LITERACY IN CHILDREN AT FAMILY-RISK OF DYSLEXIA

# The foundations of literacy development in children at family-risk of dyslexia

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Abstract

The development of reading skills is underpinned by oral language abilities, with phonological skills appearing to have a causal influence on the development of early word-level literacy skills, and reading comprehension ability depending in addition on broader (semantic and syntactic) language skills. Here, we report a longitudinal study of children at family-risk of dyslexia, children with preschool language difficulties and typically developing controls. Preschool measures of oral language predicted phoneme awareness and grapheme-phoneme knowledge just before school entry which in turn predicted word-level literacy skills shortly after school entry. Reading comprehension at 8½ years was predicted by word-level literacy skills at 5½ years and by language skills at 3½ years. These patterns of predictive relationships were similar in both typically developing children and those at-risk of literacy difficulties. Our findings underline the importance of oral language skills for the development of both word-level literacy and reading comprehension skills. [148 words]

KEY WORDS

Dyslexia; language impairment; reading development; reading comprehension; phonological skills; language skills; family-risk.

RUNNING HEAD: LITERACY IN CHILDREN AT FAMILY-RISK OF DYSLEXIA

# The foundations of literacy development in children at family-risk of dyslexia

The current study focuses on early language skills and their role in predicting variations in reading skills in a large sample of children selected to be at high risk of reading difficulties, either because of a family history of dyslexia, or because they experience a preschool language impairment. It is well established that in unselected samples of children variations in reading skills are highly correlated with variations in oral language skills. In alphabetic writing systems, phonological (speech sound) skills are particularly important for learning to decode print. Indeed, two of the most important predictors of early word reading skills across languages are phoneme awareness and letter knowledge (Caravolas et al., 2012) and there is evidence of reciprocal interaction between them (e.g. Muter, Hulme, Snowling & Stevenson, 2004; Lervåg, Braten & Hulme, 2009; Perfetti, Beck, Bell & Hughes, 1987).

The goal of reading is comprehension. In the early years of learning to read, reading comprehension depends strongly upon word reading (Vellutino, Tunmer, Jaccard & Chen, 2007): in order to understand print it must first be decoded (Gough & Tunmer, 1986). However, oral language skills beyond phonology, including vocabulary knowledge and grammatical skills are significant predictors of individual differences in reading comprehension (Muter et al., 2004). Furthermore, two recent studies have shown that improvements in oral language skills brought about by intervention translate into gains in reading comprehension (Clarke, Snowling, Truelove & Hulme, 2010; Fricke, Bowyer-Crane, Haley, Hulme & Snowling, 2013). In addition to being important for reading comprehension, broader oral language skills may also play a causal role in supporting the development of reading accuracy skills. For example, vocabulary knowledge appears to be particularly important in English for learning to read irregular words which cannot be decoded phonologically (e.g., Ricketts, Nation & Bishop, 2007).

Three large scale studies have investigated the impact of early oral language skills on later literacy skills in the transition from preschool to formal schooling. Storch and Whitehurst (2002) found that oral language skills did not affect reading development until Grade 3 when its contribution was to reading comprehension; before that stage, reading comprehension was highly dependent on decoding skills as measured by reading accuracy. In contrast, Belsky et al., 2005, found that there was a direct effect of oral language on reading accuracy skills in Grade 1 as well as on reading comprehension in Grade 3. Finally, a recent longitudinal study of twins (Christopher et al., 2015) assessed a broad range of oral of language skills prior to reading instruction. This study demonstrated that variations in vocabulary, and verbal memory as well as prereaders’ print knowledge, rapid naming, and phonological awareness, were important predictors of later reading and spelling accuracy, and furthermore, these longitudinal influences appeared to reflect both genetic and environmental influences on development.

