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Correspondence: Ken Blaiklock, School of Education, Unitec, PB 92025, Auckland, New Zealand.
Email: kblaiklock@unitec.ac.nz

The Importance of Letter Knowledge in the Relationship between Phonological Awareness and Reading.

Ken E. Blaiklock

Unitec Institute of Technology

Auckland

New Zealand

Abstract

Previous correlational and experimental research has found a positive association between phonological awareness and reading skills. This paper provides an overview of studies in this area and shows that many studies have neglected to control for extraneous variables such as ability, phonological memory, preexisting reading skills, and letter knowledge. The paper reports on the results of a longitudinal study that took account of these variables when examining the relationship between phonological awareness and reading for a group of children during their first two years at school. Children showed rhyme awareness before they began to read but were unable to perform a phoneme deletion task until after they had developed word reading skills. Concurrent and predictive correlations between phonological awareness scores and later reading were often significant and remained so after adjusting for verbal ability or phonological memory. Controlling for letter knowledge, however, reduced most correlations to nonsignificant levels.

The Importance of Letter Knowledge in the Relationship between Phonological Awareness and Reading.

In the past 25 years, numerous studies have found an association between phonological awareness and the acquisition of literacy. Studies have used many ways to assess phonological awareness but have most commonly used tests of rhyme and phoneme awareness. Correlational studies have frequently found significant concurrent and predictive relationships between rhyme awareness and literacy (e.g., Bradley & Bryant, 1983; Ellis & Large, 1987; Rohl & Pratt, 1995), and between phoneme awareness and literacy (e.g., Juel, Griffith, & Gough, 1986; McDonald & Cornwall, 1995; Stuart, 1995). Some correlational studies have indicated that certain phonological skills may be a consequence of reading (e.g., Read, Zhang, Nie, & Ding, 1986; Wimmer, Landerl, Linortner, & Hummer, 1991). Other correlational studies have found evidence in support of reciprocal relationships whereby phonological awareness skills influence reading, and reading influences phonological awareness skills (e.g., Cataldo & Ellis, 1988; Perfetti, Beck, Bell, & Hughes, 1987). A number of experimental studies have shown that children who receive training in phonological awareness skills score significantly higher on reading tasks than children who have not had the phonological awareness training (e.g., Blachman, Ball, Black, & Tangel, 1994; Byrne & Fielding-Barnsley, 1991; Uhry & Shepherd, 1993).

Despite the large amount of research in this area, there is still considerable debate about the nature of the relationship between phonological awareness and reading. Recent debate has focused on the relative contributions of rhyme awareness and phoneme awareness to the development of reading skills (see e.g., Goswami, 2002; Hulme, Hatcher, Nation, Brown, Adams, & Stuart, 2002). Associated with this debate has been an increased scrutiny of the methodological limitations of studies of phonological awareness and reading (see Macmillan, 2002; Troia, 1999).

A major limitation of many correlational and experimental studies appears to have been the failure to take account of extraneous variables. If extraneous variables are not taken into account, any finding of a relationship between phonological awareness and reading may be spurious (i.e., the result of variation in the extraneous variable). Several factors that could plausibly impact on the relationship between phonological awareness and reading are (1) general or verbal ability, (2) phonological memory, (3) preexisting reading levels, and (4) letter knowledge.

The need to control for general or verbal ability is apparent from findings that ability is significantly correlated with reading skills (McDougall, Hulme, Ellis, & Monk, 1994; Stanovich, Cunningham and Feeman, 1984) and may also influence performance on phonological awareness tasks

(McBride-Chang, 1995). Numerous correlational studies have found, however, that controlling for ability scores has generally not altered the finding of significant concurrent and predictive correlations between rhyme awareness and reading (e.g., Kirtley, Bryant, MacLean & Bradley, 1987) and between phoneme awareness and reading (e.g., Juel et al., 1986). Experimental studies that have found positive effects of phonological awareness training have also often controlled for ability, either by randomly assigning participants to treatment and control groups, or by measuring ability to ensure that groups are comparable (e.g., Castle, Riach, & Nicholson, 1994; Cunningham, 1990).

Although studies of phonological awareness and reading have often taken account of general or verbal ability, they have not given the same attention to phonological memory. There have been mixed findings on the relationship between phonological memory and reading; some studies have found significant correlations (e.g., Nation & Hulme, 1997) whereas others have not (e.g., Bowers, 1995). Tunmer and Hoover (1993) suggest that phonological memory could influence reading by facilitating the learning and application of grapheme-phoneme correspondence rules, and by helping readers to identify words by combining graphophonic cues with contextual information.

Phonological memory may also affect performance on phonological awareness tasks. Hansen and Bowey (1994) note that phonological awareness tasks may place strong demands on phonological memory. It is also possible that phonological awareness and phonological memory both stem from a single latent phonological processing ability. Some studies have found significant correlations between phonological memory and phonological awareness but there are variations in findings depending on which measures have been used (see Oakhill & Kyle, 2000).

Only a small number of correlational studies of phonological awareness and reading have included controls for phonological memory. These studies found that although measures of phonological awareness and phonological memory overlap in task demands, phonological awareness is still able to predict reading skills after first taking account of phonological memory (e.g., Nation & Hulme, 1987; Rohl & Pratt, 1995). Phonological memory has received very little attention in experimental studies of phonological awareness and reading.

Preexisting reading levels are another variable that should be considered when examining the relationship between phonological awareness and reading. In concurrent correlational studies where children are reading at the time that phonological awareness is measured (e.g., McDougall et al., 1994), it is impossible to determine whether a significant correlation is the result of the influence of phonological awareness on reading, the influence of reading on phonological awareness, or a reciprocal relationship.

