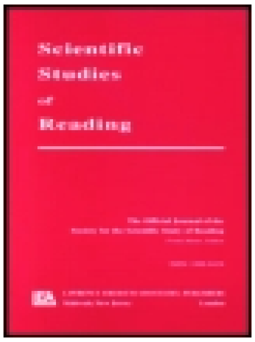

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The Home Literacy Environment as a Predictor of the Early Literacy Development of Children at Family-Risk of Dyslexia

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ABSTRACT

The home literacy environment (HLE) predicts language and reading development in typically developing children; relatively little is known about its association with literacy development in children at family-risk of dyslexia. We assessed the HLE at age 4 years, precursor literacy skills at age 5, and literacy outcomes at age 6, in a sample of children at family-risk of dyslexia (n = 116) and children with no known risk (n = 72). Developmental relationships between the HLE and literacy were comparable between the groups; an additional effect of storybook exposure on phoneme awareness was observed in the family-risk group only. The effects of socioeconomic status on literacy were partially mediated by variations in the HLE; in turn, effects of the HLE on literacy were mediated by precursor skills (oral language, phoneme awareness, and emergent decoding) in both groups. Findings are discussed in terms of possible gene–environment correlation mechanisms underpinning atypical literacy development.

Learning to read in the early years of education provides a foundation for later literacy development and academic success. Children vary widely in the skills they bring to formal reading instruction, including oral language, phonological awareness, and print knowledge (Storch & Whitehurst, 2002); in turn, these foundational skills are influenced by the home literacy environment (HLE) that children experience in the preschool years (Frijters, Barron, & Brunello, 2000; Levy, Gong, Hessels, Evans, & Jared, 2006; Niklas, Tayler, & Schneider, 2015). The current study assesses the developmental relationships between HLE and early literacy development in a sample of children at family-risk of dyslexia. More specifically, we examine whether home-based literacy interactions at 4 years of age predict oral language and emergent literacy measured 1 year later in a similar way for children at family-risk as for children who are not at risk. We then link these precursor skills to measures of word-level literacy and reading comprehension at age 6.

The "home literacy environment" is an umbrella term used to describe the literacy-related interactions, resources, and attitudes that children experience at home. Previous studies have operationalized the HLE in various ways. In general "active" models, emphasising children's participation in interactions involving print, are better predictors of literacy than "passive" models, which envisage children learning by observing family members' behaviours (Bracken & Fischel, 2008; Burgess, Hecht, & Lonigan, 2002). Home-based literacy interactions provide a social context for children's earliest encounters with the printed word, and much research on the HLE assumes an important role for experienced others (most often parents) in children's early literacy development. For example, parents may choose the texts that children encounter, prompt children to focus attention on print in the environment, and guide children's participation in storybook reading interactions (Fletcher & Reese, 2005; Vygotsky, 1978). In the present study, the

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HLE is defined as the three-way interactions between children, parents, and text that take place in the home.

Sénéchal and Lefevre's (2002) home literacy model makes a distinction between "informal" and "formal" home-based literacy interactions. In informal interactions (e.g., shared storybook reading) the printed word is not the primary focus, whereas formal interactions denote adults directly teaching children literacy skills (e.g., writing the child's name; linking letters and sounds). Differential relationships exist between these two broad interactional categories and children's developing skills. Specifically, storybook reading predicts oral language and, indirectly, reading comprehension (Sénéchal, Lefevre, Hudson, & Lawson, 1996; Sénéchal, Pagan, Lever, & Ouellette, 2008). A meta-analysis of 34 studies reports a medium pooled effect size (d = .67) for the relationship between shared reading and language (Bus, Van IJzendoorn, & Pellegrini, 1995). Conversely, parental teaching predicts "code-based" skills, including letter knowledge, print concepts, and decoding (Martini & Sénéchal, 2012). The predictions of the home literacy model have been supported in a number of studies (e.g., Hood, Conlon, & Andrews, 2008; Rodriguez & Tamis-LeMonda, 2011).

Shared storybook reading provides a unique context for language learning, offering exposure to novel concepts and vocabulary items rarely encountered in everyday conversation, through both the text and adults' talk around the text (DeTemple & Snow, 2003; Montag, Jones, & Smith, 2015). Fletcher and Reese (2005) posited a bidirectional relationship between the frequency and quality of shared reading. If parents read with children regularly from an early age, their sensitivity to the child's linguistic competence increases, allowing more effective use of strategies to support children's contributions and comprehension. This in turn encourages children's interest in books, leading to more frequent book-sharing episodes. Children's active participation in shared reading has been shown to have positive effects on vocabulary in experimental evaluations of dialogic reading programmes (e.g., Whitehurst et al., 1988).