Together these findings from groups of typically developing children highlight the important contribution of oral language skills to reading development though only the study of Christopher et al., (2015) included measures of Rapid Automatized Naming (RAN) which is known to be a powerful predictor of the development of word reading skills (Lervåg et al., 2009; Caravolas et al., 2012; Caravolas et al., 2013). Our particular focus in the present paper, however, is on children selected to be at risk of later reading difficulties. Three prospective longitudinal studies of children at family-risk of dyslexia have attempted to identify factors predisposing children to later difficulties with literacy and pre-literacy skills. Snowling, Gallagher and Frith, (2003) assessed the impact of early language skills on later reading skills (assessed at 8 years) in an English family-risk sample. Language together with letter knowledge assessed at 3 years 9 months predicted phonological awareness at age 6 years which, in turn, together with grapheme-phoneme skills predicted word-level reading skills at 8 years. Torppa et al. (2010), using data from a large Finnish family-risk study, showed that receptive language at 2½ years predicted phonological awareness (and RAN objects) at 3½ years, while expressive language at 2½ years predicted letter knowledge a year later. Between 3½ and 5½ years, oral language skills continued to be important with expressive language predicting literacy-related measures (phonological awareness, letter naming and RAN) at 5½ years. Reading outcomes in Grade 3 (reading accuracy and fluency) were predicted by phonological awareness, letter naming and RAN at 5½ years. Finally, Carroll, Mundy and Cunningham (2014) reported a family-risk study starting later when children were aged 4;5 to 7;0; they found that language and phonological processing scores in the early school years were predictors of later variations in reading and spelling skills across the whole sample.

The present study aims to extend the findings of these three family-risk studies by investigating the role of early oral language and speech skills as influences on reading outcomes approximately one and three years after the introduction of formal reading instruction. Given the importance of oral language as a predictor of later phonological awareness and letter knowledge, we also included in our sample, children with preschool specific language impairment (SLI) to increase the range of language skills represented. Hayiou-Thomas et al., (2006) used data from a twin study to argue for two separable language factors: a general language factor with loadings from measures tapping syntax and semantics and an ‘articulation’ factor with loadings from measures tapping phonological skills (articulation and nonword repetition).

In the analyses presented here we will assess the relative impact of speech skills (assessed by measures of articulation and word and nonword repetition – similar to the “articulation” measure of Hayiou-Thomas et al. 2006) compared to broader language skills (vocabulary and grammatical skills) on reading development in this large and diverse sample of children. Our particular interest is to identify if early speech and language skills predict variations in pre-literacy skills (particularly phoneme awareness, letter knowledge and RAN) and thereby influence literacy skills. A further question is whether children at high-risk of reading difficulties will show a similar pattern of relationships between early language and later literacy skills as typically developing children.

**Method**

## Design

This study was a prospective longitudinal study of children at-risk of reading difficulties, either because of a family history of dyslexia or because of preschool language difficulties (children being in receipt of speech and language therapy at the beginning of the study). Data were collected in five assessments conducted with the children at approximately yearly intervals. Data from two assessments before the beginning of formal schooling (T1, T2) and two after school entry (T3, T5) are reported here. T1 was completed when the children were 3 – 4 years old, T2 at 4 – 5 years, T3 at 5-6 years, and T5 at 7-9 years (mean age = 8.7 years). Data were collected at T4 (6-7 years) but are not reported here. The sample size was determined largely by the practicalities of participant recruitment: we sought to recruit as many children at family-risk of dyslexia and children with pre-school language difficulties (within a narrow age range) as was possible in the area where the study was conducted (York, UK).

## Participants

Ethical clearance for the study was provided by the University of York, Department of Psychology Ethics Committee and the NHS Research Ethics Committee. Families were recruited to the study via advertisements and via speech and language therapy services. Of the 245 children recruited, none met our exclusionary criteria (MZ twinning, chronic illness, deafness, English as a 2nd language, care provision by local authority and known neurological disorder such as cerebral palsy, epilepsy, or ASD) at T1. Parents provided informed consent for their family’s involvement.

Following recruitment, children were classified using a two-stage process, determining whether they were at family-risk of dyslexia and then using diagnostic criteria to determine whether they had a language impairment (SLI). This led to the classification of children into four groups according to family and language status: Typically developing (TD; N= 71), family-risk only (FR; N=86), language impaired (SLI; N=36) and family-risk with language impairment (FR-SLI; N=37) and 15 children who had been referred as SLI but did not fulfil our research criteria for this group (see Nash et al., 2013 for further details). In addition, 15 children entered the project at the second time point (5 TD, 7 FR, 1 FR –SLI, 1 SLI and 1 referred SLI but who did not meet diagnostic criteria). There was a small amount of attrition between time points, which was greatest between T1 and T2 (N = 16) and reduced between later assessments (T2 – T3 N = 3, T3 – T4 N = 2, T4-T5 N = 5).

