter identification, reading, arithmetic, rhyme and phoneme by group for the children at risk of reading delay ($N = 137$)

Measure		Group				$F(3,133)$ ratios
		Reading with Rhyme and Phoneme ($N = 42$)	Reading with Rhyme ($N = 36$)	Reading with Phoneme ($N = 31$)	Reading alone ($N = 28$)	
Age	t1	4.63 (.29)	4.55 (.26)	4.60 (.28)	4.59 (.28)	<1.0
Receptive vocabulary ($\alpha = .94$)	t1	86.96 (11.19)	85.19 (11.85)	87.86 (9.99)	88.61 (10.65)	<1.0
Matrices ($\alpha = .78$)	t1	97.11 (16.00)	88.08 (14.39)	94.75 (15.38)	90.78 (15.34)	2.57
General ability	t1	92.04 (11.04)	86.64 (10.17)	91.30 (10.37)	89.70 (9.81)	1.95
Letter identification ²	t1	.71 (1.17)	.67 (1.04)	.55 (.77)	.96 (1.55)	<1.0
($\alpha = .69$)	t2	10.45 (7.03)	13.11 (8.13)	13.13 (7.08)	12.82 (9.19)	1.07
	t3	21.40 (4.36)	21.42 (4.57)	22.65 (3.76)	22.39 (4.69)	<1.0
	t4	23.33 (1.96)	23.17 (3.83)	23.35 (2.86)	22.93 (3.90)	<1.0
Early word recognition ³	t1	.05 (.31)	.00 (.00)	.23 (.62)	1.14 (1.90)	10.21**
($\alpha = .96$)	t2	2.88 (4.35)	4.17 (4.44)	3.19 (5.52)	4.79 (6.52)	<1.0
	t3	20.50 (10.43)	17.94 (13.00)	20.68 (11.15)	19.32 (10.89)	<1.0
	t4	31.48 (8.79)	29.72 (11.62)	30.94 (11.32)	27.86 (9.17)	<1.0
BAS word reading ⁴	t1	.00 (.00)	.00 (.00)	.03 (.18)	.14 (.45)	2.95*
($\alpha = .98$)	t2	.69 (1.31)	1.39 (1.96)	1.42 (3.20)	1.75 (2.74)	1.34
	t3	11.43 (9.63)	10.36 (9.55)	13.65 (12.44)	10.36 (8.39)	<1.0
	t4	26.71 (16.93)	24.11 (16.56)	27.00 (19.13)	20.75 (15.27)	<1.0
Nonword reading ⁵	t1	.00 (.00)	.00 (.00)	.00 (.00)	.00 (.00)	–
($\alpha = .96$)	t2	.00 (.00)	.00 (.00)	.00 (.00)	.14 (.76)	1.31
	t3	2.02 (3.13)	1.33 (2.60)	3.00 (4.16)	1.18 (2.75)	2.09
	t4	4.90 (5.26)	4.11 (5.08)	6.03 (6.86)	2.00 (3.79)	2.97*
BAS arithmetic ⁶	t1	4.17 (2.00)	4.06 (1.76)	4.35 (1.96)	4.43 (1.87)	<1.0
($\alpha = .84$)	t2	8.23 (2.59)	7.92 (2.58)	7.97 (2.24)	8.75 (2.10)	<1.0
	t3	12.83 (3.53)	11.89 (3.08)	11.90 (3.17)	13.32 (2.92)	1.54
	t4	16.71 (3.40)	14.94 (3.79)	15.45 (3.93)	16.00 (3.45)	1.67
Rhyme detection ⁷	t1	1.19 (1.80)	1.00 (1.49)	1.74 (1.98)	.75 (1.40)	1.87
($\alpha = .94$)	t2	7.93 (6.27)	5.67 (5.60)	5.39 (5.31)	4.32 (4.55)	2.70*
	t3	11.60 (6.74)	9.72 (7.10)	7.19 (5.62)	9.14 (6.21)	2.80*
	t4	15.19 (7.37)	12.61 (7.21)	13.26 (7.20)	15.11 (6.09)	1.21
Rhyme production	t1	.05 (.22)	.11 (.32)	.23 (.62)	.11 (.32)	1.30
	t2	5.38 (5.88)	3.81 (5.19)	3.71 (4.99)	2.93 (4.61)	1.39
	t3	10.24 (6.54)	8.06 (6.91)	6.03 (5.64)	8.25 (6.96)	2.49
	t4	13.38 (6.57)	11.31 (7.14)	12.00 (8.80)	13.46 (6.99)	<1.0
Sound deletion (initial) ⁸	t1	.02 (.15)	.03 (.17)	.03 (.18)	.14 (.36)	2.08
($\alpha = .95$)	t2	.81 (2.71)	.63 (2.36)	1.13 (2.95)	.14 (.59)	<1.0
	t3	6.64 (6.19)	5.92 (6.32)	7.29 (6.90)	3.36 (5.83)	2.10
	t4	11.55 (5.98)	10.11 (7.22)	10.74 (7.81)	9.07 (7.21)	<1.0
Sound deletion (final) ⁸	t1	.00 (.00)	.00 (.00)	.03 (.18)	.00 (.00)	1.14
($\alpha = .97$)	t2	1.33 (3.65)	2.08 (4.26)	1.74 (4.49)	.82 (3.13)	<1.0
	t3	6.00 (6.44)	6.69 (6.79)	6.48 (6.95)	2.86 (5.17)	2.30
	t4	10.31 (8.61)	10.33 (8.37)	11.32 (9.90)	10.57 (8.41)	<1.0

Note: ¹Raw scores are presented apart from those for listening vocabulary, matrices and general ability which are expressed as standardised scores with a mean of 100 and a SD of 15.

²Maximum score = 12 at t1 otherwise 26.

³Maximum score = 42.

⁴Maximum score = 90.

⁵Maximum score = 20.

⁶Maximum score = 49 (inclusive of 15 items added to the beginning of the test).