Other authors have reported effects of shared storybook reading on print-related skills as well as oral language. Bus et al.'s (1995) meta-analysis yielded a medium effect size (d = .58) for the effect of shared reading on emergent literacy (including name writing, letter naming, and phonological awareness). Eye-tracking studies suggest that young children spend very little time spontaneously focusing attention on print during shared storybook reading (e.g., Evans & Saint-Aubin, 2005). However, training parents to use "print referencing" techniques (e.g., tracking text with a finger, commenting or asking questions about print forms) has been shown to increase children's attention to print (Justice, Pullen, & Pence, 2008) and enhance print concepts, letter knowledge, and later reading and spelling skills (Justice, Kaderavek, Fan, Sofka, & Hunt, 2009; Piasta, Justice, McGinty, & Kaderavek, 2012). In the classroom setting, a meta-analysis evaluating the added value of interactive over standard storybook reading reported that such programmes explained 7% of the variance in kindergartners' alphabetic knowledge, despite print skills not being targeted (Mol, Bus, & De Jong, 2009). It is plausible that older preschool children learn about print forms incidentally during storybook reading, whereas younger children's cognitive resources are fully taken up comprehending the story (Mol et al., 2009).

Several studies have demonstrated an association between the HLE and children's phonological awareness, but whether this relationship is mediated by other skills is less clear. Although Burgess (2002) found that the HLE at age 4 to 5 contributed unique variance to phonological awareness 1 year later, other studies have shown the relationship to be mediated by vocabulary and print knowledge (e.g., Hood et al., 2008). Notwithstanding these conflicting findings regarding specific effects of HLE on foundational skills, there is good evidence that the effect of the HLE on later reading is mediated by oral language and emergent literacy at school entry (De Jong & Leseman, 2001; Sénéchal & Lefevre, 2002).

It is important to note that the effects of the HLE are not unidirectional; the frequency and quality of home-based literacy interactions in the early years are likely to be influenced by child characteristics, including language skills (Majorano & Lavelli, 2014). The degree of children's exposure to print through development may therefore reflect underlying gene–environment correlations (Plomin, DeFries, & Loehlin, 1977; van Bergen, van der Leij, & de Jong, 2014). Child characteristics (influenced by genetic factors shared with parents) may affect the frequency and/or quality of early shared reading with parents, which in turn predict language and early literacy development; later in development, children with better language and literacy skills are more likely to read independently (Mol & Bus, 2011). Similarly, the relationship between formal home-based literacy interactions and children's reading changes over time; parents increase input when children's progress is slower than expected. Thus, parental teaching predicts letter knowledge at the start of school, but by Grade 2 formal parental input is negatively associated with reading (Sénéchal & Lefevre, 2014).

Various aspects of the proximal home environment are associated with distal contextual variables such as family socioeconomic status (SES), often indexed by parental education level and/or occupational status. Several studies have reported that the HLE mediates the relationship between family SES and children's literacy development (Chazan-Cohen et al., 2009; Foster, Lambert, Abbott-Shim, McCarty, & Franze, 2005). However, home-based literacy practices also vary within groups of similar socioeconomic standing (Payne, Whitehurst, & Angell, 1994; Van Steensel, 2006). Christian, Morrison, and Bryant (1998) compared performance on a range of academic tasks between kindergarten children divided into groups along two dimensions (high/low maternal education level and HLE). Children whose mothers had lower levels of education but who experienced a rich HLE outperformed "high maternal education–low HLE" children on measures of oral language, emergent literacy, and general knowledge. Moreover, in a 28-year longitudinal study, the amount of time spent reading to young children was found to be an independent predictor of later reading achievement and motivation, which in turn predicted educational attainment, when maternal education was controlled (Gottfried, Schlackman, Gottfried, & Boutin-Martinez, 2015). Taken together, these findings suggest that HLE experienced by young children predicts growth in academic skills independently of parents' educational background.