## Tests and Procedures

Each child was administered cognitive, language and literacy tests at each time point. Research assistants were trained and observed by the project manager to ensure fidelity and where possible, the same assistant visited the child on each occasion. Here we report only details of the measures used in the present analyses. At T1 and T2 the assessments took place at home, in a single 1½ hour session at T1 and across two one-hour sessions at T2, with breaks as necessary. At T3 and T5 the assessments usually took place at school, and lasted for approximately two hours with a break. The tasks were administered in a fixed order.

 *Articulation (T1).*

The articulation subtest of the Diagnostic Evaluation of Articulation and Phonology (DEAP, Dodd, Hua, Crosbie, Holm & Ozanne., 2002) provided a measure of percentage of consonants correctly produced (PCC). The child named 30 pictures (e.g. pig, moon, sheep, five, television) or imitated the name if they could not produce it spontaneously.

 *Word and Nonword repetition (Pre-School Repetition subtest from the Early Repetition Battery, Seeff-Gabriel, Chiat, Roy, 2008) (T1).*

The child was asked to repeat 18 words and 18 nonwords (6 one-syllable, 6 two-syllable and 6 three-syllable words and nonwords). Nonwords were created from the words by altering the vowel in the one-syllable items and swapping two consonants in the multi-syllabic items (e.g., ‘lamb’ -> /lom/, ‘machine’ -> /shameen/, ‘dinosaur’ -> /sinodaur/).

*Basic Concepts (CELF-Preschool 2 UK; Wiig et al, 2006) (T1).*

The child heard a sentence (e.g. point to the one that is long) and had to select from a choice of three, the picture that represented the concept.

*Expressive vocabulary (CELF-Preschool 2 UK ; Wiig et al, 2006) (T1).*

The child was asked to name objects (e.g. carrot, telescope) or to describe what a person is doing (e.g. riding a bike).

 *Sentence Repetition* (*SIT-16; Seeff-Gabriel, Chiat, Roy, 2008*) (T1)

The child repeated 16 sentences increasing in length and complexity (e.g. The cat ate a big mouse). The total number of sentences, content words, function words and grammatical inflections repeated correctly was recorded.

 *Sentence Structure (CELF-Preschool 2 UK; Wiig et al, 2006) (T1).*

The child heard a sentence (e.g. The bear is in the wagon) and had to select from a choice of four pictures the one that conveyed its meaning. The sentences included a range of different syntactic structures.

 *Letter Sound Knowledge (T2) (York Assessment of Reading for Comprehension (YARC; Snowling et al., 2009)*

The child was shown 32 single letters and digraphs one at a time and was asked what sound each one made. If they provided the letter name they were prompted to provide the sound.

 *Writing Letters (T2)*

In this task we asked the child to write 10 letter sounds, 5 of which had consistent sound to letter mappings (/b/,/h/,/m/,/g/ and /w/) and 5 of which had inconsistent sound to letter mappings (/s/,/k/,/ ʤ /,/f/,/z/). One point was awarded for each letter written correctly, (for the inconsistent items either letter was accepted).

 *Phoneme Awareness (T2)*

*Phoneme isolation of initial sounds*

In this task the child was asked to repeat a spoken nonword and then to say its first sound. There were 2 demonstration and 2 practice items followed by 8 monosyllabic test items (4 CVC and 4 CCVC). Testing was discontinued after 4 incorrect responses.

*Phoneme isolation of final sounds*

Following the initial isolation task, the child was asked to say the last sound in each nonword. There were 2 practice and 8 test items, 4 CVC and 4 CVCC. Testing was discontinued after 4 incorrect responses.

*Rapid Automatized Naming (RAN)(T2)*

There were two versions of this task: colours and objects. Children were first asked to name each of the 5 stimuli (objects: pictures of a dog, eye, key, lion and table; colours: squares coloured brown, blue, black, red and green) to check that they knew the names. Following this children were presented with an 8 x 5 array of stimuli (each of the 5 stimuli was presented 8 times in a random order) and were told to name each of the stimuli (moving from left to right) as quickly as possible. The time taken to name all 40 stimuli and the number of errors made were recorded. RAN rate was calculated (number correct (max 40)/time (s)).