⁷Maximum score = 32.

⁸Maximum score = 24.

* $p < .05$; ** $p < .01$.

Data analysis strategy

An important issue for our data is the unit of analysis. The children were taught individually and in classes (each from a different school) that were grouped into one of three experimental conditions or a taught control condition. Given that the data are hierarchically structured so that school represents a level above children, and group a level above school,

then school might emerge as having a significant effect on gains in attainment. We therefore used multilevel modelling (Rasbash et al., 2000) to regress the t2, t3 and t4 scores for our dependent variables (phoneme ability, rhyme ability, word reading, non-word reading and number) on the equivalent scores at t1. These analyses were conducted separately for the normally developing and at-risk children. For the normally developing children, when phonological

Table 6 Means (and standard deviations)¹ for the composite measures of rhyme, phoneme and word reading, and the measures of nonword reading and number ability, for the four groups of normally developing children ($N = 273$)

		Group			
		Reading with Rhyme and Phoneme ($N = 60$)	Reading with Rhyme ($N = 70$)	Reading with Phoneme ($N = 82$)	Reading alone ($N = 61$)
Rhyme ²	t1	103.83 (14.57)	103.27 (15.80)	106.80 (17.36)	105.99 (15.68)
	t2	106.11 (12.39)	108.45 (15.28)	102.11 (13.92)	99.37 (13.98)
	t3	105.94 (13.76)	106.26 (13.31)	102.27 (13.69)	102.75 (15.56)
Phoneme ²	t1	103.64 (19.91)	101.21 (14.99)	101.33 (18.40)	102.30 (19.12)
	t2	102.84 (16.05)	104.61 (15.92)	105.10 (17.86)	100.96 (15.49)
	t3	106.09 (12.58)	103.94 (13.20)	104.90 (13.71)	101.93 (15.19)
Word reading ³	t1	101.33 (24.06)	100.51 (8.38)	102.36 (24.00)	102.29 (7.58)
	t2	102.25 (18.03)	103.98 (11.68)	104.39 (17.85)	106.15 (17.56)
	t3	105.24 (12.86)	104.23 (14.28)	104.29 (14.13)	105.72 (16.53)
	t4	105.74 (10.76)	103.97 (14.18)	103.15 (13.97)	104.94 (13.82)
Nonword reading	t1	102.08 (25.35)	99.04 (1.96)	101.80 (25.34)	99.34 (4.19)
	t2	101.76 (16.43)	98.57 (8.49)	104.75 (21.54)	103.63 (21.26)
	t3	103.09 (15.34)	102.42 (15.25)	103.74 (16.60)	103.64 (18.04)
	t4	104.63 (15.14)	103.33 (14.98)	102.47 (15.17)	102.75 (15.45)
Number ⁴	t1	107.72 (15.15)	104.77 (12.79)	105.23 (13.74)	104.96 (14.37)
	t2	104.60 (13.82)	102.10 (11.54)	105.41 (15.10)	105.55 (16.02)
	t3	105.29 (14.17)	105.50 (14.77)	101.18 (13.07)	106.02 (14.46)
	t4	107.40 (13.29)	100.85 (13.96)	103.55 (14.71)	103.05 (14.20)

Note: ¹The scores are presented as standardised scores with a mean of 100 and a standard deviation of 15.

²The phonological scores are derived from Principal Components Analyses ($N = 410$) of the Rhyme production and detection scores (Rhyme), and the initial and final Phoneme deletion scores (Phoneme).

³The word reading scores are derived from a Principal Components Analyses ($N = 410$) of the Early word and, BAS word reading measures ($N = 410$).

⁴The number scores are derived from the BAS Basic Numbers skills test supplemented by 15 items added to the beginning of the test.

scores were being modelled, scores were also regressed on receptive vocabulary at t1 because receptive vocabulary had been found to be predictive of rhyme and phoneme skills at t3 and the groups differed on this measure at t1. For the children at risk of reading delay, when nonword reading scores were being modelled, scores were also regressed on the number of weeks of phonological training because there was a significant association between weeks of phonological training and nonword reading outcome for the at-risk children.

The advantage of multilevel modelling is that it permits the variance to be partitioned between the different levels and it is well recognised that analyses that ignore the fact that children are nested within school may lead to erroneous conclusions (see, for example, Goldstein (1955) for examples concerning research on school effectiveness). In the models reported below we partitioned the variance between time (level 1), child (level 2) and school (level 3) and dropped school as a level where it made no significant contribution to explaining variance. For the phonological skill measures we assess effects of the interventions across t1 to t3 (i.e., from the beginning of the study to the time when the intervention ceased). This allows us to assess the extent to which phonological training had produced selective effects on phonological skills over the period of the teaching

intervention. For the educational attainment measures (word reading, nonword reading and arithmetic) we assess effects of the interventions across t1 to t4 (i.e., from the beginning of the study to the post-intervention follow-up). This allows us to assess the extent to which effects of the intervention had moderately durable effects on educational outcome measures. As there were only five schools per experimental group, contrasts between the three phonological groups and the Reading alone group were undertaken using dummy variables. For the normally developing and at-risk children, we present the results first for phonological awareness and then for reading.