With these findings as a backdrop, we turn to consider the HLE of children at family-risk of dyslexia. Dyslexia has long been known to run in families and shows substantial heritability (Harlaar, Spinath, Dale, & Plomin, 2005). It is therefore plausible that the HLE created by parents with dyslexia will differ from that observed in families in which parents have typical reading skills (a possible example of passive gene–environment correlation). Alternatively, the HLE may show different developmental relationships with language and reading development in children at family-risk of dyslexia compared with typically developing children. Scarborough, Dobrich, and Hager (1991) reported that children at family-risk who were later identified as dyslexic (FR-dyslexia) were read to less often by fathers at 24 months and mothers at 30 months, though not at other preschool testing points, compared to at-risk children who were not identified as dyslexic themselves. However, mothers also reported that children in the FR-dyslexia group rarely engaged with books independently, suggesting that the effect was at least partially child driven (a possible example of evocative gene–environment correlation). Findings from other prospective studies have indicated that differences in the early HLE do not discriminate those children at family-risk who go on to develop dyslexia themselves from those who do not (Elbro, Borstrøm, & Petersen, 1998; Van Bergen et al., 2011).

A number of studies have reported minimal differences between the HLE experienced by young children with and without a dyslexic parent (regardless of the reading status of the child). For example, in a Danish longitudinal study, Elbro et al. (1998) reported no difference in the amount of time parents with and without dyslexia spent reading to their 6-year-old children. At an earlier stage in development, Laakso, Poikkeus, and Lyytinen (1999) observed no differences in the interactional behaviours employed by Finnish mothers with and without dyslexia when reading to their 14-month-old infants. Further, the developmental relations between mothers' interactional behaviours during shared reading and children's language development were largely comparable between the two groups. Torppa et al. (2007) found no differences between children at family-risk of dyslexia and controls in aspects of the HLE involving children's participation, or in children's interest in books, between the ages of 2 and 6 years old (although there was significantly more variation in the amount of shared reading experienced by children in the family-risk group at 2 years old, but not at later testing points). Dyslexic parents reported reading for pleasure themselves less often than parents without dyslexia; however, this measure was not related to children's skills. In this study, the developmental relationships between HLE (shared reading, access to print in the home, children's interest in reading) and children's early literacy skills were also highly comparable between the two risk groups. However, there were stronger associations among HLE factors (shared reading, access to print, children's interest in reading) in the group at family-risk than in the control group, and an association between children's vocabulary level and interest in reading was found in the family-risk group only. The authors suggest that these differences could reflect an underlying accumulation of gene–environment correlation, that is, genetic vulnerabilities combining with less parental modelling of reading behaviours leading to slower development of precursor literacy skills (Torppa et al., 2007). Torppa, Poikkeus, Laakso, Eklund, and Lyytinen (2006) reported a role for parental teaching of letters in the growth of letter knowledge in children at family-risk of dyslexia in the same sample. These studies indicate that there may be subtle differences in the relationships between home-based literacy interactions and early literacy development between children with and without a family history of dyslexia.

The current study examined the HLE in an English-speaking sample of children at family-risk of dyslexia, in comparison with a control group with no such family history, and the developmental relationships between the HLE and early literacy development in these two groups. We aimed to compare means and variance in variables tapping "informal" and "formal" aspects of the HLE at 4 years between children with and without family-risk of dyslexia, expecting that, although there may not be group differences in mean scores, there may be more variance in the HLE experienced by children in the family-risk group (Torppa et al., 2007). The second aim of the study was to relate measures of family SES and HLE to precursor literacy skills (oral language, phoneme awareness, emergent decoding) at age 5 and literacy skills (word-level literacy and reading comprehension) at age 6. We tested a number of predicted relationships between the constructs, in each case, comparing the strength of the relationship in the family-risk and control groups using multigroup longitudinal path modelling. The following hypotheses guided the construction of the longitudinal model:

(1) We predicted that family SES would be associated with HLE and with children's language and literacy skills. We predicted that the relationship between SES and children's skills would be mediated by the HLE (Foster et al., 2005).
(2) We expected that the HLE would predict foundational skills for literacy (oral language, phoneme awareness, emergent decoding) at age 5. Specifically, we predicted that informal HLE (storybook exposure) would predict children's oral language skills, whereas formal HLE (parental literacy instruction) would predict emergent decoding (Sénéchal & Lefevre, 2002).
(3) We expected that foundational skills for literacy at age 5 would predict literacy outcomes at age 6. Specifically, we expected word-level literacy skills at age 6 to be predicted by phoneme awareness and emergent decoding measured 1 year earlier (Sénéchal & Lefevre, 2002). Because in the early stages of its development, reading comprehension is highly constrained by children's decoding skills (Muter, Hulme, Snowling, & Stevenson, 2004), we predicted that reading comprehension at age 6 would be predicted by word-level literacy measured concurrently, as well as by oral language measured at age 5. We expected the HLE to predict word-level literacy and reading comprehension indirectly via the precursor skills measured at age 5 (De Jong & Leseman, 2001).

