



University of Warwick institutional repository: <http://go.warwick.ac.uk/wrap>

This paper is made available online in accordance with publisher policies. Please scroll down to view the document itself. Please refer to the repository record for this item and our policy information available from the repository home page for further information.

To see the final version of this paper please visit the publisher's website. Access to the published version may require a subscription.

Author(s): Anna J. Cunningham & Julia M. Carroll

Article Title: Reading-Related Skills in Earlier- and Later-Schooled Children

Year of publication: 2011

Link to published article:

<http://dx.doi.org/10.1080/10888431003706309>

Publisher statement: This is an electronic version of an article published in Cunningham, A. J. and Carroll, J. M. (2011). Reading-Related Skills in Earlier- and Later-Schooled Children. *Scientific Studies of Reading*, Vol. 15(3), pp. 244-266. *Scientific Studies of Reading* is available online at:

<http://www.tandfonline.com/doi/pdf/10.1080/10888431003706309>

Running Head: The development of reading-related skills

Reading-related skills in earlier and later schooled children

Anna J. Cunningham

Julia M. Carroll

University of Warwick, UK

Abstract

We investigate the effects of age-related factors and formal instruction on the development of reading-related skills in children aged four and seven years. Age effects were determined by comparing two groups of children at the onset of formal schooling; one aged seven (later-schooled) and one aged four (earlier-schooled). Schooling effects were measured by comparing the later-schooled group with earlier-schooled age-matched controls. There were significant effects of age and schooling on phonological awareness and visual-verbal learning, and an effect of age, but not schooling, on vocabulary and short-term verbal memory. We conclude that age-related factors and reading instruction contribute to the development of phoneme awareness and that vocabulary and verbal memory improve with age.

Keywords: Reading, age, vocabulary, phonological awareness

Reading-related skills in earlier and later schooled children

Previous research has shown evidence of a significant improvement in cognitive skills between the ages of 5 and 7, otherwise known as the ‘5-7 shift’ (Morrison, Griffith, & Frazier, 1996). Of these, many have been related to early reading, such as vocabulary, verbal memory, and in particular phonological awareness, all of which show an important developmental change at this time (Muter, Hulme, & Snowling, 1997; Wagner, et al., 1997). However, such changes have previously only been shown in children who began receiving formal reading instruction between the ages of 4 and 6. Therefore, it is unknown to what extent the improvements may have been stimulated by the process of reading itself or by age-related processes such as spontaneous maturation and informal experience of language (referred to in the current paper as age effects). We address this issue in the present study by comparing three groups of children: two groups tested shortly after the onset of formal reading instruction, one younger and one older, and a matched older group of experienced readers. The results will help to elucidate the relative contributions of age and formal instruction in reading to the development of reading-related skills during the first years of school.

It is reasonable to assume that exposure to formal reading instruction would lead to a corresponding improvement in reading-related skills. In line with this hypothesis, there is evidence of bidirectional relationships between reading-related skills and reading. For example, phonological awareness is thought to have a reciprocal relationship with reading with gains in one leading to gains in the other (Perfetti, Beck, Bell, & Hughes, 1987; Wagner, Torgesen, & Rashotte, 1994). There is also evidence of ‘Matthew effects’ in reading whereby cognitive development is enhanced through a process of ‘bootstrapping’ (Stanovich, 1986). For instance, reading will increase exposure to new words, thus improving vocabulary while vocabulary helps children to decode new words, thus improving reading. In line with this

hypothesis, Stanovich, Nathan and Valarossi (1986) found that poor readers in fifth grade had similar levels of vocabulary and phonological skills to reading-matched controls in third grade.

Age-related processes independent of formal reading instruction also play a role in the development of reading-related skills. For example, spoken word vocabulary develops in pre-literate children, stimulated by exposure to oral language (Metsala, 1999). Additionally, vocabulary can be further enhanced by being read to in school and at home (Lonigan, Anthony, Bloomfield, Dyer, & Samwel, 1999). Furthermore, studies have consistently shown evidence of large segment (syllable and rime) awareness in pre-school children who have not yet been exposed to formal reading instruction (Carroll, Snowling, Hulme, & Stevenson, 2003; Lonigan, Burgess, & Anthony, 2000). Researchers have argued that such awareness can be stimulated at school or at home by activities such as singing songs, rhyming games (Goswami & Bryant, 1990), and being read to (Lonigan, et al., 1999). Therefore, it is reasonable to assume that, given these informal experiences of language, skills like vocabulary and syllable awareness would continue to develop in the absence of formal reading instruction.

Measuring the effects of age vs. formal instruction

Previous studies have typically confounded age with length of reading instruction, making it difficult to disentangle the effects of each. One way of separating the two is to use the ‘cut-off’ method (Morrison, Smith, & Dow-Ehrensberger, 1995). Such studies use the natural school cut-off date to examine the youngest and oldest pupils in the same year group. This way, children may be matched on exposure to school-based reading instruction but differ by up to twelve months in age. Conversely, the effect of formal reading instruction can be measured by comparing the oldest children in a year group with the youngest children in

the year above. This way, participants may be approximately matched on age but differ by one year of schooling.

A limitation of cut-off studies is that, due to being constrained by the school cut-off date, they can only compare children who have a maximum of twelve months difference in age. Therefore, any differences observed will be limited to a small window of development and, as a consequence, the effect of age may be underestimated. In addition, the groups in cut-off studies, although closely matched on background variables, typically are not matched for reading ability (between the oldest and youngest in the same year group) (Bowey & Francis, 1991; Morrison, Griffith, & Alberts, 1997). Therefore, the superior reading-related skills of the older children may be due to their superior reading ability. The current study seeks to address these limitations by comparing reading-related skills in non-reading children of the ages of four and seven, and an age-matched control group of seven-year-old readers. The comparison can be viewed as an extension of the cut-off method, comparing children with a three year difference in age with similar levels of exposure to formal instruction and an age -matched control group with 3 years of additional instruction.

Age and schooling effects on vocabulary and memory

In a study using the cut-off method, exposure to formal schooling in grade one was found to be the major determinant of the ability to retain the names of pictures in working memory, while there was no significant effect of age (Morrison et al., 1995). Similarly, a study by Ferreira and Morrison (1994) found that children's ability to isolate and repeat the longest subjects in a sentence improved with schooling, but not with age. On the other hand, vocabulary has been found to be relatively unaffected by early schooling experiences. Frazier and Morrison (1998) found no difference in the vocabulary of Kindergartners who had experienced an extended school year compared to those who had experienced a shorter year. In addition, a study by Christian, Morrison, Frazier and Massetti (2000), using the cut-off

method, found no significant effect of schooling on a measure of receptive vocabulary during Kindergarten and first grade. Age effects were not measured.