The effects of the four interventions on the development of phonological skills

Normally developing children. A multilevel (time, child, school) model was constructed in which rhyme skill scores (for t2 and t3) were regressed on rhyme skills and receptive vocabulary at t1, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables. For the normally developing children this analysis indicated that the variance in rhyme skill (t2 to t3) was explained by differences in time (.311(.027), $z = 11.52$), child (.253(.039), $z = 6.66$), school

Table 7 Means (and standard deviations)¹ for the composite measures of rhyme, phoneme and word reading, and the measures of nonword reading and number ability, for the four groups of children at risk of reading delay ($N = 137$)

Measure		Group			
		Reading with Rhyme and Phoneme ($N = 42$)	Reading with Rhyme ($N = 36$)	Reading with Phoneme ($N = 31$)	Reading alone ($N = 28$)
Rhyme ²	t1	89.75 (3.44)	89.57 (3.11)	91.29 (3.76)	89.08 (2.98)
	t2	96.41 (14.21)	91.15 (13.62)	90.64 (11.92)	88.11 (10.09)
	t3	95.99 (13.64)	91.43 (13.25)	86.39 (11.09)	91.07 (12.78)
Phoneme ²	t1	95.82 (.64)	95.84 (.69)	95.98 (1.42)	96.32 (1.48)
	t2	92.81 (6.81)	93.69 (7.72)	93.94 (10.52)	90.98 (4.81)
	t3	92.64 (13.05)	92.84 (14.23)	94.34 (14.50)	85.06 (12.69)
Word Reading ³	t1	96.19 (.59)	96.09 (.00)	96.58 (1.35)	98.50 (3.66)
	t2	90.57 (4.14)	92.09 (4.61)	91.39 (6.65)	92.84 (6.98)
	t3	90.98 (10.25)	88.91 (12.11)	92.01 (11.86)	89.79 (10.23)
	t4	93.18 (13.22)	90.72 (15.59)	92.82 (16.04)	87.88 (12.91)
Nonword Reading	t1	98.80 (.00)	98.80 (.00)	98.80 (.00)	98.80 (.00)
	t2	95.31 (.00)	95.31 (.00)	95.31 (.00)	96.22 (4.80)
	t3	93.93 (8.94)	91.96 (7.41)	96.72 (11.88)	91.52 (7.84)
	t4	94.82 (12.01)	93.00 (11.61)	97.39 (15.67)	88.18 (8.66)
Number ⁴	t1	88.49 (10.58)	87.90 (9.29)	89.49 (10.37)	89.88 (9.92)
	t2	91.42 (13.43)	89.75 (13.36)	90.01 (11.62)	94.07 (10.88)
	t3	92.92 (14.10)	89.15 (12.32)	89.21 (12.64)	94.87 (11.65)
	t4	96.27 (12.95)	89.51 (14.45)	91.44 (15.00)	93.54 (13.18)

Note: ¹The scores are presented as standardised scores with a mean of 100 and a standard deviation of 15.

²The phonological scores are derived from Principal Components Analyses ($N = 410$) of the Rhyme production and detection scores (Rhyme), and the initial and final Phoneme deletion scores (Phoneme).

³The word reading scores are derived from a Principal Components Analyses ($N = 410$) of the Early word and, BAS word reading measures ($N = 410$).

⁴The number scores are derived from the BAS Basic Numbers skills test supplemented by 15 items added to the beginning of the test.

(.111(.046), $z = 2.41$), rhyme ability at t1 (.355(.038), $z = 9.34$) and receptive vocabulary at t1 (.218(.052), $z = 4.19$). Additional variance was explained by the contrasts between the Reading alone group and the Reading with Rhyme group, .509(.248), $z = 2.05$, and the Reading with Rhyme and Phoneme group, .526(.250), $z = 2.10$, but not the contrast with the Reading with Phoneme group, .144(.246), $z = .59$. These results parallel the form of training received by the children: children who had received training in rhyme manipulation developed enhanced rhyme skills relative to the group of children that had not received training in phonological awareness.

A preliminary multilevel (time, child, school) model in which phoneme skill scores for the normally developing children (for t2 and t3) were regressed on phoneme skills and receptive vocabulary at t1, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables, indicated that school did not account for any significant variance. We therefore dropped school as a level. An equivalent, simplified multilevel (time, child) model showed that variance in phoneme scores could be explained by differences in time (.478(.041), $z = 11.66$), child (.373(.056), $z = 6.66$), phoneme ability at t1 (.243(.040), $z = 6.08$) and receptive vocabulary at t1 (.293(.060), $z = 4.88$).

Additional variance was explained by the contrasts between the Reading alone group and the Reading with Phoneme group, .385(.135), $z = 2.85$, and the Reading with Rhyme and Phoneme group, .287(.144), $z = 1.99$, but the contrast with the Reading with Rhyme group was not significant, .264(.137), $z = 1.93$. These results also parallel the form of training received by the children: children who had received training in phoneme manipulation developed enhanced phoneme skills relative to the group of children that had not received training in phonological awareness.

At-risk children. For the at-risk children a preliminary multilevel (time, child, school) model in which rhyme skill scores (for t2 and t3) were regressed on rhyme skills and receptive vocabulary at t1, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables, indicated that school did not account for any significant variance. We therefore dropped school as a level. An equivalent, simplified, multilevel (time, child) model showed that variance in rhyme scores could be explained by differences in time (.285(.034), $z = 8.38$) and child (.416(.070), $z = 5.94$) but not by rhyme ability at t1 (.525(.291), $z = 1.80$). Additional variance was explained by the contrast between the Reading alone group and the Reading with Rhyme

and Phoneme group, .418(.183), $z = 2.28$, but not by the contrast with the Reading with Rhyme group, .097(.189), $z = .51$, nor with the Reading with Phoneme group, -.149(.200), $z = -.75$. These results are broadly similar to those for the normal children but it is noteworthy that the group of at-risk children that received training in rhyme alone did not make significant gains in rhyme skills.

A preliminary multilevel (time, child, school) model for the at-risk children in which phoneme skill scores (for t2 and t3) were regressed on phoneme skills and receptive vocabulary at t1, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables, indicated that school did not account for any significant variance. We therefore dropped school as a level. An equivalent, simplified multilevel (time, child) model showed that variance in phoneme scores could be explained by differences in time (.434(.052), $z = 8.35$) and child (.103(.047), $z = 2.19$) but not by phoneme ability at t1 (-.544(.683), $z = -.80$). Additional variance was explained by the contrasts between the Reading alone group and the Reading with Phoneme group, .396(.148), $z = 2.68$, the Reading with Rhyme and Phoneme group, .296(.140), $z = 2.11$, and the Reading with Rhyme group .332(.144), $z = 2.3$. These results are similar to those for the normal children and provide support for the effectiveness of the training in phoneme manipulation. It is of interest that for the at-risk children, and almost so for the normal children, growth in phoneme skill was enhanced by training in rhyme. It seems likely that the rhyme training (involving manipulation of onset and rime) had an effect on phoneme skill because onsets are frequently phonemes.