A similar problem exists in longitudinal correlational studies that have included children who may have already been reading when phonological awareness was first assessed (e.g., Bryant, MacLean, Bradley, & Crossland, 1990; Juel et al., 1986). A significant correlation between early phonological awareness and later reading in these circumstances could be due to the influence of phonological awareness on later reading. Alternatively, the correlation could be due to the influence of early reading on initial phonological awareness, and the likelihood that children who had the highest early reading skills will continue to make the greatest progress in reading. Some longitudinal studies have taken account of preexisting reading skills, either by partialling out initial reading levels, or by ensuring that children are nonreaders at the start of a study. These studies have reported mixed findings about whether there is a predictive relationship between rhyme or phoneme awareness and reading. Significant correlations have been found in some studies (Mann & Dittuno, 1990; Muter, Hulme, Snowling, & Taylor, 1998; Stuart, 1995) but not in others (Badian, 1995; Bowey, 1995; Rohl & Pratt, 1995).

Most experimental studies have controlled for preexisting reading levels by ensuring that treatment and control groups initially consist of children who are nonreaders, or have comparable reading levels. Studies that have controlled for preexisting reading in these ways have generally reported positive effects of phonological awareness training on reading (e.g., Byrne & Fielding-Barnsley, 1991; Castle et al., 1994).

In addition to ability, phonological memory, and preexisting reading levels, studies should also consider the impact of letter knowledge on the relationship between phonological awareness and reading. Letter knowledge has been found to be significantly correlated with reading in numerous studies (e.g., Gallagher, Frith, & Snowling, 2000; Muter & Diethelm, 2001). Knowledge of letter names and sounds helps young children to see that words are not simply whole units but are made up of patterns of letters. Letter knowledge assists children to establish and recall words in memory, and to decode unfamiliar words (Roberts, 2003; Thompson, 1999).

Letter knowledge also appears to influence the development of phonological awareness. Studies have found significant correlations between letter knowledge and growth in phonological awareness for preschool children (Burgess & Lonigan, 1998) and for children in the first years of schooling (Caravolas, Hulme, & Snowling, 2001; Wagner, Torgesen, & Rashotte, 1994, Wagner et al., 1997). Correlations in these studies remained significant after controlling for verbal abilities. Other studies have found that young children require a certain amount of letter knowledge before they can show some types of phonological awareness, especially at the phoneme level (Barlow-Brown & Connelly, 2002; de Jong & van der Leij, 1999; Johnston, Anderson, & Holligan, 1996). Barron (1994) suggests that letter-name and letter-sound knowledge supports the development of phonemic awareness by providing children with phonological representations that are linked with the orthographic units of words.

Additional evidence on links between letter knowledge and phonological awareness comes from studies of adult illiteracy. One study of adults with poor literacy skills found that there was a close connection between letter knowledge and phonemic awareness (Lukatella, Carello, Shankweiler, & Liberman, 1995). Other studies have made comparisons between adults who are illiterate and adults who have recently learnt to read. These studies indicate that rhyme and syllable awareness may develop prior to learning to read, but awareness of phonemes requires experience of reading in an alphabetic language (Mann, 1986; Morais, Bertelson, Cary, & Alegria, 1986).

Despite the evidence on the role of letter knowledge in reading and phonological awareness, only a small number of correlational studies have attempted to control for letter knowledge when examining relationships between phonological awareness and reading. Muter et al. (1998) found that letter knowledge was a stronger predictor of reading than was phonological awareness for a group of children in the first two years of reading instruction. Muter et al. were able to show, however, that letter knowledge and "segmentation" (a factor score that included phoneme awareness tasks) were both able to independently predict concurrent reading at the end of the first year at school. A similar finding was made by Muter and Diethelm (2001). Lonigan, Burgess, Anthony, and Barker (1998) were also able to show some significant concurrent correlations, after controlling for letter knowledge and other variables, between measures of phonological awareness and early word reading for a group of four-and five-year-old children. In contrast, de Jong and van der Leij (1999) found that phonological awareness at kindergarten was unable to explain additional variance in Grade 1 or Grade 2 reading after first controlling for letter knowledge and nonverbal ability.

Many experimental studies have not taken account of the influence of letter knowledge when evaluating the effects of particular interventions. Interventions that have been designed to increase children's phonological awareness skills have often incorporated activities that may enhance children's letter knowledge. If the effects of the training on letter knowledge are not taken into account it is impossible to specify whether any effects on reading are due to an increase in letter knowledge, an increase in phonological awareness skills, or a combination of both these developments (e.g., Byrne & Fielding-Barnsley, 1991; Blachman et al., 1994; Castle et al., 1994; Uhry and Shepherd, 1993).

There are a small number of experimental studies where phonological awareness training has not included exposure to letters. In some of these studies, training has been given before children received school literacy instruction. The results of these studies have shown that phonological awareness skills can be successfully taught in preschool training programmes that do not involve letters (Fox & Routh, 1976, 1984; Lundberg, Frost, & Petersen, 1988). However, the one study that examined the effect of this type of phonological awareness training on later literacy skills found a relatively small effect, despite the comparatively long training period (Lundberg et al. 1988).

The majority of studies where phonological awareness training has not included exposure to letters have been carried out with children who are attending school. This complicates the interpretation of findings as the phonological awareness training may interact with the school literacy programme. Some studies of this type have shown positive effects on phonological awareness and literacy skills (e.g., Cunningham, 1990; Lie, 1991). Other studies, however, have found that phonological awareness training had no effect on literacy skills (e.g., Weiner, 1994).

Some experimental studies of phonological awareness training are designed to control for the additional exposure to letters that may occur during the intervention. These studies have found that phonological awareness training without the involvement of letters does not produce significant benefits for reading, even though it may result in gains in phonological awareness (e.g., Bradley & Bryant, 1983; Bradley, 1988; Defior & Tudela, 1994; Hatcher, Hulme, & Ellis, 1994).