Phonological awareness

Early studies on the development of phonological awareness indicated that awareness of large units (syllables and onset/rimes) preceded awareness of small units (phonemes), and that both were important independent longitudinal predictors of literacy development (Bryant, Maclean, Bradley, & Crossland, 1990; Bryant, Nunes, & Bindman, 1998). However, more recent work has cast both of these hypotheses into doubt. For example, rime awareness does not necessarily precede phoneme awareness (PA), particularly on explicit phonological awareness tasks (Duncan, Seymour, & Hill, 1997; Geudens & Sandra, 2003). Furthermore, phoneme awareness seems to be more important than rime awareness in the prediction of literacy development (Hulme, et al., 2002; MacMillan, 2002; Savage & Carless, 2005). These results suggest that a focus on phoneme awareness may be particularly crucial for this study.

However, one potential problem with focusing on phoneme awareness tasks rather than rime and other types of phonological awareness is that alphabetic literacy is in itself a major cause of growth in phoneme awareness. For example, studies have shown that PA develops rapidly during the first year of learning to read (Muter, Hulme, Snowling, & Taylor, 1997; Wimmer, Landerl, Linortner, & Hummer, 1991) and that pre-readers struggle with PA tasks (Hulme, et al., 2002). The strongest interpretation of the evidence is that phoneme awareness does not develop in the absence of alphabetic literacy (e.g., Castles & Coltheart, 2004).

Recent research, however, has led to evidence that non-readers can solve certain explicit phoneme awareness tasks. For example, Geudens and Sandra (2003) showed above chance levels of the ability to segment two-phoneme syllables in 6-year-old Dutch speaking children who had not yet begun formal reading instruction. In addition, Hulme et al. (2005) showed significant phoneme isolation ability in Czech (age 6) and English (age 5) children at

school entry. However, in both studies, the majority of children were in possession of some letter knowledge at time of testing. Letter knowledge is a precursor of alphabetic literacy that has been strongly associated with phoneme awareness during the pre-school years (Burgess & Lonigan, 1998; Carroll, 2004). Hence, it may account for the PA skills demonstrated in the above studies.

Caravolas (2006) argued that English speaking children may be relatively late to develop phoneme awareness because of particular characteristics of the English language, and that this, coupled with the tendency for English speaking children to begin reading instruction earlier than in other countries (Bertram & Pascal, 2002), may account for why phoneme awareness does not seem to develop in the absence of literacy in English. One way to assess this claim is to examine whether English speaking children who begin reading instruction later show any phoneme awareness prior to reading instruction. This is addressed in the current study.

Age and schooling effects on phoneme awareness

Previous research suggests that phoneme segmentation skills may be stimulated by age-related processes during the year preceding formal reading instruction (usually called Kindergarten). For example, Bentin, Hammer, and Cahan (1991) found that older Kindergarteners (age 6) in Israel significantly out-performed younger Kindergarteners (age 5) on tests of phoneme segmentation. In the US, Morrison et al. (1995) found a significant age effect on a similar test of phoneme awareness during the Kindergarten year. However, this age effect did not persist into first and second grade during which there were large gains in PA. At the time of testing, formal reading instruction in the US typically did not start until first grade. Therefore, it would appear that once formal teaching of reading begins, its effect on PA is so powerful that it supersedes the age effect. However, age does seem to have an effect during the 'pre-reading' phase.

Age effects on the relationship between phonological awareness and vocabulary

There is evidence that vocabulary levels are closely associated with phonological skills in the preschool and early school years, but that this association decreases during the later school years (e.g., compare Snowling, Gallagher, & Frith, 2003; and Snowling, Muter, & Carroll, 2007). In some studies of pre-school children (up to the age of 5), vocabulary has been found to be an important concurrent and longitudinal predictor of phonological awareness (Carroll, et al., 2003; Lonigan, et al., 2000; McDowell, Lonigan, & Goldstein, 2007). However, in older children this is less frequently the case. For example, Wagner et al. (1997) found that vocabulary was a unique predictor of phonological awareness from Kindergarten to second grade and from first grade to third grade, but not from second grade to fourth grade.

There are several possible explanations for these changes. Scarborough and Dobrich (1990) argue that vocabulary tests measure different skills at different ages. Early in development, children's acquisition of vocabulary may be limited by their ability to process sound sequences, while later in development it is more dependent on other skills, such as understanding and interpreting verbal context. Another possible explanation is offered by the lexical restructuring hypothesis (Metsala & Walley, 1998; Walley, 1993). Walley argues that phonological processing abilities are dependent on vocabulary size. As children acquire new vocabulary, increasing pressure is placed on their lexicon and words must be represented in greater phonological detail, thus increasing phonological awareness for those words. Walley does not give definite ages for the start and end of this vocabulary 'growth spurt', but it is thought to take place during the pre-school and early school years (Metsala, 1999).

Both research groups cite the introduction of literacy instruction as playing a key role in the changing relationship between vocabulary and phonological awareness. One of the reasons for this is that literacy instruction allows children to begin to use explicit

metalinguistic awareness to solve phonological tasks (Gombert, 1992). However, no research has yet examined the relationship between these skills in older children who have not yet begun formal literacy instruction. These children will have a large vocabulary, but relatively undeveloped metalinguistic skills in comparison to other children of their age in standard education. The current research will examine whether the relationship between phonological awareness and vocabulary in this group is similar to that of younger children at the same reading level, or that of age-matched children at the same vocabulary level.

The Current Study

In order to separate the effects of formal schooling and age, it was necessary to access a group of children who began school at a different age from usual. In the UK, standard educated children enter formal schooling during the academic year in which they turn five. One group of children who start at a substantially later age are those educated at Steiner schools. According to the Steiner philosophy, formal learning, including the teaching of reading, should not begin until age seven. Prior to this age, children attend the Steiner Kindergarten, which caters for all those between the ages of three and seven. Steiner Kindertages are essentially play-based and there is no specific teaching of literacy or mathematics during this time (Steiner, 1924/1982). Therefore, the effect of age can be determined by comparing a group of older, later-schooled (Steiner) children with a group of younger, earlier-schooled children (reading controls), both at the onset of formal education and in possession of no or minimal reading skills. Schooling effects can be calculated through comparison of the later-schooled children with a group of earlier-schooled age-matched controls.

Three main questions are addressed:

1. What is the effect of formal schooling compared to age-related factors on the development of vocabulary and verbal memory skills?

2. What is the role of formal instruction in reading compared to age-related factors in the development of phoneme awareness?
3. Does the relationship between vocabulary and phonological awareness change with age or exposure to formal reading instruction?

Method

Participants

Participants were 93 children out of 167 who participated in the initial screening procedure, recruited from four schools in the United Kingdom. Thirty later-schooled children (average age 7,10 years; range 7,3 to 8,3) were compared to 33 earlier-schooled reading controls (average age 4,9 years, range 4,3 to 5,2) and 30 earlier-schooled age controls (average age 7,10 years; range 7,6 to 8,3). The later-schooled group consisted of 15 boys and 15 girls, the reading control group of 14 boys and 19 girls, and the age control group of 16 boys and 14 girls.

The schools

The later-schooled children were recruited from two independent Rudolf Steiner schools in the London area. The first school ($n = 21$) was located in a semi-rural Suburban area. According to the latest ACORN statistics ("ACORN statistics," 2009) (which combine demographic and lifestyle variables to describe the characteristics of different postcodes in the UK), the school was in a 1, C, 9 area: Category: wealthy achievers, Group: flourishing families, Type: larger families, prosperous suburbs. Out of a total of 45 children in the two Class Two classes, 41 participated in the initial screening procedure. Two children did not participate because they did not speak English at home with either parent, one child had severe learning difficulties, and one had parental consent withdrawn.