In order to make the extent of their progress clearer, the effect sizes for the three groups of normal and at-risk children that received training in phonological awareness are presented in Tables 8 and 9. These indicate that for the normally developing children (Table 8) the training in rhyme skills had a small to medium effect on rhyme and that both the rhyme and the phoneme training had a small effect (Cohen, 1988) on phoneme skills. For the at-risk children (Table 9) the combined training in rhyme and phonemes had a small effect on rhyme and both rhyme and phoneme training had a medium to large effect (Cohen, 1988) on phoneme skills.

These data indicate that the training in phoneme skills enhanced performance on phoneme manipulation tasks, particularly for the at-risk children. The training in rhyme skills enhanced performance on rhyme for the normal children, but only when combined with training in phonemes for the at-risk children. Thus the phonological training programmes were effective in promoting phonological skills in these young children, though only the Phoneme training was truly selective in facilitating

Table 8 Effect sizes for improvement in phonological skills¹, word and nonword reading² in the normally developing children relative to the reading alone group ($N = 273$)

Measure	Group		
	Reading with Rhyme and Phoneme	Reading with Rhyme	Reading with Phoneme
Phoneme ¹	.19	.20	.26
Rhyme ¹	.34	.40	-.08
Word Reading ²	.13	.06	-.13
Nonword Reading ²	-.06	.06	-.18

Notes: ¹The effect sizes for phoneme and rhyme skills were calculated by dividing the difference between the progress of the group of interest and that of the Reading alone group by the standard deviation of the Reading alone group at t3.

²The effect sizes for word and nonword reading skills were calculated by dividing the difference between the progress of the group of interest and that of the Reading alone group by the standard deviation of the Reading alone group at t4.

Table 9 Effect sizes for improvement in phonological¹, word and nonword reading² skills for the at-risk children relative to the reading alone group ($N = 137$)

Measure	Group		
	Reading with Rhyme and Phoneme	Reading with Rhyme	Reading with Phoneme
Phoneme ¹	.64	.65	.76
Rhyme ¹	.33	.00	-.54
Word reading ²	.59	.41	.53
Nonword reading ²	.77	.56	1.06

Notes: ¹The effect sizes for phoneme and rhyme skills were calculated by dividing the difference between the progress of the group of interest and that of the Reading alone group by the standard deviation of the Reading alone group at t3.

²The effect sizes for word and nonword reading skills were calculated by dividing the difference between the progress of the group of interest and that of the Reading alone group by the standard deviation of the Reading alone group at t4.

phoneme skills without affecting rhyme skills. (In the at-risk group, Rhyme training had a clear effect in facilitating phoneme skills as well as in enhancing rhyme in the Rhyme and Phoneme group).

The effects of the four interventions on the development of reading

In order to evaluate progress in reading, composite measures of reading were derived from Principal Components Analyses of t1, t2, t3 and t4 scores on the two word reading tests (Early Word Recognition and BAS Word Reading). For ease of interpretation, in Tables 6 and 7 the reading factor scores are presented as standard scores with a mean of 100 and a standard deviation of 15. The scores for nonword reading are also presented as standard scores. We present separate analyses for word and nonword reading outcome because previous studies (Byrne &

Fielding-Barnsley, 1995; Olson et al., 1997; Whitehurst et al., 1999; Wise & Olson, 1995) have reported effects of phonological training to be largely confined to nonword reading. Inspection of Tables 6 and 7 suggests that word and nonword reading scores increase marginally for the normal children during the period of intervention and decline for the at-risk children, particularly for the groups that did not receive training in phonological awareness. However, in word reading, by between t2 and t3 the two at-risk groups that had received training in phoneme skills had halted or had begun to reverse this decline. Between t3 and t4 the Reading with Rhyme group had also begun to reverse the decline but the Reading alone group continued to decline. For nonword reading there is a similar pattern but between t2 and t3 the only group to have halted the decline in scores was the Reading with Phoneme group. The Reading with Rhyme group and the Reading with Rhyme and Phoneme groups halted the decline between t3 and t4 as the Reading alone group continued to decline.

Normally developing children: word reading. A multilevel (time, child, school) model was constructed in which word reading scores for the normally developing children (for t2 to t4) were regressed on word reading skills at t1, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables. This analysis indicated that the variance in word reading skill scores (t2 to t4) could be explained by differences in time (.241(.015), $z = 16.07$), child (.436(.046), $z = 9.48$), school (.131(.048), $z = 2.38$) and reading ability at t1 (.334(.038), $z = 8.79$). However, no significant additional variance was explained by the contrasts between the Reading alone group and the Reading with Rhyme and Phoneme group, .215(.274), $z = .79$, the Reading with Rhyme group, .253(.271), $z = .93$, or the Reading with Phoneme group, .128(.269), $z = .48$.

Normally developing children: nonword reading. A parallel and preliminary multilevel model constructed for nonword reading indicated that school did not account for any significant variance. We therefore dropped school as a level. An equivalent, simplified, multilevel (time, child) model indicated that the variance in nonword reading scores (t2 to t4) could be explained by differences in time (.505(.031), $z = 16.29$), child (.561(.063), $z = 8.91$) and nonword reading ability at t1 (.297(.042), $z = 7.07$). However, no significant additional variance was explained by the contrasts between the Reading alone group and the Reading with Rhyme and Phoneme group, $-.066(.156)$, $z = -.42$, the Reading with Rhyme group, $-.121(.150)$, $z = -.81$, or the Reading with Phoneme group, $-.028(.145)$, $z = -.19$.