In summary, the above discussion of extraneous variables has shown that there are plausible reasons for considering that (1) general or verbal ability, (2) phonological memory, (3) preexisting reading levels, and (4) letter knowledge, could all have an impact on the finding of a relationship between phonological awareness and reading. The above discussion has also shown that correlational and experimental studies have often given insufficient attention to controlling for these variables. Some studies have controlled for specific variables but no single study appears to have considered the effects of each of the four variables.

The present study was designed to take account of extraneous variables. The aim of the study was to examine the relationships between phonological awareness and reading and determine whether controlling for particular extraneous variables would affect the finding of significant relationships. The study began with a group of nonreading children and followed their progress during the first two years at school. Previous longitudinal studies have often assessed children only at the beginning and end of their first years at school but more frequent assessments were made in the current study.

More frequent assessments provided a clearer picture of changes during a time in which there is considerable development of children's phonological awareness and reading skills.

Method

Participants

The participants in this study came from the first year classes of two schools in a large regional city of New Zealand. A total of 36 children had started at the schools in February of the year in which the study began, or in December of the previous year. All of these children spoke English as their first language. A letter requesting parental permission for children's participation in the study was sent to each child's family. Permission was granted for 35 of the children. The data reported in this paper are for the 29 children (17 boys, 12 girls) who completed all assessments in the first year of the study, and for the 27 children (15 boys, 12 girls) who then completed all assessments in the second year of the study. The children who did not complete the assessments had transferred to schools out of the region. At the time of first testing, the children's ages ranged from 5 years 0 months, to 5 years 3 months (mean age = 5 years 1 month).

During the time of the study, reading instruction in New Zealand generally followed a "Whole Language" approach (Smith and Elley, 1994; Thompson, 1993). Official guidelines on the teaching of reading emphasised the importance of reading meaningful text and making use of context cues for word identification. Children were taught the names of letters but were not exposed to systematic instruction in letter-sound relationships (Ministry of Education, 1991). Classroom writing instruction included some teaching of sound to letter correspondences when teachers encouraged children to attempt the spellings of unfamiliar words (Ministry of Education, 1992).

Procedures

The assessments discussed in this paper were part of a wider study of phonological skills and the acquisition of literacy during the first two years at school. The full study also included an examination of the development of spelling skills (see Blaiklock, 1999).

Assessments were made on 6 occasions during the first year of the study and on three occasions during the second year. Testing periods were spaced to give as even a gap as possible between sessions in each year. In the first year there was a gap of seven or eight weeks between the first five testing sessions, with a five week gap between the fifth and sixth sessions. In the second year there was a fourteen or fifteen week gap between testing sessions. On each occasion, tests were given to all children over a two week period. The subjects in one school were usually assessed in one week, followed by the subjects in the other school during the next week. All tests were administered individually by the researcher.

The following tests were included in the assessments:

1) Clay Ready-to-Read Tests

The three Ready-to-Read Word Tests (Clay, 1985) were used to screen children for early reading skills at the time of first assessment. The tests contain a total of 48 high-frequency words. Children's performance was not scored for the two words that could also be read as letters (i.e., "I" and "A"). A criterion level of no more than one word correct was used to classify children as "nonreaders". On this basis, one child who could read four words was excluded from the sample.

2) Peabody Picture Vocabulary Test (PPVT)

Form M of the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn, 1981) was used as a measure of verbal ability, or more specifically, receptive vocabulary. It was administered at the first and last testing sessions of the first year, and at the last session of the second year.

3) Letter Name Knowledge

The Letter Name test required children to give the name of each letter from a sequence of the 26 lower case letters printed in random order on a card (Clay, 1985).

4) Letter Sound Knowledge

The Letter Sound test used the same letter card that was used for the Letter Name test. Children were asked to name the sound of each letter. (The letter x was omitted. The sound "qw" was accepted for q.)

5) Phonological Memory: Digit Span

The forward Digit Span subtest of the WISC-R (Wechsler, 1974) was used as a measure of phonological memory. The test requires children to repeat back series of digits that are first spoken by the researcher. The test begins with items containing three digits. The number of digits to be repeated increases from three digits for the first test item to nine digits for the last test item. Two trials are provided for each item. Testing is stopped if the child fails both trials. The score recorded for the Digit Span test was the total number of trials performed correctly (maximum = 14) rather than the highest number of items that the child could recall on any single trial.

6) Rhyme Awareness

Rhyme awareness was assessed with a sound categorization task adapted from the test used by MacLean, Bryant and Bradley (1987). Introductory procedures similar to those described by Bradley (1984) were used to familiarise the children with the test. The test consisted of 2 practice trials, for which corrective feedback was given, followed by 9 experimental trials for which there was no corrective feedback. The test items are listed in the Appendix.

In each trial, a triplet of three-phoneme monosyllabic words was said aloud to the child. As each word was said, a picture representing the word was placed in front of the child. Use of pictures helped to reduce the memory demands of the task. Each triplet contained two words that shared the same rime unit (e.g., *sail nail boot*). The child was asked to identify the two words which "sounded most the same".

In previous research that has used this type of test, children have always been asked to name the "odd one out" (e.g., Bradley & Bryant, 1978, 1983). This required a child to first work out which two words have similar sounds and then to identify the remaining word. Identifying the two words which "sound most the same" should be a simpler task that may more accurately reflect a child's awareness of rhyming sounds.

7) Phoneme Awareness

The phoneme deletion items from Rosner's (1979) Test of Auditory Analysis Skills (TAAS) were used as a test of phoneme awareness. The TAAS assesses whether children can delete particular sounds from words. The test begins with two demonstration items followed by three items that assess syllable deletion. The next ten items assess phoneme deletion. In the current study the syllable items were administered but only the phoneme items contributed to the child's phoneme awareness score. Each phoneme deletion item required a child to repeat a word said by the researcher, and then change the word by deleting an initial, final or medial phoneme (e.g., "Say *coat*. Now say it again, but don't say /*c*/). Testing was stopped when the child made two consecutive errors. The last item scored correctly was taken as the child's TAAS-Phonemes score. Test items are listed in the Appendix.