The second Steiner school (n = 9) was located in an urban area of inner-city London. ACORN classified it as being in a 5, Q, 55 area: Category: hard-pressed, Group: inner-city adversity, Type: multi-ethnic purpose built estates. However, due to the fee-paying nature of the school, most children travelled in from the more affluent surrounding areas. Out of a total of 16 children, parental consent was acquired from 14 parents, all of whom participated in the initial screening procedure.

The earlier-schooled, reading matched controls (n = 33) were recruited from one state-run Infant school in a semi-rural area of Warwickshire. It was classified by ACORN as being in a 1, A, 1 area: Category: wealthy achievers, Group: wealthy executives, Type: affluent mature professionals, large families. Sixty children participated in the initial screening procedure.

The earlier-schooled, age matched controls (n = 30) were recruited from one state-run Junior school in the Warwickshire area. It was located in a semi-rural area, classified by ACORN as a 3, H, 28 postcode: Category: comfortably-off, Group: secure families, Type: working families with mortgages. Out of 86 children in the three classes, parental consent and home literacy environment questionnaires were acquired from 60 parents. Seven children were excluded due to not falling within the required age range. Therefore, 53 children took part in the initial screening procedure.

Educational practices

The later-schooled children were tested during the first semester of Class Two (ages 7-8). Children were exposed to letters in Class One (ages 6-7) and learnt some sounds and names. However, there was no formal relation of these sounds to decoding words. Parents were discouraged from teaching their children how to read at home and engaging in 'reading-readiness' activities. Previous to this, the children had attended the Steiner Kindergarten for three to four years (ages 3-6). At this time, they were deliberately shielded from the influence

of formal teaching and although the children were told stories and sang songs, there was no relation of language to the printed word.

The reading controls were tested during the first semester of the Reception year (ages 4-5), which is the first year of formal reading instruction in the UK. Some children had previously attended preschool (ages 2-4) for one to two years and had been exposed to letters in an informal context. In addition, a certain amount of phonic work had already taken place during the first part of the Reception year, which mainly involved learning letter sounds. The age controls were tested during the second semester of Year 3 (ages 7-8). They had all attended school since the Reception year and had experienced an average of 3½ years formal reading instruction at the time of testing.

The screening and matching procedure

A sample of 55 later-schooled 7- and 8-year olds (representing 89% of children in the year group) was initially tested for word reading. Thirty-one of them reported attending a Steiner school since Kindergarten and claimed not to have been taught how to read at home by their parents. Eleven children said that they had previously attended a standard school where reading had been taught and 18 children (five of whom had also attended a standard school) reported to have been taught reading at home by their parents. These latter two groups ($n = 24$) were excluded because they could all read more than 5 words on the British Ability Scales (BAS) word reading test (Elliot, Smith, & McCulloch, 1996), mean = 34.96, $SD = 24.79$, range 7 -71. The remaining 31 children who had been pure 'Steiner-taught' were found to have no or minimal reading skills (≤ 5 on the BAS). Complete data for one child was not obtained due to him being absent for virtually the entire testing period, resulting in a final sample of 30. Home literacy environment questionnaires were sent home twice and were returned by 21/30 parents. Data on maternal education level was obtained from an additional three children during a follow-up visit.

Sixty 4- and 5-year-olds (representing 100% of the children in the year group) were screened for word reading ability (mean = 1.18, $SD = 5.70$, range 0-43) and vocabulary (mean standard score = 111.05, $SD = 10.25$, range 80-131). One child was excluded due to scoring more than 5 on the BAS. Each child in the later-schooled group was matched to one child from this group on the basis of standardised vocabulary score (within five points). This was to ensure that there was a similar level and distribution of verbal ability (as expected for their age) in each group. Finally, an additional three children were selected such that the groups were also matched for average score on the home literacy environment questionnaire. Therefore, 33 earlier-schooled reading controls were selected for the final sample. Home literacy environment questionnaires were sent home twice to this group and were returned by 24 parents. An additional two questionnaires were obtained during a follow-up visit.

A sample of 53 earlier-schooled 7- and 8-year-olds (representing 62% of children in the year group) was initially screened for word reading ability (mean = 58.81, $SD = 12.49$, range 6-74). Each child for the final sample was selected on the basis of three criteria: First, one, two or three participants were matched to one of the later-schooled children according to age (within three months). Of these children, one or two were selected on the basis of having the highest maternal education score, and finally (if more than one child remained), the one with a standardised reading score closest to the national average was selected. This produced a final sample of 30 earlier-schooled age controls.

Design and Procedure

Children were tested individually by the first author in a quiet corner of the school. The later-schooled and age control children were tested during two sessions lasting 20-30 minutes each and the reading controls during three sessions lasting about 15 minutes each. Sessions for the younger children were shorter to encourage them to remain focused. Children in the first two groups completed a total of seven tasks each, whereas children in the age control

group completed six tasks each (as all children in this group were skilled readers, it was assumed that they would perform at ceiling for the letter knowledge task). Tasks were presented in fixed order with the language and phonological tests interspersed to maintain interest. The deleting and blending sounds tasks and non-word repetition task were presented orally by the experimenter, which differs from the usual procedure with a standardised recording. This was because teachers at the Steiner schools were not comfortable with the children receiving pre-recorded tests.

Materials

Reading tasks

Word reading. Single words were printed in large font on a sheet of paper for the British Ability Scales 2 word reading task (Elliot, et al., 1996). If the child was not able to read any of the first ten words the test was stopped. Guessing was encouraged. If a child did not know a word, they were asked to try and ‘sound it out’ and then blend the sounds together.

Letter-sound knowledge. Each of the 26 lower case letters were presented individually on cards. Children were asked to pronounce the sound of the letter. If they replied with the letter name, they were asked if they knew what the letter sound was. This test was untimed. Sample-specific reliabilities were high: Later-schooled group, Cronbach’s $\alpha = .87$; reading controls, $\alpha = .92$.

Phonological tasks

Deleting sounds. Children’s ability to segment and manipulate sounds at the level of the syllable and phoneme was measured using the elision test from the Comprehensive Tests of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999). The test consisted of three items in which children were asked to delete the first or final syllable of a word followed by five items that required deletion of the initial or final phoneme of a word and by

12 items that required deletion of a word's medial phoneme. Sample-specific reliabilities were good: Later-schooled group, Cronbach's $\alpha = .82$; reading controls, $\alpha = .87$; age controls, $\alpha = .81$.

Blending sounds. Children's ability to blend syllables and phonemes was measured using the blending words test from the CTOPP (Wagner et al., 1999). The experimenter pronounced individual sounds and asked the child to blend them together. There were three items that required blending of syllables, five items that required blending of two phonemes and 12 items that required blending of three or more phonemes. Sample-specific reliabilities were medium - high: Later-schooled group, Cronbach's $\alpha = .81$; reading controls, $\alpha = .91$; age controls, $\alpha = .67$.