Method

Design

The Wellcome Language and Reading Project followed children from age 3½ to 9 years with assessments at approximately annual intervals (T1–T6). Selected data from three time points are reported here: (a) information on the HLE at T2 (when children were 4 years old), (b) measures of precursor literacy skills at T3 (5 years), and (c) measures of word-level literacy and reading comprehension at T4 (6 years).

Ethical permission for the study was obtained from the University of York, Department of Psychology's Ethics Committee, and the NHS Research Ethics Committee. Informed consent was gathered from parents for their own and their child's participation in the study.

Participants

The Wellcome Language and Reading Project recruited children at family-risk of dyslexia, children with specific language impairment, and typically developing controls (N = 260). Families were recruited via advertisements, nurseries and speech and language therapy clinics, and children were allocated to groups on the basis of family history of dyslexia (family-risk/no family-risk) and children's language status (impaired/typically developing). Family-risk of dyslexia was dependent on the presence of an affected first-degree relative (parent or full sibling). Parental dyslexia status was ascertained by self-report initially and confirmed by objective testing of consenting parents (95% of mothers; 60% of fathers). Children were allocated to the family-risk group if they met at least one of the following criteria: (a) a parent self-reported as dyslexic; (b) a parent scored below 90 on a composite of standardised nonword reading and spelling scores; (c) a parent had a discrepancy of 1.5 standard deviations or more between nonverbal ability and the literacy composite, where the standardised literacy composite was not higher than 96; and (d) a sibling had received a diagnosis of dyslexia from an educational psychologist or specialist teacher (i.e., siblings were not assessed by a member of the research team, and thus different standardised tests of literacy may have been used in the diagnostic process). Some children (n = 29) within the resulting family-risk group also met the research criteria for language impairment (not achieving criterion on two out of four standardised language tests at age 3½; see Nash, Hulme, Gooch, & Snowling, 2013, for full details). These children were retained in the family-risk group for the current study, because the aim was to compare children at family-risk of dyslexia (irrespective of language status) with controls. However, children who were identified as having a language impairment without a family history of dyslexia are excluded from the analyses; we aimed to compare children with a family history of dyslexia with children with *no* known risk of reading difficulties, and early language impairment has been demonstrated to predict later dyslexia status (e.g., Snowling, Bishop, & Stothard, 2000).

The sample contained a number of sibling pairs; one child from each pair was randomly excluded, to avoid duplicating family-level data. Data on the HLE were unavailable for two children. The final sample consisted of 188 children (72 control, 116 family-risk). Attrition was low; two children from the family-risk group (1.1%) were lost from the sample during the study due to families moving away between T2 and T3; there was no further attrition between T3 and T4. Sample characteristics are reported in Table 1.

The family-risk group comprised 60% boys, whereas the gender split was equal in the control group. The majority of children in both groups were of White British ethnicity, and all spoke English as their first language. Children's mean age was 4 years 8 months at T2 (range = 50–67 months). In total, 102 (54%) children had started the school reception year at T2; the average time in school was less than 3 months at time of testing. None of the variables included in these analyses differed significantly between children who had started school at T2 and those who had not. At T3, children's mean age was 5 years 8 months (range = 60–78 months); on average, children had been in school for

Table 1. Sample characteristics in the control and family-risk groups.

	Whole Sample	Control	Family-Risk	Group Difference	Cohen's *d*
N	188	72	116		
Gender (% boys)	56%	50%	60%	$\chi^2(1) = 1.93$	
Age at T2	56.54 (3.78)	55.78 (3.46)	57.01 (3.91)	$t(186) = 2.20$*	.33
Age at T3	68.29 (3.45)	67.81 (3.08)	68.60 (3.64)	$t(186) = 1.13$	—
Age at T4	78.99 (4.33)	78.89 (4.63)	79.14 (3.83)	$t(186) = .56$	—
Months in school at T2	2.61 (3.35)	2.51 (3.46)	2.68 (3.30)	$t(186) = 0.72$	—

Note. Age is in months.
*$p < .05$.

13 months at this point. The mean age was 6 years 7 months at T4 (range = 70–90 months), and children had been in school for 24 months, on average. Children in the family-risk group were slightly older than those in the control group at T2; at T3 and T4 there were no significant differences in age between the two groups, reflecting minor variation in the length of interval between testing points. To account for the variation in age within the sample, all language and literacy measures were residualised for age in inferential analyses.

The parent-report measures were completed by the child's primary caregiver in all cases. In 177 cases (94% of the sample), this was the biological mother; in nine cases (5%), the biological father; and in two cases (1%), the adoptive mother. Because risk of dyslexia could come from any first-degree relative, only 53 (46%) of the questionnaire respondents in the family-risk group met the research criteria for dyslexia themselves.