8) Word Reading

The Burt Word Reading Test (Gilmore, Croft, & Reid, 1981) was used as a measure of children's word reading knowledge at each testing occasion. The test begins with high frequency words (the first ten words are: to, is, up, for, big, he, at one, my, sun) and becomes progressively more difficult. A total of 120 words are contained in the test but testing was discontinued if a child made 5 successive errors.

Results

Reliability

Several approaches were used to provide information about the reliability of the tests. (Table1). Information from published test manuals was used for the PPVT-R (Dunn and Dunn, 1981) and Burt Word Reading Test (Gilmore et al., 1981).

The Kuder-Richardson Formula 21 (Guilford & Fruchter, 1978) was used to estimate the reliability of tests that had items of approximately the same level of difficulty, that is, Letter Name, Letter Sound, and Rhyme Categorisation. Separate reliability coefficients were calculated for each of the nine test points that a particular test was administered. A "Mean KR-21 Reliability Coefficient" was then calculated to provide an overall indication of a test's reliability during the study.

For tests containing items that become progressively more difficult (i.e. TAAS-Phonemes and Digit Span), the Kuder-Richardson Formulas should not be used (Guilford & Fruchter, 1978). It is possible, however, to calculate test-retest reliability for these tests. Because the tests were given on multiple occasions a "Mean Test-Retest Reliability Coefficient" was calculated by taking the average of the correlations between adjacent test times.

The reliabilities of the tests were at least 0.80 except for TAAS-Phonemes, which had a coefficient of 0.64. The lower reliability of TAAS-Phonemes may have reduced the size of the correlations between this task and other variables.

Mean scores

The means and standard deviations for all the measures are given in Table 2. The mean scores of children on the receptive vocabulary test (PPVT) were within the ranges expected for their ages at the times of testing.

Mean scores on the digit span task showed an overall pattern of increases during the first and second years of the study.

Letter-name knowledge grew rapidly during the first months at school. The average number of letters that children could name was 4.1 at first testing, rising to 13.8 at Time 2, eight weeks later. By the end of the first year most children could name nearly all the letters. Letter-sound knowledge lagged behind letter-name knowledge. Twenty-four of the twenty nine children knew no letter sounds at first testing while the remaining five children knew just one sound. Letter-sound knowledge increased throughout the study period, with an average of 12.6 letter sounds known at the end of the first year, and 19.2 at the end of the second year.

At the beginning of the study, the children's mean score on the Burt Word Reading Test was near zero. By the end of the first year, the mean score on the Burt test was 14.1. By the end of the second year, when the children's mean age was 6 years 11 months, their mean score on the Burt test was 27.2. This score has an Equivalent Age Band of 6 years, 5 months to 6 years, 11 months on the New Zealand norms for the Burt test (Gilmore et al., 1981), and shows that the sample children were within the range of scores expected for their age group.

A number of children were able to perform successfully on the rhyme categorisation task at first testing. The maximum score for the task was 9, with a score of 3 to be expected for children operating at chance level. The mean score for the rhyme task was 4.8 at first testing, rising steadily to 8.1 at the end of the first year and near maximum scores for the second year.

The TAAS-Phonemes task was very difficult for many children, especially in the first year of the study. No children scored above zero for the first two test times and only one child scored above zero at Time 3. The numbers of children scoring above zero increased to 9 by the end of the first year, and to 20 by the end of the second year.

Correlational Analysis

Concurrent Correlations

Concurrent correlations between rhyme awareness and other variables are presented in Table 3. Correlations are shown only for the first year as most children were scoring at maximum levels on the rhyme task during the second year. Significant correlations were found between Rhyme Categorisation and Burt Reading at Times 2, 3, and 4. The decline in the size of the correlations at Times 5 and 6 may have been linked to the increasing ceiling effects for the rhyme awareness measure. Significant correlations were also found between Rhyme Categorisation and Letter

Name and Digit Span on some occasions. Rhyme awareness, however, was not significantly correlated with phoneme awareness at any point.

Table 4 shows concurrent correlations between TAAS-Phonemes and other variables. Results are not reported for the first three test times, as no more than one child was able to carry out the deletion task until Time 4. TAAS-Phonemes was significantly correlated with Burt Reading at Times 4, 5, 7, 8 and 9. Correlations with Letter Name were small and nonsignificant from Times 4 to 6. (Correlations with Letter Name are not provided for the second year because of the ceiling effects for the letter-name measure during this time.) Higher correlations were found between TAAS-Phonemes and Letter Sound, and most of these were significant. Some significant correlations were also found between TAAS-Phonemes and Digit Span in the second year.

Concurrent correlations between Burt Reading and PPVT-R, letter knowledge, and Digit Span, are shown in Table 5. Burt Reading and PPVT-R were significantly correlated at Time 9. Correlations between Burt Reading and Digit Span were generally low and non-significant but most correlations between Burt Reading and letter knowledge were significant.

Concurrent correlations between the phonological awareness measures and reading were adjusted to take account of possible extraneous factors

(Tables 6 and 7). The adjustments were made to determine whether controlling for PPVT-R, Digit Span, or letter knowledge would affect the occurrence of significant relationships between rhyme or phoneme awareness, and reading.

Letter Name was used to control for letter knowledge in the correlations between rhyme awareness and reading (Table 6). Letter Sound was not used as a control for these correlations as many children were scoring at very low levels on this task during the earlier test times. Letter Sound, however, was used as the control for the correlations between phoneme awareness and reading (Table 7) because most children did not begin scoring on the phoneme awareness task until the second half of the first year. Letter Sound could still be used as a control in the second year because, unlike Letter Name, it was little affected by ceiling effects during this time.