Language tasks

Receptive Vocabulary. Vocabulary was measured using the British Picture Vocabulary Scale, 2nd edition (Dunn, Dunn, Whetton, & Burley, 1997). Children were asked to point to one of four pictures to identify a word spoken by the experimenter. The test continued until the child made eight or more errors in a block of ten. This test was standardised in the UK for children between the ages of 3 and 15. Sample-specific reliabilities were high: Later-schooled group, Cronbach's $\alpha = .93$; reading controls, $\alpha = .89$; age controls, $\alpha = .81$.

Recalling sentences. Knowledge of sentence structure and verbal short-term memory were evaluated using the Recalling Sentences test from the school age version of the Clinical Evaluation of Language Fundamentals (CELF -3/UK) (Semel, Wiig, & Secord, 1995). Children were introduced to two puppets. The child took on the role of one of the puppets. The examiner's puppet said 'Now I am going to say some things to you. I want you to listen carefully and repeat exactly what I say.' If the child repeated the sentence verbatim, they received a score of 3; if they made one error, a score of 2; and if they made 2-3 errors, a score of 1. No response or four or more errors received a score of 0. Sample-specific reliabilities

were high: Later-schooled group, Cronbach's $\alpha = .90$; reading controls, $\alpha = .87$; age controls, $\alpha = .85$.

Non-word repetition

The non-word repetition task from the Comprehensive Tests of Phonological Processing (Wagner et al., 1999) was used to measure children's short-term verbal memory. The task was presented with puppets to encourage children's engagement. The experimenter pronounced a nonword and the child was asked to repeat it back as accurately as possible. Sample-specific reliabilities were less good: Later-schooled group, Cronbach's $\alpha = .65$; reading controls, $\alpha = .43$; age controls, $\alpha = .66$.

Visual-verbal learning

The ability to remember associations between visual and verbal stimuli was measured using a visual verbal learning task adapted from the memory confusions task developed by Treiman and Breaux (1982). To begin, the children were introduced to three finger puppets and asked to remember their names. Next, the experimenter mixed the order of the puppets and the child was asked to point to the puppet named by the experimenter. Each set of three responses formed a triad, with a maximum of six triads per section. After each triad, the puppets were mixed up again and the names pronounced in a different order. The test was discontinued after all three puppets were correctly recognised for two consecutive triads and children were given full marks for the remaining four triads. In the second and third section, the procedure was repeated with different finger puppets and names. Sample-specific reliabilities were high: Later-schooled group, Cronbach's $\alpha = .91$; reading controls, $\alpha = .90$; age controls, $\alpha = .81$.

Home Literacy Environment

A questionnaire adapted from the Family reading survey used by Samuelsson et al. (2005) was handed out to parents. Twenty-one parents from the later-schooled group, 26

parents from the reading control group, and 30 parents from the age control group completed the questionnaire. It consisted of 16 questions that focused on the child's exposure to literacy-related activities in the home and two questions on parental education level. Questions pertaining to shared-book reading activities were considered an inappropriate comparison for the parents of independent readers, and were therefore omitted from the questionnaire given out to the age control group. A composite score was calculated for the six questions about family literacy and nine questions about shared-book reading activities. There was some missing data due to some parents leaving certain questions blank (results and reduced sample sizes are reported in Table 1).

Results

Background characteristics

Table 1 shows background characteristics for the three groups. ANOVAs revealed that exposure to reading-related activities in the home was broadly similar across groups. There was no significant main effect of group on shared book reading, $F(1,43) = 0.21$, $p = .65$, $r^2 < .01$ (later-schooled and reading control groups only), family literacy, $F(2,70) = 1.25$, $p = .29$, $r^2 = .05$ or the age the parents began reading to their child, $F(2, 71) = 1.18$, $p = .31$, $r^2 = .04$. There was, however, a main effect of group on paternal education level, $F(2, 71) = 5.15$, $p < .01$, $r^2 = .08$. Fathers in the later-schooled group were better educated than those in the reading control group, $t(71) = 2.44$, $p < .05$, $r = .28$, but there was no significant difference between the two older groups, $t(71) = -0.37$, $p = .72$, $r < .01$. There was also a main effect of group on maternal education level, $F(2,76) = 10.08$, $p < .01$, $r^2 = .37$. Mothers in the later-schooled group were better educated than those in the reading control group, $t(76) = 4.48$, $p < .01$, $r = .50$, and age control group, $t(71) = 2.44$, $p < .05$, $r = .28$. Maternal education is highly reflective of a child's socio-economic status, a variable that has been shown by

numerous studies to influence early language and phonological skills (Bowey, 1995; Lonigan, Burgess, Anthony, & Barker, 1998). Maternal education is therefore co-varied in the main analyses below.

Mean comparisons of reading-related skills between groups

Table 2 shows descriptive statistics for the measures of reading-related skills. Raw vocabulary scores are reported in this instance to reflect the absolute vocabulary level of each group. ANCOVAs were performed to test for mean differences in reading-related skills between groups with maternal education co-varied. Data on maternal education level was missing for 16% of the overall sample ($n = 14$). Missing Values Analysis ("PASW Statistics, 17.0," 2009), indicated that these data were missing completely at random (MCAR), Little's MCAR test, $\chi^2(6) = 10.14, p = .12$. Therefore, imputation of missing values was undertaken using multiple regression techniques (Tabachnik & Fidell, 2007)¹.

Seven ANCOVAs and 12 pairwise comparisons were performed. Therefore, adaptive linear step-up procedures were adopted to control for false discovery rate (Benjamini, Krieger, & Yekutieli, 2006). Sixteen null hypotheses were rejected using the single linear step-up procedure at level 0.05. Sixteen were also rejected at the first stage of the two-stage procedure run at level 0.05/1.05. At the second stage the linear step-up procedure was used at level $(0.05/1.05) \times 19/(19-16) = 0.301$, resulting in the rejection of 17 hypotheses with $p \leq .059$. Results of the ANCOVAs are reported in Table 2 while pairwise comparisons are reported below².

A higher level of performance in the later-schooled group compared to the reading controls indicates an age effect. Significant age effects were found for deleting sounds, $t(89) = 3.37, p < .01, r = .34$; blending sounds, $t(89) = 3.78, p < .01, r = .37$; vocabulary, $t(89) = 10.31, p < .01, r = .74$; recalling sentences, $t(89) = 6.52, p < .01, r = .57$; non-word repetition, $t(89) = 6.85, p < .01, r = .59$; and visual-verbal learning, $t(89) = 2.66, p < .01, r = .27$. The

reading controls significantly out-performed the later-schooled group on letter-sound knowledge, $t(60) = 2.71, p < .01, r = .33$.

Better performance in the age controls compared to the later-schooled group indicates a schooling effect. Significant schooling effects were found for deleting sounds, $t(89) = 17.15, p < .01, r = .88$; blending sounds, $t(89) = 9.43, p < .01, r = .71$; and visual-verbal learning, $t(89) = 2.64, p < .05, r = .27$. There were no significant effects of schooling on vocabulary, $t(89) = 1.04, p = .30, r = .11$, and recalling sentences, $t(89) = 1.01, p = .32, r = .11$. On the non-word repetition test, the later schooled group outperformed the age controls, $t(89) = 1.92, p = .059, r = .20$. However, low reliabilities for this task mean that this result should be treated with caution.