Contrary to our expectations, these results show that for word and nonword reading normal 4.5-year-

old children presented with a programme of Reading that includes phonics do not benefit from additional training in phoneme or rhyme manipulation linked to reading.

At-risk children: word reading. A preliminary multilevel (time, child, school) model in which word reading scores for the at-risk children (for t2 to t4) were regressed on reading skills at t1 and weeks of phonology teaching, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables, indicated that weeks of phonology teaching and school did not account for any significant variance. We therefore dropped weeks of phonology teaching as a covariate and school as a level. An equivalent, simplified, multilevel (time, child) model indicated that the variance in word reading scores (t2 to t4) could be explained by differences in time (.235(.020), $z = 11.75$), child (.262(.042), $z = 6.24$) and by word reading ability at t1 (1.580(.422), $z = 3.74$). Additional variance was explained by the contrasts between the Reading alone group and the Reading with Rhyme and Phoneme group, .337(.156), $z = 2.16$, and the Reading with Phoneme group, .329(.161), $z = 2.04$, but not by the contrast with the Reading with Rhyme group, .279(.162), $z = 1.72$. These results suggest that for the at-risk children the additional training in phoneme manipulation and phoneme-grapheme linkage skills was effective in reducing the extent to which children of average and above average potential accelerate ahead of them. Without such training the trend is for the at-risk children to fall further behind their peers in word reading skills. As can be seen in Figure 2, the Reading with Phoneme group and the Reading with Rhyme and Phoneme group appear to reverse their decline first and the Reading with Rhyme group last, with the Reading alone group continuing their (relative) decline into their third year in school. A follow-up analysis in which contrasts were made between the Reading with Phoneme group and all other groups showed that the Reading with Phoneme

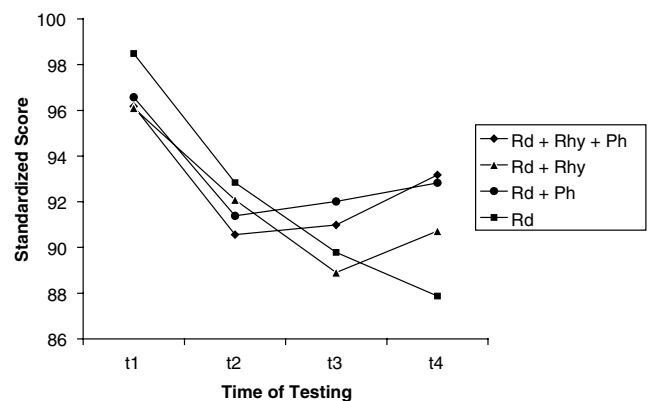


Figure 2 Progress in word reading of at-risk children ($N = 137$) relative to total sample of 410 children

group did not differ significantly from either of the other two intervention groups (Reading with Rhyme group ($z = -.459$), Reading with Rhyme and Phoneme group ($z = -.461$)).

At-risk children: nonword reading. A preliminary multilevel (time, child, school) model was conducted in which nonword reading scores for the at-risk children (for t2 to t4) were regressed on weeks of phonology teaching, with contrasts between the three intervention groups and the taught control group as fixed explanatory variables. Nonword reading scores at t1 were not included in the model as there was no variance at t1: all of the at-risk children scored zero. Since the preliminary model indicated that school did not account for any significant variance we dropped school as a level. An equivalent, simplified, multilevel (time, child) model indicated that variance in nonword reading scores (t2 to t4) could be explained by differences in time (.244(.021), $z = 11.62$), child (.105(.0024), $z = 4.375$) and by weeks of phonological awareness teaching (.017(.007), $z = 2.429$). No significant variance was explained by the contrasts between the Reading alone group and the Reading with Rhyme and Phoneme group, $-.509(.301)$, $z = -1.69$, the Reading with Rhyme group, $-.548(.285)$, $z = -1.92$, or the Reading with Phoneme group, $-.495(.344)$, $z = -1.44$. (It is important to note, however, that an equivalent analysis in which the effect of weeks of phonological training was omitted showed that variance in nonword reading could be explained by differences in time (.244(.021), $z = 11.62$) and child (.113(.024), $z = 4.71$) and by the contrast between the Reading alone group and the Reading with Phoneme group, $.300(.115)$, $z = 2.61$, but not by the contrast with the Reading with Rhyme and Phoneme group, $.181(.108)$, $z = 1.68$ nor with the Reading with Rhyme group, $.097(.111)$, $z = .87$.) These results show that for the at-risk children the amount of training in phonological awareness is an important factor in reducing the extent to which children of average and above average potential accelerate ahead of them. Because of the advantage of 8.5 additional weeks of phonological awareness training for the Reading with Phoneme group, in comparison to the Reading with Rhyme group, we are not able to determine whether the phoneme training was more effective than the training in rhyme. However, as can be seen in Figure 3, the Reading with Phoneme group appears to reverse their decline first (between t2 and t3), with the Reading with Rhyme and Phoneme group and the Reading with Rhyme group reversing their decline later (between t3 and t4) as the Reading alone group continues its (relative) decline into the third year of school.