Table 6 shows the unadjusted and adjusted correlations between Rhyme and Burt Reading. Unadjusted correlations were significant at Times 2, 3, and 4. Controlling for PPVT-R and Digit Span usually made little difference to the size of the correlations between rhyme awareness and reading. Controlling for letter name knowledge, however, generally resulted in larger declines in the size of the correlations.

Unadjusted and adjusted correlations between TAAS-Phonemes and Burt Reading are presented in Table 7. Unadjusted correlations were significant for all but one point from Time 4 onwards. There was little change in the size of the correlations after adjusting for PPVT-R and Digit Span. Controlling for letter-sound knowledge resulted in larger reductions and meant that most of the correlations between phoneme awareness and reading were reduced to nonsignificant levels.

An examination of individual children's scores on the TAAS-Phonemes task showed that no child began to score on this task until he or she could read a number of words on the Burt Word Reading Test. Two children were reading from 5 to 7 words on the test when they first began to score on the TAAS-Phonemes task. The other children were reading at least 11 words when they first succeeded on the TAAS-Phonemes task.

Predictive Correlations

Predictive correlations were calculated to investigate the relationship between measures of phonological awareness and later reading, and to examine whether these correlations were affected by controls for the influences of possible extraneous factors.

Predictive correlations from rhyme awareness to later reading were mostly nonsignificant, even before controlling for PPVT-R, Digit Span, or letter knowledge (Table 8). All but one of the correlations between rhyme awareness during the first year, and reading at the end of the first or second years, were nonsignificant.

The largest correlations between rhyme awareness and later reading occurred when there was a small time interval between the assessment of rhyme awareness and the assessment of reading. Rhyme awareness at Times 1 to 4 was always significantly correlated with word reading at the next test time. Most of these correlations remained significant after controlling for PPVT-R or Digit Span, but they were all reduced to nonsignificant levels after controlling for letter-name knowledge.

Once children began to score on the TAAS-Phonemes task, correlations between phoneme awareness and later reading were nearly all significant (Table 9). Controlling for PPVT-R or Digit Span made little difference to the size of the correlations, but controlling for letter-sound knowledge reduced many of the correlations to nonsignificant levels.

Regression Analysis

Stepwise regression analysis was used to provide information about which combination of variables best predicted later reading. Two analyses were carried out. The first regression analysis used all the variables at one time, except Burt Reading, to predict Burt Reading at the next time (see

Figure 1). The second regression analysis took the autoregressive effects of prior reading into account by including Burt Reading as a predictor variable (see Figure 2).

When prior reading was excluded from the regression analysis, a measure of letter knowledge was always the largest predictor of reading at the next time point (Figure 1). Letter Name was the largest predictor for the first year, and Letter Sound the largest predictor for the second year. At no time did Rhyme Categorisation explain significant additional variance in later reading. TAAS-Phonemes, however, was able to explain additional variance in reading at Times 5 and 9.

When prior reading was included as a predictor variable, it explained a large proportion of the variance in reading at the next test time (Figure 2). Letter Sound was also a significant contributor to reading at Times 4, 5, and 8. Measures of rhyme or phoneme awareness were unable to explain significant additional variance in later reading at any point.

Discussion

The findings of this study provide support for the existence of positive relationships between phonological awareness and the development of reading. The study also indicates, however, that these relationships may largely be mediated by the role of letter knowledge.

Significant concurrent correlations between rhyme awareness and reading, and between phoneme awareness and reading, were found at a number of points during the study. Controlling for PPVT-R and Digit Span generally made little difference to the size of these correlations but larger declines in the correlations occurred after adjusting for letter knowledge.

Predictive correlations from rhyme awareness to later reading were mostly nonsignificant, even before adjusting for PPVT-R, Digit Span, or letter knowledge. No significant correlations were found between rhyme awareness at Time 1 and word reading at the end of the first or second years. This finding is of particular interest because Time 1 was the only time in the study that rhyme awareness was measured before the children had begun to read. Previous research in this area has often not taken sufficient care to check that children are nonreaders at the start of a study, leaving open the possibility that predictive correlations to later literacy could be the result of unassessed differences in reading levels at first testing. The absence of a connection between rhyme awareness at school entry, and word reading after one or two years of schooling, does not provide support to studies that have proposed a connection between early rhyme awareness and the acquisition of reading skills (e.g., Bradley & Bryant, 1983; Ellis & Large, 1987; Rohl & Pratt, 1995).

On the other hand, some support for a connection between rhyme awareness and reading is available from the predictive correlations that were found when there was only about a two month interval between the assessment of rhyme awareness and the assessment of reading. Rhyme awareness at Times 1 to 4 was always significantly related to word reading at the next test time. However, although these correlations nearly all remained significant after controlling for PPVT-R or Digit Span, they were all reduced to nonsignificant levels when letter-name knowledge was taken into account.

Children found the phoneme awareness task to be considerably more difficult than the rhyme awareness task, a pattern of results that has been found in many other studies (e.g., Stanovich, Cunningham, & Cramer, 1984; Yopp, 1988). However, because the tasks in the current study varied not only in the size of the phonological unit (i.e., phonemes or rimes and onsets), but also in the type of operations required (i.e., deletion or categorization), it is not possible to state that phoneme tasks will always be more difficult than rhyme awareness tasks (see Hulme et al. 2002).

Children were able to score on the rhyme awareness task before they began to read but were unable to succeed on the phoneme awareness task until at least halfway through the first year, by which time they were reading a number of words on the Burt Reading test. This finding is consistent with a number of studies that indicate that phoneme awareness is initially a consequence of developing literacy skills (e.g., Read et al., 1986; Wimmer et al., 1991). It is possible, however, that children in the current study could have succeeded on a phoneme awareness task before they were reading if a different measure had been used. For example, Yopp (1988) found that kindergarten children scored at low levels on two phoneme deletion tests but performed at higher levels on a phoneme segmentation test that required them to separately articulate the phonemes in words.