*Early Word Reading (T3, T4) (York Assessment of Reading for Comprehension (YARC; Snowling et al., 2009)*

The child read aloud 30 single words, graded in difficulty. Half of the words were phonemically regular (decodable), and the other half were irregular. Each correct response scored 1 point; testing was discontinued if the child made 10 consecutive reading errors.

*Single word reading (T3, T4, T5) (SWRT; Foster, 2007)*

 Children read 60 words of increasing difficulty. Testing was discontinued after 5 consecutive errors/refusals.

 *Spelling words (T3, T4)*

The child was asked to spell 5 words (dog, cup, tent, book, heart), each represented by a picture. They first named each picture but if they could not or made an error, the examiner provided the name before the child attempted to write the word.

*Reading Comprehension (T5) (York Assessment of Reading for Comprehension (YARC; Snowling et al., 2009)*

The Passage Reading subtest of the YARC required the child to read a series of short texts during which reading errors were corrected by the examiner up to a given number at which point testing was discontinued following procedures in the test manual. The passage the child started with was determined by their single word reading accuracy level (SWRT score). For each passage which was not discontinued due to reading errors, the child then answered 8 spoken comprehension questions. Accuracy, rate and comprehension ability scores were calculated based on the two most difficult passages the child read. Reading comprehension was measured using Ability scores.

**Results**

We wished to assess the patterns of predictive relationships between early measures of language and speech skills and later literacy skills in children at-risk of literacy difficulties and controls. Initial explorations of the data indicated that the levels of performance and pattern of relationships between variables were very similar in the children at family-risk of dyslexia and those referred because of concerns about preschool language difficulties. Data for these two groups were therefore combined for the purposes of further analyses here (this group will be referred to as the at-risk group in what follows).

The means, standard deviations and reliabilities for all variables for the at-risk and typically developing control groups are shown in Table 1. As expected the control group perform better than the at-risk group on all the language and literacy measures, with moderate to large effect sizes.

Table 1

*Performance of the samples at times 1-5 on key language and literacy measures*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | At Risk | Control |  |  |  |
| Measure (Maximum score) | N | Mean | SD | N | Mean | SD | Reliability | Cohen’s d1 [95% CI] |
| *Time 1* |  |  |  |  |  |  |  |  |
| Age in Months | 174 | 45.13 | 3.65 | 71 | 44.69 | 3.20 |  | -.12 [-.40-.15] |
| Articulation (100) | 172 | 73.60 | 20.43 | 71 | 89.48 | 7.58 |  | .90 [.61-1.18] |
| Word Repetition (18) | 161 | 13.51 | 3.96 | 68 | 16.74 | 1.93 | .89 | .93 [.63-1.22] |
| Nonword Repetition (18) | 160 | 10.65 | 3.94 | 67 | 14.12 | 2.52 | .89 | .97 [.67-1.27] |
| Basic Concepts (18) | 171 | 13.39 | 3.54 | 71 | 16.35 | 1.64 |  | .95 [.66-1.24] |
| Vocabulary (40) | 169 | 15.00 | 7.06 | 71 | 20.69 | 5.24 | .82 | .87 [.58-1.15] |
| Sentence Structure (22) | 170 | 11.21 | 4.16 | 71 | 14.39 | 3.27 | .78 | .81 [.52-1.10] |
| Sentence Repetition (16) | 144 | 4.17 | 4.23 | 67 | 9.27 | 4.28 |  | 1.18 [.87-1.49] |
| *Time 2* |  |  |  |  |  |  |  |  |
| Letter-sound knowledge (32) | 169 | 15.03 | 10.03 | 74 | 19.78 | 9.36 | .95 | .48 [.21-.76] |
| Writing letters (10) | 169 | 3.30 | 3.03 | 74 | 4.65 | 3.05 | .85 | .44 [.17-.72] |
| Phoneme Isolation –Beg (8) | 126 | 4.59 | 2.95 | 70 | 5.76 | 2.54 | .91 | .42 [.12-.71] |
| Phoneme Isolation –End (8) | 121 | 2.06 | 2.87 | 68 | 3.44 | 3.32 | .95 | .45 [.15-.75] |
| RAN Objects Rate | 150 | .65 | .19 | 71 | .79 | .17 |  | .78 [.49-.1.07] |
| RAN Colors Rate | 137 | .56 | .18 | 67 | .69 | .19 |  | .72 [.42-1.02] |
| *Time 3* |  |  |  |  |  |  |  |  |
| Early Word Reading (30) | 167 | 13.89 | 8.70 | 74 | 20.15 | 8.04 | .98 | .74 [.45-1.01] |
| Single Word Reading (60) | 165 | 7.88 | 9.30 | 74 | 15.52 | 13.53 |  | .71 [.43-.99] |
| Spelling (5) | 167 | 1.66 | 1.34 | 74 | 2.55 | 1.22 |  | .68 [.40-.96] |
| *Time 5* |  |  |  |  |  |  |  |  |
| Reading Comprehension (88) | 155 | 54.66 | 9.35 | 72 | 60.58 | 8.71 | .77 | .65 [.36-.93] |