The effect sizes, for improvement in word and nonword reading for the normal and at-risk children who had received training in phonological awareness, are presented in Tables 8 and 9. In keeping with the

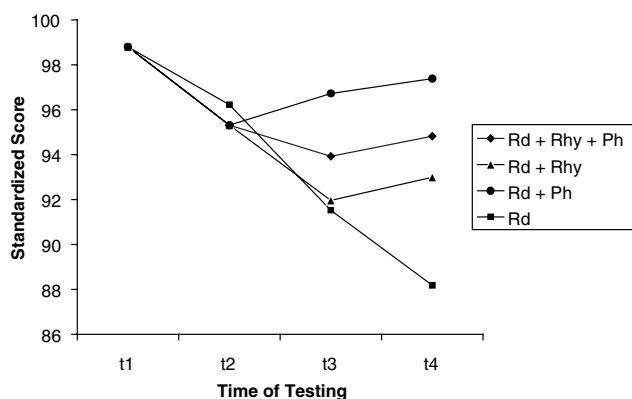


Figure 3 Progress in nonword reading of at-risk children ($N = 137$) relative to total sample of 410 children

multilevel analyses, all effect sizes for reading measures in the normal children are negligible. For the at-risk children the two groups that received training in phoneme awareness showed medium effect sizes (Cohen, 1988) for word reading and the group that had received just rhyme training exhibited a small to medium effect (although statistically the gains were not significant). In keeping with the findings of previous studies (Byrne & Fielding-Barnsley, 1995; Olson et al., 1997; Whitehurst et al., 1999; Wise & Olson, 1995), the effect sizes for nonword reading were larger, particularly for the Reading with Phoneme group. However, as indicated by the multilevel analyses presented earlier, these large effects on nonword reading appear to depend critically on uncontrolled differences in the amount of time spent on phonological training in the different groups.

Predictors of reading progress amongst the children at risk of reading failure

Our initial hypothesis was that training phonological skills, and particularly training phoneme skills, would be especially helpful to young children at risk of reading failure. The analyses presented so far provide limited support for this view: the children at risk of reading failure make more progress in word reading if they are in the Intervention groups given phoneme training. However, the Reading with Phoneme group did not perform significantly better than the groups given rhyme training (the Reading with Rhyme and the Reading with Rhyme and Phoneme groups). While it is possible that the gains in reading ability in these latter groups were a product of increased rhyme skills, such a conclusion is clouded by the fact that these groups also showed gains in phoneme skills. We can evaluate the relative importance of rhyme and phoneme skills for the development of reading skills more directly by the use of regression.

We first looked at the predictors of word and nonword reading at t4 in the whole sample of at-risk children, using phoneme and rhyme factor scores at

t3 as predictors together with Group, EPVT, matrices and reading scores at t1. In these simultaneous regression analyses phoneme skills accounted for 29.7% ($p < .001$) of variance in word reading scores and 30.4% of variance in nonword reading scores ($p < .001$), but rhyme skills accounted for no variance in either case. The only other significant predictors of t4 word reading scores were t1 matrices (4.6% variance) and t1 reading (3.6% variance). The only other significant contributor to nonword reading variance was listening vocabulary (EPVT). Hence, for the sample of at-risk children as a whole, the level of phoneme awareness they had achieved at the end of the intervention period (t3) was a very powerful predictor of their final attainment in both word and nonword reading, but their level of rhyme skills was essentially irrelevant to the prediction of their reading skills. This supports the idea (based on the pattern of improvements in phoneme and rhyme skills in the different groups of at-risk children) that phoneme, rather than rhyme, skills are linked to the progress these children make in learning to read.

It is also of interest to consider the patterns of predictive relationship between t3 phoneme and rhyme skills and t4 word and nonword reading skills in the four intervention groups separately. Because the N 's in these separate groups are relatively small, we only used the two t3 phonological measures as predictors. The unique r^2 values for each group are presented in Table 10. The pattern is quite striking for both word and nonword reading.

For children taught about phonemes and phoneme linkage activities (the Reading with Phoneme and Reading with Rhyme and Phoneme groups) the level of phoneme awareness developed at the end of the intervention accounts for large proportions of variance in their final level of word and nonword reading skill, but rhyme skills are essentially irrelevant to predicting their levels of reading skill. Conversely, for the children taught only about Rhyme and Rhyme level linkage activities (the Reading with Rhyme group), rhyme skills make a contribution to predicting t4 word reading skills (but not nonword reading), but even for this group phoneme level skills are a stronger predictor. This pattern of results from considering the groups separately is similar to that for the whole sample, with phoneme level skills being stronger predictors of reading attainment than rhyme skills. It is interesting, however, that the strength of these relationships varies slightly in a systematic way according to the form of teaching the children have received. It is also interesting that for nonword reading in particular the teaching of rhyme skills appears to attenuate the predictiveness of phoneme skills.

Specificity of the effects of the interventions

As Bradley and Bryant (1983) argued, it is important when assessing the effects of an intervention on lit-

Table 10 Unique variance (part r^2) contributed to word and nonword reading by phoneme and rhyme skills in the four groups of at-risk children ($N = 137$)

Measure	Group			
	Reading with Rhyme and Phoneme	Reading with Rhyme	Reading with Phoneme	Reading alone
Word reading ¹				
Phoneme ²	.36**	.16**	.48**	.22**
Rhyme ²	.01	.08*	.01	.04
Nonword reading ¹				
Phoneme ²	.21**	.28**	.40**	.39**
Rhyme ²	.01	.03	.00	.04

Notes: ¹The word reading scores, derived from a Principal Components Analyses ($N = 410$) of the Early word and BAS word reading measures ($N = 410$), and the nonword reading scores are for reading at t4.

²The phonological scores are derived from Principal Components Analyses ($N = 410$) of the rhyme production and detection scores (Rhyme), and the initial and final phoneme deletion scores (Phoneme), at t3.

* $p < .05$; ** $p < .01$.

eracy development to check whether its effects are specific or whether they are more general and indicative of a type of 'Hawthorne effect'. We examined this possibility by assessing the effects of the different interventions on a non-targeted area of educational attainment, that of early number skills. The t1, t2, t3 and t4 standardised scores for number skills for the normally developing and at-risk children are presented in Tables 6 and 7. If there were any discrepancy between the overall quality of teaching received by the groups that could explain the results for reading, we might expect to find differences in number skills that paralleled the pattern of change for reading. Inspection of Tables 6 and 7 suggests that this was not the case. Between t1 and t4, there was a trend for the normal children to have declined marginally and for the at-risk children to have made gains, with the Reading with Rhyme and Phoneme group and the Reading alone group making more progress than the Reading with Rhyme and the Reading with Phoneme groups. To investigate these effects the data for number skills were analysed using multilevel modelling.