Once children in the current study had developed some reading skills, their scores on the phoneme deletion task were nearly all significantly correlated with reading at the same time and at later times. Controlling for PPVT-R or Digit Span made little difference to the size of the correlations but a larger decline in the correlations, often to nonsignificant levels, occurred when letter-sound knowledge was taken into account.

Although controlling for PPVT-R or Digit Span usually made little difference to the size of the correlations in this study, it is possible that the use of other measures of ability or phonological memory would have had a greater effect. McMillan (2002) presents evidence that measures of intelligence are able to explain more variance in reading than measures of vocabulary (such as the PPVT-R). Oakhill and Kyle (2000) found that a simple memory task, involving only storage of items (as in the digit span task) was unable to account for independent variance in phonological awareness tasks. However, a memory task that required processing of material, as well as storage, was able to explain independent variance in a sound categorisation task.

Many previous longitudinal studies of phonological awareness and reading have assessed children only at two or three time points over the first years of schooling (e.g., Ellis & Large, 1987; Rohl & Pratt, 1995; Stuart, 1995). The more frequent assessments used in the current study provided additional information about the relationship between variables. Use of the same tests at each measurement point provided consistency in assessing the development of children’s performance over time. However, repeated use of the same tests may have resulted in practice effects. Operating against the possibility of practise effects was the fact that the period between testing sessions was at least seven weeks in the first year of the study and at least fourteen weeks in the second year.

Overall, the findings of this study emphasise the importance of taking account of letter knowledge when examining the relationship between phonological awareness and reading. Numerous significant correlations were found between rhyme awareness, or phoneme awareness, and reading but most of these were reduced to nonsignificant levels after adjusting for differences in children's letter knowledge. Earlier studies that have not controlled for letter knowledge may have provided an incomplete picture of the connections between phonological awareness and reading. Significant correlations between measures of phonological awareness and reading in previous studies may have been the result of the common association of these variables with letter knowledge. Such associations were apparent in the current study where significant correlations were found between measures of phonological awareness and letter knowledge, and between letter knowledge and reading. Letter knowledge is known to be a strong predictor of reading (Adams, 1990) and appears to facilitate phonological awareness skills by helping children to gain insights into the phonological structure of words (Burgess & Lonigan, 1998; Johnston et al., 1996; Wagner et al., 1997).

Children in the current study learnt letter names quickly in the first year at school but their letter-sound knowledge lagged behind and appears to be lower than the levels seen in some studies of early readers in other countries (e.g., Caravolas et al., 2001; McBride-Chang, 1999; Treiman & Rodriguez, 1999). This result may reflect the lesser emphasis given to letter sound instruction in New Zealand reading programmes (see Connelly, Johnston, & Thompson, 2001; Thompson, 1993). Although letter-sound knowledge may not be emphasised in New Zealand classrooms, the high correlations that were found between letter-sound knowledge and reading show that children who learnt letter sounds quickly were more likely to make greater progress in reading.

The finding that controlling for letter knowledge reduced many of the correlations between phonological awareness and reading to nonsignificant levels does not necessarily mean that the relationship between phonological awareness and reading is unimportant. Rather it indicates that measures of letter knowledge and phonological awareness overlap in the variance they explain in reading development. However, although there may be overlap in the contributions of these variables to reading, the stepwise regression analyses showed that a measure of letter knowledge was always a stronger predictor of reading at the next time point than was rhyme or phoneme awareness. After letter knowledge was entered as a predictor, rhyme awareness was unable to explain significant additional variance in word reading for any test time. Phoneme awareness was only able to explain significant additional variance in reading on two occasions, and only when the regression analysis did not include prior reading as a predictor.

Although the current study is correlational in design, the findings about letter knowledge have important implications for experimental studies. The findings reinforce the necessity for experimental studies to take account of the effects of training on letter knowledge. Many experimental studies have neglected to rule out the possibility that any gains in reading may have resulted from gains in letter knowledge rather than gains in phonological awareness. The interactive effects of letter knowledge and phonological awareness need to also be examined (see Hatcher et al., 1994). Future studies should consider both letter-name and letter-sound knowledge as these types of knowledge develop at different rates and have different relationships with phonological awareness and reading.

Appendix

Rhyme Categorization

The items for the Rhyme Categorization test were developed by MacLean, Bryant and Bradley (1987). All items were administered with pictures.

Practice Items

A.	sail	nail	*boot*
B.	cat	*bell*	hat

Test Items

1.	*sock*	hay	tray
2.	peg	*cot*	leg
3.	fish	dish	*book*
4.	*bus*	arm	farm
5.	*cup*	sand	hand
6.	hen	*car*	pen

7. gun sun *tap*

8. wall *dog* ball

9. *paw* boat goat

TAAS-Phonemes Test

The sound to be deleted is represented in parentheses.

Practice Items

A. cowboy (boy)

B. spaceship (space)

Preliminary Syllable Items (not included in total score)

1. Say sunshine (shine)

2. Say picnic (pic)

3. Say cucumber (cu)

Phoneme Items

1. Say coat (c)

2. Say meat (m)

3. Say take (t)

4. Say game (m)

5. Say wrote (t)

6. Say please (z)

7. Say clap (c)

8. Say play (p)

9. Say stale (t)

10. Say smack (m)

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Table 1

Reliability of Tests

Test	Reliability Coefficien
PPVT-R	.81
Rhyme Categorisation	.77
TAAS-Phonemes	.64
Digit Span	.80
Letter Name	.86
Letter Sound	.89
Burt Reading	.96