Phoneme and syllable awareness

On both the blending sounds and deletion tasks, the first three items tested the ability to manipulate syllables and the next five tested the ability to manipulate phonemes. Therefore, data was re-coded as either 1 = Can delete phonemes (scored ≥ 3 out of 5) or 0 = Cannot delete phonemes (scored ≤ 2 out of 5). The same coding strategy was applied to the blending phonemes part of the blending task. The variables were then re-analysed as dichotomous to examine differences between groups.

All of the age control group could delete and blend phonemes compared to 46.7% and 66.7% of the later-schooled group, respectively. Differences between these two groups (schooling effect) were significant for deletion, $\chi^2(1) = 21.8, p < .01$, and blending, $\chi^2(1) = 12.0, p < .01$. In the reading control group, 12.1% of the children could delete phonemes while 24.2% could blend phonemes. Differences between the later-schooled and reading control group (age effect) were significant for deletion, $\chi^2(1) = 59.2, p < .01$, and blending, $\chi^2(1) = 11.5, p < .01$.

Next, data from the first three items, which measured syllable awareness, were analysed using a similar coding strategy; 1 = Can delete/blend syllables (scored ≥ 2 out of 3) and 0 = Cannot delete/blend syllable (scored ≤ 1 out of 3). All of the later-schooled children and age controls could delete and blend syllables compared to 81.8% and 48.5% of the reading control group respectively. A significant age effect was shown in both cases, $\chi^2(1) = 6.0, p < .05$ (deletion), and $\chi^2(1) = 16.4, p < .01$ (blending).

Relationship between vocabulary and phonological awareness

Correlations among all reading-related skills are shown in Tables 3 and 4. Deleting and blending sounds had non-significant correlations with vocabulary in the later-schooled and age control groups ($r = .14-.22$) whereas correlations between vocabulary and the phonological measures were moderate and significant in the reading control group ($r = .48-.53$). To determine whether the contribution of vocabulary to variance in phonological awareness differed between groups, hierarchical multiple regressions were performed on the combined sample ($n = 93$). Because we wished to assess the relationship with phonological awareness as a unitary construct, composite scores were calculated by adding the two phonological awareness tasks together (deleting and blending sounds). Group was dummy coded as two variables with the later-schooled group as the reference category (the group to which the other two were compared). Vocabulary and the two group variables were entered in the first step, one of the interaction terms was entered in the second step, and the other interaction term was entered in the third step (alternated so that each of the interaction terms was included last). The regressions confirmed the pattern of results suggested from the correlations. There was a significant interaction between vocabulary and group, $\Delta R^2 = .01, p < .05$, when the later-schooled group was compared to the reading controls, and a non-significant interaction, $\Delta R^2 = < .01, p = .78$, when the later-schooled group was compared to the age controls.

Discussion

The current study assessed the roles of age and schooling on the development of seven reading-related skills by comparing three groups of children differing in either exposure to formal reading instruction or chronological age. There were age effects, but not schooling effects, on vocabulary and short-term memory measures. On the visual-verbal learning measure and the phonological awareness tasks, there were both age and schooling effects. On the letter sound knowledge measure, the younger, reading level controls outperformed the later-schooled children. Finally, hierarchical multiple regressions revealed that the association between vocabulary and phonological awareness was significantly stronger in the younger reading control group compared to the older groups.

The later schooled children showed similar scores to the age matched controls on vocabulary and recalling sentences (and performed better on the nonword repetition), while both groups outperformed the younger group. This indicates the importance of age-related factors, and the relative unimportance of schooling in the development of receptive vocabulary and verbal memory skills. The non-significant effect of schooling on vocabulary is consistent with previous research suggesting that vocabulary is not significantly affected by exposure to formal instruction during early childhood (Christian et al., 2000; Frazier & Morrison, 1998). Yet it conflicts with the hypothesis that reading causes vocabulary increases over time (Stanovich et al., 1986). It may be that this age control group is not yet advanced enough in reading for Matthew effects to be evident. Alternatively, it could be that the later-schooled children encountered a wide range of vocabulary as part of the Steiner curriculum, which diminished the comparative advantage incurred by the age control group through reading. Finally, the relative lack of schooling effects on the short-term verbal memory tasks may be due to a link between the development of vocabulary and phonological memory (Gathercole, Willis, Emslie, & Baddeley, 1992; Metsala & Walley, 1998).

On a test of visual-verbal paired associate learning, there were both age and schooling effects. This task mimics the process of acquiring sight words in reading, and therefore it could be expected to be related to reading level. In the Morrison et al. (1995) study, the ability to recall the names of pictures (a visual-verbal paired associate task) was enhanced by formal instruction during first grade, but in contrast to our research, no age effect was found. This difference in results is most likely due to the larger age range covered by the current investigation (3 years compared to 1 year), and therefore more experience of visual-verbal mapping activities such as drawing and being read to.

Traditionally, it has been assumed that syllable awareness is primarily dependent upon age-related processes prior to learning to read, whereas phoneme awareness is dependent on formal literacy instruction (e.g., Goswami & Bryant, 1990). In the current study, both age and schooling effects were found on two explicit phoneme awareness tasks, indicating that this is somewhat of an over-simplification. A larger proportion of the later schooled compared to reading control children demonstrated phoneme awareness (a half compared to tenth on the deletion task). There was also an age effect for syllable awareness. It is likely that age-related processes, such as greater exposure to rhyming games, music and poetry (see Fazio, 1997a; Fazio, 1997b), led to better phonological skills in the later-schooled children. Ceiling levels of phoneme awareness in the age control group were probably due to the reciprocal relationship between reading and PA (e.g., Wagner, et al., 1994). Our findings are in line with previous research which shows an age effect on phoneme awareness prior to formal instruction in reading and a strong schooling effect once reading tuition has begun (Bentin, et al., 1991; Morrison, et al., 1995). They also provide support for the view that PA can, to a certain extent, develop in the absence of formal literacy instruction (Geudens & Sandra, 2003; Hulme, 2005).

All of the later-schooled children knew at least one letter sound, raising the possibility (as suggested by Castles & Coltheart, 2004) that these children used letter knowledge to help them solve the phoneme awareness tasks. If this was the case, however, the relationship was not straightforward: the later-schooled children showed significantly lower levels of letter knowledge than their reading level controls, yet had higher levels of phoneme awareness. While letter knowledge was significantly correlated with phoneme awareness within each group, there was clearly not a direct relationship such that learning, for example, ten letters conveyed the ability to solve a phoneme blending task. Therefore, letter knowledge does not fully account for the presence of phoneme awareness skills in the current sample.