Measures and procedure

Environmental measures (Age 4)

Family SES. The educational level of both parents was assessed on a scale ranging from 1 to 6 (1 = no formal qualifications, 2 = GCSEs (i.e., exams taken at the end of compulsory education at age 16 in the United Kingdom) or equivalent, 3 = A levels (i.e., exams taken at the end of secondary education at age 18 to 19 in the United Kingdom) or equivalent, 4 = professional vocational qualification, 5 = undergraduate degree, 6 = postgraduate degree). In addition, the occupational status of both parents was collected, using the Standard Occupational Classification (Office for National Statistics, 2010), which ranges from 1 (*unemployed*) to 10 (*managers, directors, senior officials*). Best occupational status was preferred to current occupational status, because many respondents were on parental leave from work at the time of data collection.

Home literacy environment. The HLE was conceptualised as two separable constructs—storybook exposure and parental literacy instruction (Sénéchal & Lefevre, 2002). HLE measures were collected from the child's primary caregiver when the children were 4 years old.

Storybook exposure was measured using two items from a family interview and two parent-report checklists based on previous versions in the literature. The interview items asked primary caregivers to report how often they read storybooks to their children in a typical week (summed responses to two items: How many times in a typical week do you read a bedtime story with your child? How many times in a typical week do you read stories with your child at other times of day?). Parents were also asked to estimate the number of children's books in the home on a 7-point scale (0–20; 20–40; 40–60; 60–100; 100–155; 150–200; 200+). For the Children's Title Checklist (CTC), titles of picture books popular in the United Kingdom were collated through surveys of bestseller lists, excluding titles that had been televised. The 30 most frequently cited titles were selected and interspersed with 30 plausible foils (e.g., *Letty Spaghetti*). For the Children's Author Checklist

(CAC), 40 authors of books elicited for the CTC were intermixed with 40 foils Checklist scores were calculated by subtracting the number of foils checked from the number of target items checked, in order to correct for guessing (maximum scores: CTC = 30, CAC = 40).

Parental literacy instruction was measured using three items from a family interview, adapted from Sénéchal and Lefevre (2002). Parents were asked to rate how often they taught their children to recognise letters, read words, and write words using a 5-point scale: 1 (*never/occasionally*), 2 (*about once a month*), 3 (*about once a week*), 4 (*several times a week*), and 5 (*daily*).

Child measures (Age 5)

Oral language was assessed using two subtests from the Clinical Evaluation of Language Fundamentals (Semel, Wiig, & Secord, 2006). For Expressive Vocabulary, children are asked to name pictures of objects and actions (e.g., drawing, telescope; maximum score = 54). For Sentence Structure, children listen to a sentence read by the examiner (e.g., "The bear is in the wagon") and choose the matching picture from an array of four (maximum score = 26).

Phoneme awareness was measured using two tests. For Phoneme Isolation, children identify the first or last sound in a series of simple nonwords (e.g., *guf*; maximum score = 16). Second, the Phoneme Deletion subtest from the York Assessment of Reading for Comprehension: Early Reading (YARC; Hulme et al., 2010) was administered. Children repeat a given word, removing the initial, medial, or final phoneme (e.g., plant → plat; maximum score = 12).

Emergent decoding was assessed with three subtests of the *YARC: Early Reading*. For Letter-Sound Knowledge, children are asked to say the sounds represented by a series of letters and digraphs (maximum score = 32). For Early Word Recognition, children are asked to read a list of regular and irregular words found in early readers (maximum score = 30). For Single Word Reading, children read a list of words of increasing difficulty (maximum score = 60).

Child measures (Age 6)

Word-level literacy. In addition to reassessing early word recognition and single word reading (as at age 5), two further tests were administered. For the Graded Nonword Reading Test (Snowling, Stothard, & McLean, 1996), children read aloud a list of phonotactically legal nonwords of increasing complexity (e.g., *tegwop*; maximum score = 20). For Spelling, children spell words (e.g., *cat, train*) dictated by the examiner and accompanied by pictures (maximum score = 10).

Reading comprehension was assessed using the YARC Primary Passage Reading test (Snowling et al., 2009). Children read aloud three short passages, then answer questions testing literal and inferential understanding (maximum score = 24).

Reliability coefficients for all child measures are reported in Table 3. The tests reported here formed part of a comprehensive assessment battery, which was administered by trained research assistants in the child's home or school setting. Children were offered breaks as necessary during the testing sessions and afterward given a small gift as a token of appreciation for their participation.