Table 2

Means and Standard Deviations of Tests

Time	PPVT-R[a]		Digit Span[b] (max = 14)		Letter Name (max = 26)		Letter Sound (max = 25)		Rhyme Categorisation (max = 9)		TAAS-Phonemes (max = 10)		Burt Reading (max = 120)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
1	54.7 (97)	11.2	5.79	1.42	4.14	4.81	0.17	0.38	4.76	2.37	0.00	0.00	0.17	0.38
2			6.28	1.13	13.79	7.19	3.21	4.15	6.21	2.53	0.00	0.00	3.59	2.63
3			6.17	1.47	17.62	6.46	4.76	5.60	6.62	2.26	0.10	0.56	6.34	4.13
4			6.83	1.77	20.83	4.55	8.10	7.48	7.34	2.04	0.83	2.16	7.90	5.30
5			7.07	1.62	21.93	4.48	11.03	7.77	7.97	1.88	1.14	2.46	12.00	6.45
6	67.7 (100)	11.8	7.31	1.95	23.83	2.94	12.59	8.27	8.14	1.71	1.59	2.63	14.07	7.27

7			7.26	2.09	24.96	1.02	15.11	6.33	8.41	1.39	1.96	2.39	17.78	8.03
8			7.96	2.05	25.44	0.85	18.67	5.42	8.63	1.57	3.04	3.11	22.56	10.15
9	81.5 (103)	11.2	8.22	1.87	25.93	0.27	19.22	4.20	8.96	0.19	4.56	3.25	27.19	9.17

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R standard scores are in parentheses.

[b] The Digit Span scores represent the number of trials performed correctly.

Table 3

Concurrent Correlations Between Rhyme Categorisation and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span	TAAS-Phonemes	Burt Reading
1	.41*	.41*	-	.24		
2		.36*	.21	.57**		.37*
3		.28	.18	.25		.35*
4		.49**	.08	.24	.28	.57**
5		.00	.08	.14	.12	.30
6	.28	.20	-.07	.36*	.19	.26

Note. Times 1 - 6, $n = 29$.

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .0005$.

Table 4

Concurrent Correlations between TAAS-Phonemes and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span	Burt Reading
4		.30	.60***	.15	.55**
5		.23	.37*	.08	.45**
6	-.06	.18	.30	.19	.28
7			.41*	-.13	.43**
8			.41*	.36*	.54**
9	.49**		.48**	.32*	.51**

Note. Times 4 - 6, $n = 29$; Time 7 - 9, $n = 27$.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 5

Concurrent Correlations between Burt Reading and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span
2		.54**	-.03	.27
3		.59***	.30	.34*
4		.59***	.28	.26
5		.63***	.61***	.21
6	.30	.70***	.62***	.10
7			.61***	.02
8			.59***	.18
9	.42*		.61***	.26

Note. Times 2 - 6, $n = 29$; Time 7 - 9, $n = 27$.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 6

Concurrent Correlations Between Rhyme and Burt Reading: Unadjusted and Adjusted for Key Variables

Time	Unadjusted correlation	Correlation adjusted for		
		PPVT-R[a]	Digit Span	Letter Name
2	.37*	.32*	.27	.22
3	.35*	.34*	.29	.24
4	.57**	.54**	.55**	.40*
5	.30	.27	.28	.39*
6	.26	.20	.24	.17

Note. Times 2 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 7

Concurrent Correlations Between TAAS-Phonemes and Burt Reading: Unadjusted and Adjusted for Key Variables

Time	Unadjusted correlation	Correlation adjusted for		
		PPVT- R[a]	Digit Span	Letter Sound
4	.55**	.58**	.53**	.49**
5	.45**	.48**	.44**	.30
6	.28	.32	.27	.13
7	.43*	.48**	.47**	.30
8	.54**	.49**	.52**	.41*
9	.51**	.38*	.46**	.31

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 8

Predictive Correlations from Rhyme Categorization at Time (t) to Burt Reading at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for Key Variables

Time (t)	Burt Reading at next Time (t+ 1)				Burt Reading at end of Year One (Time 6)				Burt Reading at end of Year Two (Time 9)			
	Un-adjusted	Adjusted for:			Un-adjusted	Adjusted for:			Un-adjusted	Adjusted for:		
		PPVT-R[a]	Digit Span	Letter Name		PPVT-R[a]	Digit Span	Letter Name		PPVT-R[a]	Digit Span	Letter Name
1	.41*	.31	.39*	.28	.28	.21	.26	.17	.05	-.09	-.04	-.04
2	.39*	.34*	.29	.24	.25	.21	.20	.01	.02	-.04	-.06	-.12
3	.38*	.38*	.33*	.28	.22	.20	.20	.02	-.01	-.03	-.03	-.16
4	.44**	.40*	.41*	.16	.40*	.36*	.38*	.06	.23	.17	.22	-.12
5	.19	.16	.17	.25	.19	.16	.17	.25	.03	.02	.01	.08
6	.18	.13	.16	-.01			.24		.19	.11	.16	.01

Note. Times 1 - 6, *n* = 29; Times 7 - 9, *n* = 27.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 9

Predictive Correlations from TAAS-Phonemes at Time (t) to Burt Reading at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for Key Variables

Time (t)	Burt Reading at next Time (t+ 1)				Burt Reading at end of Year One (Time 6)				Burt Reading at end of Year Two (Time 9)			
	Un-adjusted	Adjusted for:			Un-adjusted	Adjusted for:			Un-adjusted	Adjusted for:		
		PPVT-R[a]	Digit Span	Letter Sound		PPVT-R[a]	Digit Span	Letter Sound		PPVT-R[a]	Digit Span	Letter Sound
4	.59***	.61***	.58***	.43*	.58***	.60***	.58***	.38*	.46**	.47**	.48**	.33*
5	.43**	.45**	.42*	.27	.43*	.45**	.42*	.27	.32*	.34*	.34*	.20
6	.23	.25	.23	.14					.24	.28*	.24	.16
7	.46**	.49**	.48**	.26					.43*	.46*	.46**	.24
8	.53**	.48**	.50**	.39*					.53**	.48**	.50**	.39*

Note. Times 1 - 6, *n* = 29; Times 7 - 9, *n* = 27.