Normally developing children. A preliminary multilevel (time, child, school) model in which number scores for the normally developing children (for t2 to t4) were regressed on number skills at t1, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables, indicated that school did not account for any significant variance. We therefore dropped school as a level. An equivalent, simplified, multilevel (time, child) model indicated that the variance in number scores (t2 to t4) could be explained by differences in time (.333(.020), $z = 16.65$), children (.225(.029), $z = 7.76$) and number ability

at t1 (.620(.038), $z = 16.32$). However, no significant additional variance was explained by the contrasts between the Reading alone group and the Reading with Rhyme and Phoneme group, $-.054(.106)$, $z = -.51$, the Reading with Rhyme group, $-.129(.101)$, $z = -1.28$, or the Reading with Phoneme group, $-.111(.098)$, $z = -1.13$.

At-risk children. A preliminary multilevel (time, child, school) model in which number scores for the at-risk children (for t2 to t4) were regressed on number skills at t1, with the contrasts between the three intervention groups and the taught control group as fixed explanatory variables, indicated that school did not account for any significant variance. We therefore dropped school as a level. An equivalent, simplified, multilevel (time, child) model indicated that the variance in number scores (t2 to t4) could be explained by differences in time (.272(.023), $z = 11.83$), children (.310(.049), $z = 6.63$) and number ability at t1 (.613(.082), $z = 7.48$). Again, no significant additional variance was explained by the contrasts between the Reading alone group and the Reading with Rhyme and Phoneme group, $.015(.155)$, $z = .097$, the Reading with Rhyme group, $-.232(.160)$, $z = -1.45$, or the Reading with Phoneme group, $-.246(.165)$, $z = -1.49$. Thus, the differences in attainment in reading between the children at risk of reading failure in the different intervention groups are not paralleled by equivalent changes in number skills. The effects obtained appear to be specific to reading and cannot be attributed to general differences in teaching received during or after the period of intervention.

Discussion

This study started with three broad questions. First, does supplementing the teaching of reading with explicit phonological awareness training have beneficial effects on children's reading skills in Reception and Year-1 classes (pre-kindergarten and kindergarten)? Our results, from a large, rigorously controlled study, show that there is no significant improvement in normally developing 4.5-year-old children's reading scores as a result of the explicit package of phonological training we gave. This is all the more striking, given that we did show that the phonological training was effective in improving the children's phonological skills. Our second question was whether the size of phonological unit emphasised in training would have important effects. Once again, our results are clear in showing that for normally developing children there were selective effects of the phonological training: training on phoneme skills promoted these skills without significantly affecting rhyme skills, while, conversely, training in rhyme skills promoted the development of rhyme but not phoneme skills. However, a major finding is that

although in the normally developing children significant improvements in phonological skills were produced by training, these improvements did not translate into improvements in literacy skills.

The absence of any generally beneficial effects of phonological training on reading for normally developing children was contrary to our expectations. However, these findings are in keeping with other reports (Byrne & Fielding-Barnsley, 1995; Olson et al., 1997; Whitehurst et al., 1999; Wise & Olson, 1995) that training in phonological awareness may yield only small or possibly no immediate gains in reading skills. Byrne and Fielding-Barnsley (1993, 1995), in their kindergarten study, reported that phoneme identity training facilitated nonword reading but not word reading in kindergarten or in the first and second grades. They also reported that the use of their *Sound Foundations* programme was less effective when it was administered by classroom teachers. Similarly, Whitehurst et al. (1999) reported that children at Head Start Centres, most of whom could be considered to be at risk of reading failure, benefited from the provision of small group reading and the Sound Foundations programme in terms of growth in vocabulary, memory span, phonological skills and writing at the end of kindergarten but not reading in Grades 1 or 2. A reasonable conclusion would appear to be that if structured phonic work is included in a reading programme, the majority of children do not need training in phonological awareness in order to master the alphabetic principle. In this case, therefore, providing additional phonological training may simply be redundant for most normally developing children, because they have sufficient levels of phonological skill for the task of learning to read. It remains possible, of course, that more intensive phonological training would produce increases in reading skills in normally developing children. However, the reading skills in our sample of children were good for their age (see details below), and it seems likely that attempting to provide intensive phonological training for normally developing children would simply not be cost effective, or justified on educational grounds.

Our third major question was whether incorporating phonological training would be particularly important for young children at risk of reading failure. This seemed likely since previous research has shown that at-risk children (in kindergarten and Grade 1) benefit more from such training than normally developing and reading-delayed children (National Reading Panel, 2000). We also know that poor readers have benefited from individual training in phonological awareness that is explicitly linked to orthography (Hatcher et al., 1994; Iverson & Tunmer, 1993). The present study was an attempt to see if the use of a similar approach adapted for use in a class could help to prevent reading problems developing in very young children. Our results show that children at risk of reading failure made more pro-

gress in learning to read if they were in the classes where groups received additional phoneme-level training. We believe that the medium effects on word reading, and the large effects on nonword reading, produced by this training amongst children at risk of reading failure are related to their ability to link phonemes to print. Although phoneme skills were enhanced by training in phoneme, and in rhyme manipulation, it was only the two groups that explicitly linked phonemes to print that made significant gains in word reading. In regression analyses we showed that the level of reading attainment achieved at t4 (after the intervention had finished) was well predicted by the levels of phoneme skill achieved by the children a few months earlier at t3, but not by rhyme skills. These findings provide further support for the importance of phoneme awareness and linkage at the level of the phoneme for initial reading development (Hulme et al., 2002; Muter et al., 1998).