*Table notes*  1Cohen’s d for mean difference between groups adjusted for unequal sample size (Rosnow, Rosenthal & Rubin, 2000)

Correlations between the measures for the two groups are shown in Table 2. We used seven measures of speech and language at T1 (age 3-4 years) - Receptive Language: Basic Concepts and Sentence Structure; Expressive Language: Vocabulary and Sentence Repetition; Speech: Articulation, Word Repetition, Nonword Repetition. At T1 the language measures and speech measures were moderately correlated in the at-risk group with the correlations between these measures being lower in the control group due to restrictions of range on some measures.

At T2 (age 4-5 years) just at, or just before, the onset of formal literacy instruction, grapheme-phoneme knowledge (GPC) was defined by measures of letter-sound knowledge and of writing letters to dictation, and phoneme awareness was defined by tests involving isolation of initial and final phonemes in spoken nonwords. The T2 letter knowledge variables were strongly inter-correlated and moderately correlated with phoneme measures. T2 measures of letter knowledge and phoneme awareness correlated moderately with reading and spelling at later time points. The two RAN measures were strongly correlated with each other and moderately to weakly with the other tests.

Table 2

*Correlations between measures at times 1 to 5 (control group above and at-risk group below the diagonal)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | Age T1 | ArticT1 | BConT1 | VocabT1 | SenStT1 | WdRepT1 | NWdRepT1 | 1 SentRepT1 | LettSndT2 | LetWtT2 | PhBegT2 | PhEndT2 | RANobT2 | RANcolT2 | EWeReadT3 | SinWdRdT3 | SpellT3 | EWeReadT4 | SinWdRdT4 | SpellT4 | RedCompT5 |
| AgeT1 |  | .25 | .19 | .19 | -.03 | -.07 | .17 | .08 | .32 | .21 | .21 | .32 | .04 | .02 | .01 | -.06 | .11 | -.07 | -.08 | -.05 | .14 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| ArticT1 | .22 |  | .25 | -.08 | -.06 | -.04 | .10 | .06 | .02 | .07 | .17 | .12 | .13 | .06 | -.03 | -.11 | .02 | -.09 | -.07 | -.06 | .05 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| BConT1 | .27 | .24 |  | .34 | .48 | .22 | .24 | .35 | .32 | .32 | .38 | .22 | .40 | .24 | .27q | -.04 | .19 | .13 | .26 | .27 | .37 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| VocabT1 | .28 | .27 | .61 |  | .28 | .05 | .24 | .27 | .10 | .08 | .22 | .07 | .19 | .14 | .07 | -.08 | .01 | -.03 | .09 | -.08 | .44 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| SenStT1 | .21 | .25 | .63 | .55 |  | .21 | .04 | .26 | .18 | .16 | .04 | .15 | .09 | .27 | .15 | .10 | .09 | .07 | .11 | .13 | .37 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| WdRepT1 | .24 | .72 | .41 | .41 | .34 |  | .30 | .32 | .04 | .14 | .07 | .13 | .21 | .28 | .12 | -.08 | .06 | .03 | .07 | .09 | -.02 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| NWdRepT1 | .28 | .58 | .34 | .38 | .32 | .72 |  | .42 | .06 | .14 | .32 | .15 | .24 | .16 | .08 | -.16 | .04 | -.15 | .05 | -.04 | .14 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| SenRepT1 | .32 | .35 | .57 | .55 | .56 | .51 | .54 |  | .08 | .15 | .36 | .16 | .05 | .03 | .17 | .02 | .23 | .02 | .10 | .04 | .24 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| LettSndT2 | .42 | .26 | .32 | .26 | .30 | .27 | .20 | .38 |  | .69 | .49 | .58 | .31 | .30 | .55 | .43 | .48 | .42 | .46 | .41 | .21 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| LetWtT2 | .40 | .30 | .35 | .27 | .32 | .32 | .29 | .43 | .83 |  | .49 | .61 | .34 | .36 | .57 | .33 | .53 | .38 | .42 | .43 | .16 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| PhBegT2 | .17 | .19 | .38 | .32 | .39 | .35 | .29 | .42 | .51 | .48 |  | .56 | .26 | .22 | .33 | .09 | .41 | .15 | .23 | .11 | .09 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| PhEndT2 | .15 | .16 | .31 | .20 | .38 | .17 | .19 | .45 | .52 | .52 | .62 |  | .24 | .31 | .47 | .51 | .44 | .27 | .33 | .20 | .05 |