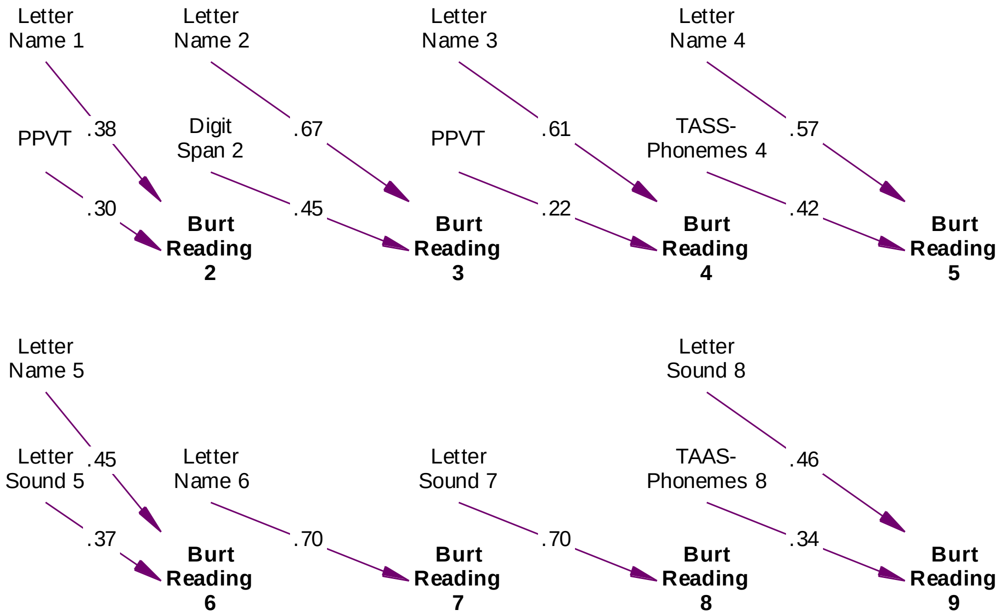
[a] PPVT-R was administered at Times 1 and 6.

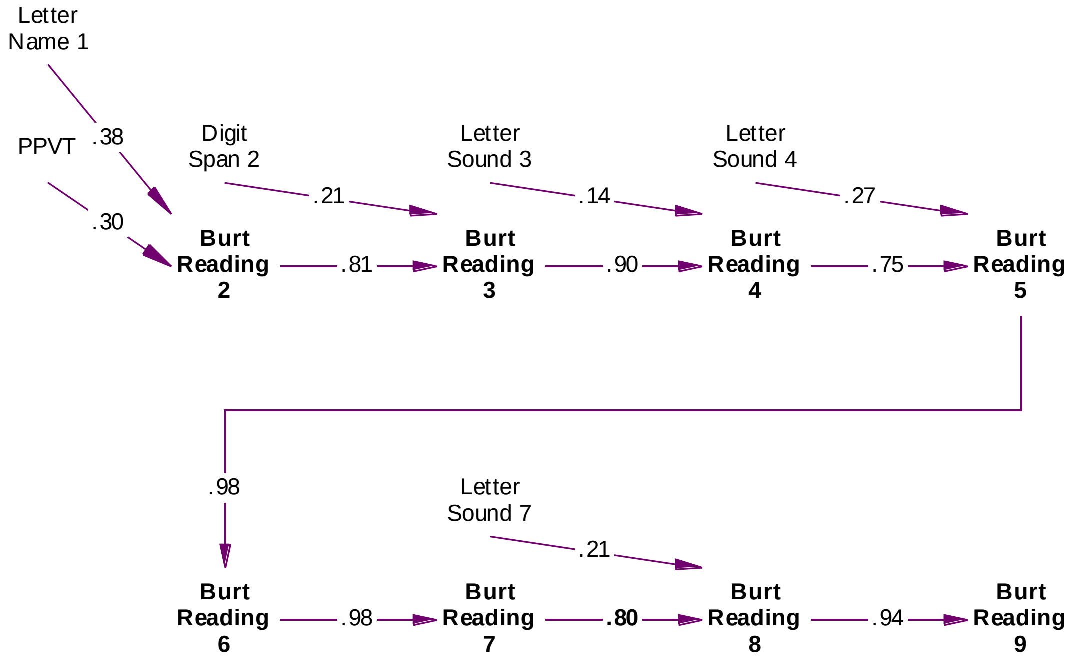
*$p < .05$. **$p < .01$. ***$p < .0005$.

Figure Captions

Figure 1. Diagram showing results of stepwise regression analysis using all variables (except Burt Reading) to predict Burt Reading at the next test time. (Standardised beta weights: $p < .05$, one tailed tests. Nonsignificant paths are not shown)

Figure 2. Diagram showing results of stepwise regression analysis using all variables (including Burt Reading) to predict Burt Reading at the next test time. (Standardised beta weights: $p < .05$, one tailed tests. Nonsignificant paths are not shown.)


Letter
Name 1
PPVT
.38
.30
Burt
Reading
2
Letter
Name 2
Digit
Span 2
.67
.45
Burt
Reading
3
Letter
Name 3
PPVT
.61
.22
Burt
Reading
4
Letter
Name 4
TASS-
Phonemes 4
.57
.42
Burt
Reading
5
Letter
Name 5
Letter
Sound 5
.45
.37
Burt
Reading
6
Letter
Name 6
.70
Burt
Reading
7
Letter
Sound 7
.70
Burt
Reading
8
Letter
Sound 8
TAAS-
Phonemes 8
.46
.34
Burt
Reading
9


Letter
Name 1
PPVT
.38
.30
Digit
Span 2
.21
Letter
Sound 3
.14
Letter
Sound 4
.27
Burt
Reading
2
.81
Burt
Reading
3
.90
Burt
Reading
4
.75
Burt
Reading
5
.98
Letter
Sound 7
.21
Burt
Reading
6
.98
Burt
Reading
7
.80
Burt
Reading
8
.94
Burt
Reading
9