Vocabulary was a significant predictor of phonological awareness for the younger reading controls but not for the older later-schooled and age control groups. Such a finding is consistent with Scarborough and Dobrich's (1990) theory that performance on vocabulary tasks is more dependent on phonological skills earlier compared to later in development. These findings imply that it is the vocabulary 'growth spurt' as occurs with age (Metsala & Walley, 1998), rather than the onset of formal literacy instruction (and corresponding growth in explicit phoneme awareness), that leads to a change in the relationship between the two variables. A possible explanation is that once the mental lexicon reaches a certain size, it no longer constrains the formation of detailed phonological representations. According to this hypothesis, the younger children's phonological skills would be closely dependent on their vocabulary size, while the older children (with larger vocabularies) would have phonological skills relatively independent of their vocabulary size.

Possible Limitations and further research

Age effects were seen on all of the tasks except letter knowledge. Our research does not tell us which aspects of these age effects caused the observed differences in skills: the groups differed both in length of exposure to and the nature of literacy-related activities in the home

and at pre-school. It is the view of the authors that exposure to varied experience with oral language over time is the likely driving force behind the age effect, but within the current study it is not possible to prove this. For example, music, poetry, and story-telling (frequently from the teacher's memory) form a large part of the Steiner curriculum (Steiner, 1919/1976). Future research may wish to investigate whether there are aspects of the Steiner curriculum which particularly promote the development of reading-related skills, and whether these experiences can be replicated in mainstream schools.

Of course, caution must be exercised in generalising the results found with Steiner educated children to English-speaking children in general. The Steiner (later-schooled) group in the current study had more highly educated mothers than average, and attended a fee-paying school, probably indicating high socio-economic status. However, there are some reasons to be confident about generalizability: the children demonstrated average vocabulary levels for their age and maternal educational level was not significantly associated with the variables tested. Additionally, this lack of association gives us confidence in the results despite imputation of missing values for maternal education level.

Finally, this research raises a few issues of methodology. For example, it could be argued that the younger children did not understand the phonological tasks and that the later-schooled group were more responsive to an assessment situation. However, given that the majority of children in both groups could delete syllables (within the same task), we can be fairly confident that the poor performance of the younger children was not an effect of lack of task understanding. The later-schooled children also did not have more experience of testing situations as Steiner schools discourage formal assessments, particularly in children under the age of seven. Furthermore, the superior performance of the reading controls on the letter knowledge task and the absence of significant floor effects suggest that the younger children were well-motivated and able to concentrate sufficiently.

Conclusions and Implications

Previous research has typically confounded age with length of formal schooling, leaving it uncertain whether developmental changes in reading-related skills are due solely to increased exposure to reading instruction or whether age-related factors also play a role. Our results suggest that exposure to formal schooling from a young age does not necessarily lead to advantages in the development of vocabulary and verbal memory, but that age-related processes may play an important role. It is important to note that these findings do not mean that vocabulary and memory skills need not be taught at school but simply that the curriculum as it currently stands does not seem to lead to benefits in these areas. Second, the results show that both age-related processes and literacy instruction influence the development of phonological awareness. Importantly, we found evidence that phoneme awareness can develop in the absence of measurable reading ability and that this is more likely to happen in older than younger children.

References

- ACORN statistics. (2009). Retrieved July 29, from <http://www.caci.co.uk/acorn/whatis.asp>
- Benjamini, Y., Krieger, A. M., & Yekutieli, D. (2006). Adaptive linear step-up procedures that control the false discovery rate. *Biometrika*, *93*(3), 491-507.
- Bentin, S., Hammer, R., & Cahan, S. (1991). The Effects of Aging and 1st-Grade Schooling on the Development of Phonological Awareness. *Psychological Science*, *2*(4), 271-274.
- Bertram, T., & Pascal, C. (2002). *Early years education: An International Perspective*: NFER.
- Bowey, J. A. (1995). Socioeconomic-Status Differences in Preschool Phonological Sensitivity and First-Grade Reading-Achievement. *Journal of Educational Psychology*, *87*(3), 476-487.
- Bowey, J. A., & Francis, J. (1991). Phonological Analysis as a Function of Age and Exposure to Reading-Instruction. *Applied Psycholinguistics*, *12*(1), 91-121.
- Bryant, P., Maclean, M., Bradley, L. L., & Crossland, J. (1990). Rhyme and Alliteration, Phoneme Detection, and Learning to Read. *Developmental Psychology*, *26*(3), 429-438.
- Bryant, P., Nunes, T., & Bindman, M. (1998). Awareness of language in children who have reading difficulties: Historical comparisons in a longitudinal study. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *39*(4), 501-510.
- Burgess, S. R., & Lonigan, C. J. (1998). Bidirectional relations of phonological sensitivity and prereading abilities: Evidence from a preschool sample. *Journal of Experimental Child Psychology*, *70*(2), 117-141.

- Caravolas, M. (2006). Refining the psycholinguistic grain size theory: effects of phonotactics and word formation on the availability of phonemes to preliterate children. *Developmental Science*, 9, 445-447.
- Carroll, J. M. (2004). Letter knowledge precipitates phoneme segmentation, but not phoneme invariance. *Journal of Research in Reading*, 27(3), 212-225.
- Carroll, J. M., Snowling, M. J., Hulme, C., & Stevenson, J. (2003). The development of phonological awareness in preschool children. *Developmental Psychology*, 39(5), 913-923.
- Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition*, 91(1), 77-111.
- Christian, K., Morrison, F. J., Frazier, J. A., & Massetti, G. (2000). Specificity in the nature and timing of cognitive growth in Kindergarten and First Grade. *Journal of Cognition and Development*, 1(4), 429-448.
- Duncan, L. G., Seymour, P. H. K., & Hill, S. (1997). How important are rhyme and analogy in beginning reading? *Cognition*, 63(2), 171-208.
- Dunn, L. M., Dunn, L. M., Whetton, C., & Burley, J. (1997). *The British Picture Vocabulary Scale. Second Edition*. Windsor, Berkshire: National foundation for educational research - Nelson.
- Elliot, C. D., Smith, P., & McCulloch, K. (1996). *British Ability Scales: Second edition*. Slough: National foundation for educational research.
- Fazio, B. B. (1997a). Learning a new poem: Memory for connected speech and phonological awareness in low-income children with and without specific language impairment. *Journal of Speech Language and Hearing Research*, 40(6), 1285-1297.