| RANobT2 | .13 | .12 | .42 | .20 | .29 | .08 | .05 | .29 | .37 | .35 | .34 | .35 |  | .70 | .26 | .15 | 031 | .19 | .28 | .22 | .21 |
| RANcolT2 | .12 | .15 | .17 | .00 | .14 | .16 | .04 | .19 | .34 | .29 | .28 | .26 | .60 |  | .30 | .19 | .32 | .20 | .23 | .23 | .09 |
| EWeReadT3 | .28 | .23 | .41 | .36 | .34 | .33 | .38 | .40 | .61 | .61 | .52 | .53 | .41 | .35 |  | .58 | .70 | .73 | .78 | .66 | .21 |
| SinWdRdT3 | .27 | .25 | .38 | .30 | .35 | .27 | .33 | .39 | .55 | .56 | .43 | .52 | .34 | .28 | .90 |  | .55 | .39 | .44 | .46 | -.03 |
| SpellT3 | .25 | .30 | .47 | .35 | .38 | .35 | .34 | .39 | .51 | .56 | .41 | .41 | .39 | .31 | .79 | .77 |  | .62 | .64 | .58 | .11 |
| EWeReadT4 | .14 | .15 | .29 | .22 | .16 | .20 | .27 | .30 | .48 | .50 | .41 | .42 | .30 | .27 | .77 | .63 | .67 |  | .78 | .55 | .21 |
| SinWdRdT4 | .19 | .19 | .35 | .26 | .26 | .24 | .35 | .39 | .50 | .54 | .46 | .49 | .35 | .29 | .87 | .85 | .74 | .84 |  | .72 | .33 |
| SpellT4 | .15 | .18 | .30 | .14 | .23 | .19 | .29 | .33 | .54 | .60 | .41 | .49 | .32 | .30 | .81 | .77 | .75 | .78 | .86 |  | .10 |
| ReadCompT5 | .14 | .17 | .37 | .45 | .31 | .26 | .21 | .38 | .32 | .27 | .43 | .30 | .22 | .10 | .42 | .38 | .41 | .47 | .45 | .34 |  |

At T3 (age 5-6 years) word-level literacy skills were measured by two word reading and one spelling test which were all strongly inter-correlated. At T5 (age 8½ years) reading comprehension was measured by the child’s Ability score on the YARC passage reading test.

Our principal interest was to trace possible causal influences from early variations in language and speech skills to variations in later pre-literacy and literacy skills. For this purpose a two-group Structural Equation Model was constructed (see Figure 1) using Mplus 7.31 (Muthén & Muthén, 1998-2015) with missing data being handled with Full Information Maximum Likelihood estimation. Before creating the two-group Structural Equation Model we established that strong (scalar) measurement invariance was present for all latent variables in the model since constraining the unstandardized factor loadings and intercepts to be equal across groups resulted in no significant change in fit (Δ*χ2* (23) = 30.464, *p* = .137).

We wished to assess the possibly separable influences of language and speech skills on later literacy skills. In the model in Figure 1, all seven measures of language and speech were used to define a language factor, while a speech factor was defined by the three speech measures alone (Articulation, Word Repetition, Nonword Repetition). The language and speech factors in this model were fixed to be uncorrelated. Therefore, the speech factor in this model reflects the variance in the three speech measures that is independent of the language factor. This allows us to detect any influence that speech alone might have on later constructs that is independent of the influence of broader language skills.