In a study of this nature, it is important to place the results in a context that is relevant to the population at large. We are able to do this by reference to the children's scores on the BAS word reading test at t4. For the sample as a whole ($N = 410$) the mean standardised t4 score was 101.35 (15.55). This indicates that the sample is representative of the general population of children of the same age in the UK. In keeping with the analyses reported, the mean standard scores on the BAS word reading test for the four groups of normally developing children were equivalent (Reading with Rhyme and Phoneme, 105.95 (13.56), Reading with Rhyme, 105.12 (15.92), Reading with Phoneme, 103.75 (15.45), Reading alone, 106.61 (16.11)) and the mean scores for the at-risk children differed (Reading with Rhyme and Phoneme, 94.93 (10.78), Reading with Rhyme, 93.25 (13.34), Reading with Phoneme, 94.63 (15.60), Reading alone, 91 (12.85)). The average difference in standard scores between our two successful groups of at-risk children and the Reading alone group is 3.8 points. This means that for each hour of phonological skills training (21.38 hours) these two groups differed at t4 by .18 standard score points relative to the Reading alone group. Although not equivalent to Torgesen et al.'s (2001) metric, where the rate of progress per hour of intervention for the group of interest is computed, this difference score falls within the range of gains (.13 to .23) made by successful programmes of intervention. It is also likely to be conservative since it takes no account of differences in reading ability between the groups at t1 (which favoured the Reading alone group).

Another way of considering the t4 scores of the at-risk children is to determine the number of children that had scores below 90, the lower end of the average range. The percentage figures for the four groups are Reading with Rhyme and Phoneme (31%), Reading with Rhyme (38.9%), Reading with Phoneme (35.5%), Reading alone (42.9%). These indicate that

approximately two-thirds (66.75%) of the groups that received phoneme training achieved normal levels of reading by t4. However, this leaves a third of those two groups (33.25%) who were reading at a below average level. Although this contrasts favourably with the (42%) of children in the Reading alone group, it is clear that for a sizeable proportion of at-risk children more help is needed than can reasonably be provided by a classroom teacher working with a class of children. Our results suggest that for children with severe problems in learning to read, whole class support of the sort provided in this study is neither intensive enough nor well enough targeted to the individual needs of these children. A natural implication of this study is that given we can identify these children quite effectively, we should evaluate programmes in which these children are given individual or small group teaching in the first two years of school in order to help prevent the development of reading problems.

For young children at risk of reading failure there are at least two important educational implications of the present research. The first concerns the identification of these children. The composite measure for vocabulary, letter identification, rhyme and phoneme deletion identified a group of children who were particularly slow to acquire literacy skills. While these children were making some progress in learning to read, without training in phonological awareness, the gap between their attainments and those of their peers gradually increased during their first three years in school. This decline in their literacy skills was not paralleled by the development of their mathematical skills. It seems, therefore, that this study along with others (e.g., Muter et al., 1998) demonstrates that it is quite feasible to identify children who are likely to fail in learning to read at a very early stage of their school careers.

The second point is that it is possible to halt the decline in performance of (at least some of these) young children, relative to their peers, if they are presented with a structured programme of phoneme and reading training at school entry. For children provided with training in phoneme awareness, the decline was halted during their second school year. For children offered the rhyme training it was halted during their third school year. Arguably, if the same amount of phoneme training were to be presented over a shorter period of time, and to smaller groups of children (National Reading Panel, 2000) or to individuals, the effects would be larger. The present study was conducted without any additional staff resources being given to the participating schools. The National Reading Panel found that over all age groups the mean effect size for reading outcome was greater for small groups ($d = .81$) than for classrooms ($d = .35$) or individual tuition ($d = .45$). However, in an earlier meta-analysis involving 38 studies, Bus and van Ijzendoorn (1999) found no significant difference between the effect size for

reading outcome when programmes of phonological awareness training were administered to groups ($d = .37$) or to individuals ($d = .68$). Whatever the merits of small group or individual-level work, we know (Hatcher et al., 1994; Iverson & Tunmer, 1993) that it is possible to ameliorate reading delay in children using an individual programme of Reading and Sound Linkage training. In the Hatcher et al. (1994) study the ratio of standardised score gains for word recognition per hour of intervention ($6.2/20$) for the group that received training in reading and phonological awareness was .31. This compares favourably with the gains (range .13 to .23) made in other intervention studies (for review see Torgesen et al., 2001) where intense and explicit programmes of intervention have been provided one-on-one for reading-delayed children. Another possibility is that for very young children programmes of phonological training should be confined to the teaching of phoneme blending and segmentation in preference to metacognitive skill across a wide range of activities at the level of the word, syllable, and phoneme. Such a view is supported by the findings of the National Reading Panel (2000) where the effect size for teaching two phonological skills ($d = .79$) was significantly greater than that ($d = .23$) for teaching three or more.

In summary, the present study shows that it is possible for teachers to teach phonological awareness and reading in Reception (pre-kindergarten) and Year-1 (kindergarten) classes of up to 30 children. This training has clear effects in boosting children's phonological (particularly phonemic) skills. However, these increases in phoneme awareness do not translate into overall gains in reading for normally developing children. We conclude that the reading programme we used (which includes a highly structured phonic component) is sufficient for most 4.5-year-old children to master the alphabetic principle and to learn to read effectively, without additional explicit phonological training. In contrast, for young children at risk of reading delay our data show that structured training in phoneme awareness and linking phonemes with letters is beneficial. Without such training these children's reading skills tend to fall behind their peers in the first three years of formal schooling. Approximately 33% of the at-risk children in the best of our interventions showed below average attainments in reading for their age, however. An important question for future studies would be to establish the extent to which reading problems for these children could be eliminated entirely by more intensive small group or individual tuition in the early school years.

To our knowledge, this study is unique in that it has attempted to answer a theoretical question about reading and phonological awareness in the context of teachers working with whole classes of 4.5-year-olds at school entry. Our results indicate that the interventions did not boost overall reading

achievement in normally developing children, but that they did have specific effects in helping to improve the reading skills of young children at risk of reading failure. Theoretically, the study also provides further evidence for the importance of phonemic skills, rather than rhyme skills, as a critical foundation for the early stage of learning to read (Hulme et al., 2002).

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