Results

There was not more than 5% missing data for any variable. Raw data are presented in tables of descriptive statistics; to form composite variables, missing data points were imputed using the estimation-maximation algorithm in SPSS v20.

Home literacy environment

Table 2 shows descriptive statistics for the measures of family SES and HLE in the control and family-risk groups, alongside tests of group difference and equality of variance.

Family SES, as indexed by parental education level and occupational status, was significantly higher in the control group and showed significantly greater variance in the family-risk group. The

Table 2. Family SES and HLE measures: Descriptive statistics in the control and family-risk groups, group comparisons of means (independent samples *t* test/Mann-Whitney *U*) with effect sizes (Cohen's *d*) and group comparisons of variances (Levene's test).

	Control						Family-Risk								
	N	M (SD)	Min	Max	Skewness	Kurtosis	N	M (SD)	Min	Max	Skewness	Kurtosis	Mann-Whitney U /t (df)	Cohen's d	Levene F
Family SES															
Maternal education[a]	72	4.75 (1.35)	1	6	−1.26	.53	115	3.59 (1.52)	1	6	−.14	−1.11	*U*(185) = 2235.00***	.81	6.33***
Paternal education[a]	70	4.59 (1.47)	1	6	−.91	−.25	111	3.30 (1.58)	1	6	.20	−1.09	*U*(179) = 2133.00***	.85	2.16
Maternal occupation[b]	72	7.56 (2.07)	1	10	−1.54	2.22	115	6.15 (2.93)	1	10	−.42	−1.02	*U*(185) = 3042.50**	.56	22.97***
Paternal occupation[b]	70	8.47 (1.65)	2	10	−2.02	4.37	111	6.95 (2.66)	1	10	−.69	−50	*U*(179) = 2632.50***	.69	31.31***
Storybook exposure															
Children's title checklist[c]	71	15.32 (6.80)	1	29	.04	−.40	112	11.25 (6.57)	−2	25	.04	−.85	*t*(181) = 4.03***	.61	17
Children's author checklist[c]	71	15.37 (9.25)	−18	31	−.55	−.73	112	10.38 (7.96)	−3	28	.57	−.73	*t*(181) = 3.87***	.63	1.29
Frequency of shared reading[d]	72	10.58 (3.25)	1	21	.09	1.51	116	9.57 (3.73)	1	21	−.07	.19	*t*(186) = 1.90†	.29	2.56
No. of children's books[e]	71	5.14 (1.21)	2	7	−.26	−.09	116	4.83 (1.57)	1	7	−.45	−.60	*U*(185) = 3788.50		5.93*
Literacy instruction															
Teaching letters[f]	72	3.61 (1.27)	1	5	−.57	−.54	116	3.76 (1.36)	1	5	−.77	−.57	*U*(186) = 3824.50		.76
Teaching reading[f]	72	3.25 (1.69)	1	5	−.26	−1.60	116	3.29 (1.63)	1	5	−.31	−1.48	*U*(186) = 4142.00		.43
Teaching writing[f]	72	3.25 (1.36)	1	5	−.16	−.96	116	3.22 (1.41)	1	5	−.22	−1.14	*U*(186) = 4145.50		.50

Note. SES = socioeconomic status; HLE = home literacy environment.
[a]1 (*no formal qualifications*) to 6 (*postgraduate degree*). [b]1 (*unemployed*) to 10 (*managers, directors, senior officials*). [3]Error-corrected raw scores. [4]Number of weekly shared reading episodes. [5]1 (0–20) to 7 (200+). [6]1 (*never/occasionally*) to 5 (*daily*).
†$p < .06$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 3. Language and literacy measures: Internal reliability. (Cronbach's alpha); descriptive statistics in control (n = 72) and family-risk (n = 111) groups; tests of group difference and effect sizes.