- Fazio, B. B. (1997b). Memory for rote linguistic routines and sensitivity to rhyme: A comparison of low-income children with and without specific language impairment. *Applied Psycholinguistics*, 18(3), 345-372.
- Ferreira, F., & Morrison, F. J. (1994). Childrens Metalinguistic Knowledge of Syntactic Constituents - Effects of Age and Schooling. *Developmental Psychology*, 30(5), 663-678.
- Frazier, J. A., & Morrison, F. J. (1998). The influence of extended-year schooling on growth of achievement and perceived competence in early elementary school. *Child Development*, 69(2), 495-517.
- Gathercole, S. E., Willis, C. S., Emslie, H., & Baddeley, A. D. (1992). Phonological Memory and Vocabulary Development during the Early School Years - a Longitudinal-Study. *Developmental Psychology*, 28(5), 887-898.
- Geudens, A., & Sandra, D. (2003). Beyond implicit phonological knowledge: No support for an onset-rime structure in children's explicit phonological awareness. *Journal of Memory and Language*, 49(2), 157-182.
- Gombert, J. E. (1992). *Metalinguistic development*. Chicago: Harvester Wheatsheaf.
- Goswami, U., & Bryant, P. E. (1990). *Phonolical skills and learning to read* Hove, East Sussex: Psychology Press.
- Hulme, C. (2005). Phoneme isolation ability is not simply a consequence of letter-sound knowledge. *Cognition*, 97(1), B1-B11.
- Hulme, C., Caravolas, M., Malkova, G., & Brigstocke, S. (2005). Phoneme isolation ability is not simply a consequence of letter-sound knowledge. *Cognition*, 97, B1-B11.
- Hulme, C., Hatcher, P. J., Nation, K., Brown, A., Adams, J., & Stuart, G. (2002). Phoneme awareness is a better predictor of early reading skill than onset-rime awareness. *Journal of Experimental Child Psychology*, 82(1), 2-28.

- Lonigan, C. J., Anthony, J. L., Bloomfield, B. G., Dyer, S. M., & Samwel, C. S. (1999). Effects of two shared-reading interventions on emergent literacy skills of at-risk preschoolers. *Journal of Early Intervention, 22*(4), 306-322.
- Lonigan, C. J., Burgess, S. R., & Anthony, J. L. (2000). Development of emergent literacy and early reading skills in preschool children: Evidence from a latent-variable longitudinal study. *Developmental Psychology, 36*(5), 596-613.
- Lonigan, C. J., Burgess, S. R., Anthony, J. L., & Barker, T. A. (1998). Development of phonological sensitivity in 2- to 5-year-old children. *Journal of Educational Psychology, 90*(2), 294-311.
- MacMillan, B. M. (2002). Rhyme and reading: a critical review of the research methodology. *Journal of Research in Reading, 25*(1), 4-42.
- McDowell, K. D., Lonigan, C. J., & Goldstein, H. (2007). Relations among socioeconomic status, age, and predictors of phonological awareness. *Journal of Speech Language and Hearing Research, 50*(4), 1079-1092.
- Metsala, J. L. (1999). Young children's phonological awareness and nonword repetition as a function of vocabulary development. *Journal of Educational Psychology, 91*(1), 3-19.
- Metsala, J. L., & Walley, A. C. (1998). Spoken vocabulary growth and the segmental restructuring of lexical representations: Precursors to phonemic awareness and early reading ability. In J. L. Metsala & L. C. Ehri (Eds.), *Word recognition in beginning literacy*. Mahwah, New Jersey: Erlbaum.
- Morrison, F. J., Griffith, E., & Frazier, J. (1996). Schooling and the 5 to 7 Shift: A Natural Experiment. In S. A & H. M (Eds.), *Reason and responsibility: the passage through childhood*. Illinois: University of Chicago Press.

- Morrison, F. J., Griffith, E. M., & Alberts, D. M. (1997). Nature-nurture in the classroom: Entrance age, school readiness, and learning in children. *Developmental Psychology*, 33(2), 254-262.
- Morrison, F. J., Smith, L., & Dow-Ehrensberger, M. (1995). Education and cognitive development: A natural experiment. *Developmental psychology*, 31, 789-799.
- Muter, V., Hulme, C., & Snowling, M. (1997). *Phonological Abilities Test*. London: Psychological corporation.
- Muter, V., Hulme, C., Snowling, M., & Taylor, S. (1997). Segmentation, not rhyming, predicts early progress in learning to read (vol 65, pg 370, 1993). *Journal of Experimental Child Psychology*, 71(1), 1-+.
- PASW Statistics, 17.0. (2009).
- Perfetti, C., Beck, I., Bell, L., & Hughes, C. (1987). Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children. *Merrill-Palmer Quarterly-Journal of Developmental Psychology*, 33(3), 283-319.
- Samuelsson, S., Byrne, B., Quain, P., Wadsworth, S., Corley, R., DeFries, J. C., et al. (2005). Environmental and genetic influences on prereading skills in Australia, Scandinavia, and the United States. *Journal of Educational Psychology*, 97(4), 705-722.
- Savage, R., & Carless, S. (2005). Phoneme manipulation not onset-rime manipulation ability is a unique predictor of early reading. *Journal of Child Psychology and Psychiatry*, 46, 1297-1308.
- Scarborough, H. S., & Dobrich, W. (1990). Development of Children with Early Language Delay. *Journal of Speech and Hearing Research*, 33(1), 70-83.
- Semel, E., Wiig, E. H., & Secord, W. A. (1995). *Clinical Evaluation of Language Fundamentals 3*. San Antonio: The Psychological Corporation

- Snowling, M. J., Gallagher, A., & Frith, U. (2003). Family risk of dyslexia is continuous: Individual differences in the precursors of reading skill. *Child Development, 74*(2), 358-373.
- Snowling, M. J., Muter, V., & Carroll, J. (2007). Children at family risk of dyslexia: a follow-up in early adolescence. *Journal of Child Psychology and Psychiatry, 48*(6), 609-618.
- Stanovich, K. E. (1986). Matthew Effects in Reading - Some Consequences of Individual-Differences in the Acquisition of Literacy. *Reading Research Quarterly, 21*(4), 360-407.
- Stanovich, K. E., Nathan, R. G., & Valarossi, M. (1986). Developmental-Changes in the Cognitive Correlates of Reading-Ability and the Developmental Lag Hypothesis. *Reading Research Quarterly, 21*(3), 267-283.
- Steiner, R. (1919/1976). *Practical advice to teachers* (J. Collis, Trans. 2nd ed.). London: Rudolf Steiner Press.
- Steiner, R. (1924/1982). *The Kingdom of Childhood* (H. Fox, Trans. 3rd ed.). London: Rudolf Steiner Press.
- Tabachnik, B. G., & Fidell, L. S. (2007). *Using Multivariate Statistics*. MA: Allyn & Bacon.
- Treiman, R., & Breaux, A. M. (1982). Common Phoneme and Overall Similarity Relations among Spoken Syllables - Their Use by Children and Adults. *Journal of Psycholinguistic Research, 11*(6), 569-598.
- Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of Reading-Related Phonological Processing Abilities - New Evidence of Bidirectional Causality from a Latent Variable Longitudinal-Study. *Developmental Psychology, 30*(1), 73-87.
- Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1999). *Comprehensive Test of Phonological Processing*: Pearson.

- Wagner, R. K., Torgesen, J. K., Rashotte, C. A., Hecht, S. A., Barker, T. A., Burgess, S. R., et al. (1997). Changing relations between phonological processing abilities and word level reading as children develop from beginning to skilled readers: A 5-year longitudinal study. *Developmental Psychology*, 33(3), 468-479.
- Walley, A. C. (1993). The Role of Vocabulary Development in Childrens Spoken Word Recognition and Segmentation Ability. *Developmental Review*, 13(3), 286-350.
- Wimmer, H., Landerl, K., Linortner, R., & Hummer, P. (1991). The Relationship of Phonemic Awareness to Reading Acquisition - More Consequence Than Precondition but Still Important. *Cognition*, 40(3), 219-249.