*Figure 1*

*Two group path model showing the longitudinal relationships between preschool measures of language and speech, T2 preliteracy skills (RAN, grapheme-phoneme skills, phoneme awareness), T3 word-level literacy skills and T5 reading comprehension for the at-risk and control samples.*

Reading Comprehension

Sentence Repetition

Vocabulary

Sentence Structure

Basic Constructs

NWD Repetition

Word Repetition

Articulation

RAN Colours

RAN Objects

Phoneme Isolation-B

Phoneme Isolation-E

EWR

SWR

Letter Sounds

Letter Writing

Spelling

.80 (.00)

.61 (.00)

.74 (.00)

.81 (.44)

.76 (.48)

.75 (.48)

.79 (.83)

.46 (.35)

.29 (.36)

.46 (.42)

.75 (.73)

.83 (.91)

.91 (.86)

.91 (.83)

.79 (.75)

.84 (.769)

.97 (.90)

.82 (.80)

.45 (.24)

.93 (.58)

.08 (.00)

.00 (.00)

.49 (.27)

.16 (.00)

.32 (.29)

.70 (.43)

.47 (.26)

.18 (.18)

.36 (.36)

.10 (.11)

.30 (.24)

.38 (.38)

.72 (.72)

.36 (.36)

.10 (.05)

Time 1

Age 3½

Time 2

Age 4½

Time 3

Age 5½

Time 5

Age 8

χ²(247) = 289.48; p = .033

RMSEA = 0.036 [90 % CI 0.011-0.053]

CFI = .98; TLI .98

N=260

*Figure 1*

For the full structural model shown in Figure 1, we first tested if the regressions, covariances and the residual variances of the latent variables differed between groups. As this was not the case, Δ*χ2* (21) = 21.538, *p* = .427, we fixed them to be equal for both samples. Figure 1 shows standardized path weights for both groups (coefficients for the at-risk group outside the parentheses and for the typically developing children inside the parentheses; these standardized coefficients differ slightly between groups due to differences in variance between the groups). In this model, the variance of the latent Speech variable was fixed to zero in the typically developing sample as the estimated variance was negative (-.009) but non-significant (p = .958). Accordingly, all factor-loadings and regressions were fixed to zero in this group.

At T1, the structural model consists of two independent latent variables (speech and language). Language at T1 predicts variations in the three latent variables representing grapheme-phoneme knowledge, phoneme awareness and RAN at T2. In contrast, variations in speech skills at T1 are not predictive of variations in these T2 measures (after language skills have been controlled). The three latent variables at T2 are moderately to strongly correlated with each other (*r*s = .36-.72) and two of these (grapheme-phoneme knowledge and phoneme awareness; but not RAN) predict T3 word-level literacy skills. Finally, reading comprehension at T5 is predicted by both language at T1 and word-level literacy skills at T3. In addition to these direct effects, we found significant indirect effects of language at Time 1 (through the Time 2 constructs) on T3 word-level literacy skills for both the at-risk (*β* =.45, *p* = .000) and the control group (*β* =.25, *p* = .000). Significant indirect effects of language at Time 1 were also found on reading comprehension at Time 5 (through the Time 2 and 3 constructs) for both the at-risk group (*β* =.08, *p* = .030) and the control group(*β* =.04, *p* = .030).

Overall, this model accounts for 60% of the variance in word-level literacy skills at T3 and 34% of the variance in reading comprehension at T5 in the at-risk sample (for controls 47% and 12% respectively) . The model fitted the data very well, *χ2* (247) = 289.48, *p* = .033, Root Mean Square Error of Approximation (RMSEA) = .036 (90% CI = .011-.053), Comparative Fit Index (CFI) = .98, Tucker-Lewis Index (TIL) = .98, confirming that the structure of the underlying abilities specified in the measurement model fits the data well.