		Control					Family-Risk						
	Cronbach's α	M (SD)	Min	Max	Skewness	Kurtosis	M (SD)	Min	Max	Skewness	Kurtosis	t	Cohen's d
Age 5													
Expressive vocabulary[a]	.84	31.88 (5.95)	20	47	.20	−.54	25.78 (10.05)	2	46	−.50	−.14	5.25***	.75
Sentence structure[a]	.66	21.74 (2.84)	14	26	−.71	−.10	20.48 (3.83)	9	26	−.91	.30	2.55*	.37
Phoneme isolation[a]	.91	14.00 (3.13)	4	16	−2.17	4.14	12.46 (4.29)	0	16	−1.38	1.07	2.84**	.41
Phoneme deletion[a]	.93	7.74 (2.26)	2	12	−.03	−.48	6.41 (2.62)	0	12	−.12	−.29	3.57***	.55
Letter-sound knowledge[a]	.98	30.18 (4.06)	9	32	−3.79	15.21	28.94 (4.25)	8	32	−2.57	7.87	1.97	.30
Early word recognition[a]	.98	20.36 (8.04)	0	30	−.65	−.31	14.98 (8.90)	0	30	.28	−.96	4.19***	.58
Single word reading[a]	.98	14.64 (9.75)	0	37	.54	−.35	8.87 (9.79)	0	44	1.31	1.12	3.95***	.57
Age 6													
Early word recognition[a]	.98	27.56 (4.86)	8	30	−.93	−.21	22.03 (8.37)	1	30	−.93	−.21	5.72***	.81
Single word reading[a]	.98	27.86 (10.29)	0	49	−.45	.35	18.87 (13.12)	0	55	.55	−.62	5.23***	.77
Nonword reading[a]	.96	12.85 (4.76)	0	20	−.54	−.29	8.22 (6.37)	0	20	.28	−1.28	5.63***	.82
Spelling[a]	.71	6.19 (2.77)	0	10	−.04	1.26	4.69 (2.77)	0	10	.55	−.58	3.65***	.55
Reading comprehension[a]	.64	16.57 (5.14)	0	23	−1.50	2.20	11.02 (7.02)	0	23	.17	−1.29	6.19***	.90

[a]Raw scores.
*p < .05. **p < .01. ***p < .001.

full range of SES was represented, although variables were negatively skewed in the control group, reflecting the relatively high average SES of this group.

On average, parents reported reading with their children approximately 10 times per week, and this frequency was marginally higher in the control than the family-risk group. Families had on average 100–150 children's books in the home; this variable did not differ between the groups, although there was greater variance in the family-risk group. Parents in the control group scored significantly higher on both checklist measures than those in the family-risk group; variance was equivalent between the groups. On average, parents reported teaching their children about letters, to read words, and to print words at least once a week; means and variances of these items did not differ between the groups.

Composite scores (mean z scores) for the two HLE constructs (storybook exposure and literacy instruction) and family SES were calculated based on a confirmatory factor analysis (presented in Figure 1). Items tapping storybook exposure (interview and checklist measures) were significantly correlated (r = .25–.79); however, the two interview items (frequency of shared reading/number of children's books) loaded weakly onto a "storybook exposure" latent variable and attenuated model fit. Therefore only the two checklists were retained as indicators of storybook exposure. The resulting CFA model showed an excellent fit to the data and supported the independence of two HLE factors (i.e., storybook exposure and literacy instruction). Family SES was positively related to storybook exposure, but not literacy instruction. The factor structure was invariant between the two groups.

To investigate the effect of specific caregiver and child characteristics on the HLE variables, two sets of one-way independent-samples analyses of variance were run on the storybook exposure and parental literacy instruction composite variables. First, it is possible that the reading status of the child's primary caregiver influences the HLE provided for children; therefore, comparisons were made between control families (n = 72), at-risk families in which the primary caregiver was not dyslexic (n = 63), and at-risk families in which the primary caregiver was dyslexic (n = 53). At-risk families in which the primary caregiver was dyslexic showed significantly lower levels of storybook exposure than the other two groups—control group: M = .36, SD = .95; at-risk/caregiver not dyslexic: M = .07, SD = .89; at-risk/caregiver dyslexic: M = –.57, SD = .72; $F(2, 185) = 17.84$, $p < .001$, representing a large effect size ($\omega^2 = .15$). When family SES was controlled in the same analysis, the effect of parental reading status on children's storybook exposure was attenuated but still statistically significant, $F(3, 184) = 3.61$, $p < .001$, $\omega^2 = .02$. (A similar pattern of results was observed in relation to parent-reported frequency of shared reading and number of children's books in the home; however, for these variables the effect of caregiver reading status was no longer statistically significant when family SES was controlled.) In contrast, there were no group differences in reported parental literacy instruction by parental reading status—control: M = –.02, SD = .75; at-risk/caregiver not dyslexic: M = .07, SD = .75; at-risk/caregiver dyslexic: M = –.05, SD = .78.