Footnotes

¹ Substitution with the group mean and deletion of cases with missing values was also performed. These two analyses led to the same pattern of results for the ANCOVAs (with adaptive linear step up procedures applied) as MVA using multiple regression. In each case, 17 null hypotheses were rejected.

² Additional ANCOVAs were performed co-varying word reading (as well as maternal education level) for those children in the later-schooled ($n = 13$) and reading control ($n = 11$) groups whose scores were above 0 (1-5) on the BAS word reading test. The pattern of results obtained was virtually identical to the ANCOVAs without this co-variate and therefore are not reported.

Author note

Anna J. Cunningham and Julia M. Carroll, Department of Psychology, University of Warwick, United Kingdom.

This research was carried out as part of Anna J. Cunningham's doctoral work, with support from a Warwick University Research Scholarship.

We thank the teachers and parents of Michael Hall Steiner School, St Paul's Steiner School, St Margaret's Junior school, Bawnmore Infant School and all of the children who took part in this study. Thanks also to Alex Wood, Friederike Schlaghecken, Chris Boyce, Linda Siegel, Maggie Snowling, and two anonymous reviewers for their comments on the manuscript. Special thanks to James Adelman for his statistical advice.

Correspondence concerning this article should be addressed to Anna J. Cunningham, Department of Psychology, University of Warwick, Coventry CV4 7AL, United Kingdom. E-mail: A.J.Cunningham@warwick.ac.uk.

Table 1

Background characteristics of the three groups

Variable	Earlier-schooled age matched controls		Later-schooled group		Earlier-schooled reading matched controls	
	<i>M (SD)</i>	Range	<i>M (SD)</i>	Range	<i>M (SD)</i>	Range
Age ^a	93.80 (3.12)	90 - 99	94.13 (3.65)	87 - 99	57.39 (3.87)	51 - 62
Standardised Vocabulary ^b	107.87 (8.11)	90 -126	104.77 (10.96)	85 -126	105.61 (10.27)	89 - 131
Word reading	59.67 (8.33)	40 - 74	1.03 (1.43)	0 - 5	0.52 (0.80)	0 - 3
Maternal education	3.62 (1.05)	2 - 6	4.42 (1.32)	2 - 7	3.00 (0.98)	2 - 5
Paternal education	3.86 (1.51)	2 - 7	3.76 (1.70)	1 - 7	2.67 (1.52)	1 - 7
Shared book reading at home	-	-	45.81 (5.32)	34-56	45.00 (6.41)	30-53
Family literacy	9.96 (2.15)	5-14	10.43 (1.86)	6-14	9.54 (1.50)	6-13
Age began reading to child ^a	7.50 (9.52)	0 - 42	11.11 (8.08)	0-30	8.68 (5.67)	0-21

Note. ^a in months, ^b vocabulary in relation to children of the same age, $M = 100$, $SD = 15$.

Maternal education; $n = 29$ (age controls), $n = 24$ (later-schooled group), $n = 26$ (reading controls). Paternal education; $n = 27$ (age controls), $n = 21$ (later-schooled group), $n = 26$ (reading controls). Family literacy and Shared-book reading at home; $n = 28$ (age controls), $n = 21$ (later-schooled group), $n = 24$ (reading controls).

Age began reading to child; $n = 30$ (age controls), $n = 19$ (later-schooled group), $n = 25$ (reading controls). All other variables; $n = 30$ (age controls), $n = 30$ (later-schooled group), $n = 33$ (reading controls).

Standardised vocabulary = British Picture Vocabulary Scale; Word reading = British Ability Scales 2 word reading test.

Table 2

Means, standard deviations, and analysis of covariance (ANCOVA) results for measures of reading-related skills

Variable		Age controls	Later-schooled	Reading	ANCOVAs	
		<i>M (SD)</i>	group <i>M (SD)</i>	controls <i>M (SD)</i>	<i>F (2,89)</i>	<i>r</i> ²
Deleting sounds	20	16.40 (2.75)	5.20 (2.30)	2.94 (2.16)	272.5**	.86
Blending sounds	20	14.83 (2.38)	6.80 (3.65)	3.27 (3.65)	113.0**	.72
Letter-sound knowledge	26	-	10.97 (5.74)	15.88 (6.24)	7.3 ^a **	.15
Vocabulary	168	88.47 (8.49)	84.77 (12.95)	53.91 (10.93)	87.9**	.68
Recalling sentences	78	38.20 (10.22)	35.27 (11.17)	18.24 (6.85)	37.5**	.48
Nonword repetition	18	10.23 (2.16)	11.17 (2.17)	7.48 (1.58)	26.2**	.40
Visual-verbal learning	54	50.30 (3.79)	45.37 (7.74)	39.27 (9.28)	16.12**	.29

Note. $r^2 = \frac{t^2}{t^2 + df}$; ^a*df* = 1,60; *n* = 30 (age controls), *n* = 30 (later-schooled group), *n* = 33 (reading controls).

All means are for raw scores. Internal consistency reliabilities (alphas) are provided in the method section.

Deleting sounds = Elision subtest of the Comprehensive Test of Phonological Processing; Blending sounds =

Blending words subtest of the Comprehensive Test of Phonological Processing; Vocabulary = British Picture

Vocabulary scale; Recalling sentences = subtest of the Clinical Evaluation of Language Fundamentals – 3/UK;

Nonword repetition = subtest from the Comprehensive Test of Phonological Processing.

* $p < 0.05$, ** $p < 0.01$

Table 3

Correlations between measures of reading-related skills in the later-schooled group and earlier-schooled reading matched controls

Variable	1	2	3	4	5	6	7
1. Deleting sounds	-	.52**	.32	.48**	.43*	.36*	.38*
2. Blending sounds	.51**	-	.52**	.53**	.30	.37*	.47**
3. Letter-sound knowledge	.67**	.45*	-	.47**	.41*	.29	.16
4. Vocabulary	.22	.04	.40*	-	.33	.23	.64**
5. Recalling sentences	.23	.15	.48**	.75**	-	.49**	-.13
6. Non-word repetition	.15	.32	.22	.45*	.50**	-	.03
7. Visual-verbal learning	.26	.22	.63**	.37*	.46*	.33	-

Note. Correlations are Bivariate (Pearson's r). Earlier-schooled reading controls are shown above the diagonal ($n = 33$), later-schooled children below the diagonal ($n = 30$).

* $p < 0.05$ (2 tailed), ** $p < 0.01$

Table 4

Correlations between reading-related skills in the earlier-schooled age matched control group

Variable	1	2	3	4	5	6	7
1. Deleting sounds	-						
2. Blending sounds	.41*	-					
3. Vocabulary	.14	.13	-				
4. Recalling sentences	.49**	.23	.56**	-			
5. Non-word repetition	.64**	.54**	.37*	.50**	-		
6. Visual-verbal learning	-.10	.31	.13	.07	.23	-	
7. Word reading	.62**	.35	.49**	.63**	.61**	.09	-

Note. Correlations are Bivariate (n = 30)

* $p < 0.05$ (2 tailed), ** $p < 0.01$