**Discussion**

This study followed the development of a large sample of children who were at-risk of reading problems either because they had a family history of dyslexia or because they had preschool language difficulties, together with a group of typically developing control children. At time 1, we found that children’s performance on the language measures could be described by two latent factors. A broad language factor with loadings from measures of both speech (phonological) and non-phonological language skills, and an independent speech factor that accounted for those aspects of speech that are independent of broader language skills (likely to reflect speech-motor processes). Only the language factor predicted later variations in phoneme awareness, grapheme-phoneme skills and RAN at T2. In turn, phoneme awareness and grapheme-phoneme skills at T2 predicted variations in word level literacy skills at T3. Finally, word level literacy skills at T3 and language at T1 accounted for substantial proportions of the variance in reading comprehension at T5.

The finding that language skills could be described by two latent factors corroborates the findings of Hayiou-Thomas et al., (2006) and supports the idea that language and speech skills tap partially separate abilities. Our finding that only the language factor predicted variations in pre-literacy skills at time 2 which subsequently predicted word-level literacy is consistent with findings from the family-risk study of Snowling, et al. (2003; see also Hindson, Byrne, Fielding-Barnsley, Newman, Hine & Shankweiler 2005). Our findings are also in line with studies of “late talkers” who show broad deficits on a range of literacy and language measures when assessed at school age (e.g., Preston et al., 2010).

The finding that grapheme-phoneme knowledge and phoneme awareness together predict word-level decoding skills is in line with a large body of evidence (see Melby-Lervåg, Lyster & Hulme, 2012). Moreover, their role in mediating the impact of oral language skills on early word-level literacy skills is in line with findings from other studies of children at high risk of dyslexia in whom early language delay is a characteristic feature (e.g., Scarborough, 1990; Snowling et al., 2003; Torrpa et al., 2010). In the current study, RAN did not predict variations in word-level literacy skills, which may reflect the fact that RAN appears to predict variations in word reading skills more strongly at later ages (see Caravolas et al., 2013).

In line with the simple view of reading (Gough & Tunmer, 1986), and previous longitudinal findings (Muter et al., 2004; Belsky et al., 2005; Storch & Whitehurst, 2002) we found that reading comprehension builds upon word reading accuracy but is also heavily influenced by variations in oral language skills. In the current study, it is striking that oral language skills assessed at 3½ years have a direct influence on the development of reading comprehension measured at age 8½ years. We believe it is likely that the effects of oral language skills on reading comprehension are causal since training studies indicate that interventions to boost children’s oral language comprehension skills also improve reading comprehension skills (Clarke et al., 2010; Fricke et al., 2013).

This study is one of few (e.g. Carroll et al., 2014) which have examined reading outcomes in children selected either as being at family-risk of dyslexia or with a preschool language impairment. Given that poor phonological skill is a major risk factor for poor reading, and that the predictive relationships between phonology and reading were the same in the children at family-risk and those with language impairment, we combined these groups for the purposes of longitudinal analyses into one at-risk group. It is clear that on average the at-risk group showed substantial deficits in word-level literacy skills at time 3 (after roughly 1 year of formal schooling). Being at family-risk of dyslexia, or being referred for pre-school language difficulties, are both associated with substantially worse reading outcomes after one year in school. A striking finding is that the predictors of early reading outcome are essentially identical in both groups, and essentially the same as in typically developing children. We believe this pattern of results supports the idea that early cognitive risk factors for later reading difficulties (early language problems, and later problems with phoneme awareness and learning letter-sound relationships) are best thought of as representing continuous risks with an approximately normal distribution in the population (see also Fletcher et al., 1994).

In summary, the findings from the present study make it clear that the development of reading depends critically upon oral language skills. Children at family-risk of dyslexia show broad deficits in oral language skills in the preschool years and a proportion of these children satisfy the criteria for the diagnosis of a language impairment. Poor oral language skills in turn appear to compromise the later development of decoding (via problems in acquiring letter-sound knowledge and phoneme awareness) as well as reading comprehension abilities. It follows that education in the early years should not only focus on phonological (speech sound) and phonic (understanding letter-sound relationships) skills but also on the development of the broader language skills which provide the foundation both for learning to decode print and for the subsequent development of reading comprehension.

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Author Contributions

M. Snowling and C. Hulme developed the study concept. H. Nash and D. Gooch developed tasks and oversaw data collection. A. Lervåg and C. Hulme performed the data analysis and modelling. M. Snowling, C. Hulme, and A. Lervåg, drafted the manuscript. C. Hulme provided critical revisions to the overall manuscript. All authors approved the final version of the manuscript for submission.