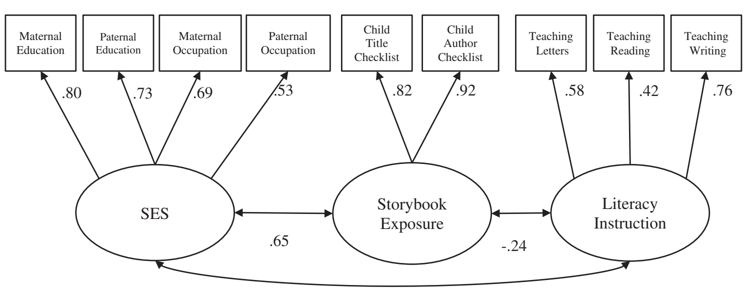

Figure 1. Confirmatory factor analysis of family socioeconomic status (SES) and home literacy environment variables.
Note. $\chi^2(24) = 24.45$, $p = .426$; root mean square error of approximation = .010, comparative fit index = 1.00, Tucker–Lewis index = 1.00.

Second, it is possible that children with poorer oral language elicit different literacy interactions in the home from parents. Therefore, comparisons were made between children in the control group, children in the family-risk group with typical language, and children in the family-risk group with language impairment. Scores on the storybook exposure composite were significantly higher in the control group (M = .36, SD = .95) than in the family-risk/typical language group (M = .11, SD = .92), which in turn were significantly higher than in the family-risk/language impairment group (M = –.58, SD = .63), $F(2, 185) = 12.68$, $p < .001$, representing a medium effect size ($\omega^2 = .11$). When family SES was controlled, however, the effect of child language status on storybook exposure was no longer statistically significant. (A highly similar pattern of results was observed when the same analyses were run on parent-reported frequency of shared reading and number of children's books in the home.) There was no effect of child language status on parental literacy instruction—control: M = –.02, SD = .75; family-risk/typical language: M = .06, SD = .73; family-risk/language impairment: M = –.58, SD = .63.

Children's language and literacy

Descriptive statistics for child measures at 5 and 6 years are shown in Table 3. The control group performed significantly better than the family-risk group on all measures (representing medium to large effect sizes), with the exception of letter-sound knowledge at age 5. Letter-sound knowledge was subject to ceiling effects in both groups and was not included in further analyses.

All language and literacy variables were moderately to strongly inter-correlated (see Table A1 in the appendix). Composite variables were computed by calculating mean age-residualized z scores. Three composite variables indexed precursor skills at age 5: oral language (expressive vocabulary and sentence structure), phoneme awareness (phoneme isolation and phoneme deletion), and emergent decoding (early word recognition and single word reading). Word-level literacy at age 6 was a composite of four measures (early word recognition, single word reading, nonword reading, spelling). Word-level literacy and reading comprehension were strongly correlated at age 6 ($r = .84$, $p < .001$); reading comprehension at this age is still highly constrained by decoding skills. However, as the two constructs are known to be predicted by different precursor skills (Storch & Whitehurst, 2002), they were included separately in the longitudinal analyses.

Associations between SES, HLE, and children's skills

Correlations between all composite variables indexing SES, HLE, precursor skills at 5, and literacy outcomes at 6 years are shown in Table 4. Both family SES and storybook exposure were weakly to moderately correlated with oral language, word-level literacy, and reading comprehension in both groups. In the family-risk group only, SES was weakly correlated with phoneme awareness and emergent decoding. Storybook exposure was also significantly correlated with phoneme awareness in

Table 4. Zero-order correlations between composite SES, HLE, and child skill variables.

		1.	2.	3.	4.	5.	6.	7.	8.
	1. SES		.38***	–.17	.31***	–.14	.05	.20	.21
Age 4	2. Storybook exposure	.48***		–.15	.28*	.06	.22	.20	.27*
	3. Literacy instruction	–.01	–.21*		–.03	.29*	.06	.09	.08
Age 5	4. Oral language	.28**	.36***	.02		.13	.23*	.21	.43***
	5. Phoneme awareness	.26**	.25**	.09	.37***		.63***	.58***	.54***
	6. Emergent decoding	.25*	.16	.19*	.45***	.69***		.75***	.60***
Age 6	7. Word-level literacy	.24*	.24**	.15	.42***	.74***	.88***		.73***
	8. Reading comprehension	.31**	.41***	.12	.61***	.60***	.80***	.86***	

Notes. Control group is above the diagonal; family-risk group is below the diagonal. SES = socioeconomic status; HLE = home literacy environment.
*$p < .05$. **$p < .01$. ***$p < .001$.

the family-risk group only, and showed weak, nonsignificant associations with emergent decoding in both groups. Literacy instruction correlated weakly with emergent decoding 1 year later in the family-risk group and with phoneme awareness in the control group. Parental literacy instruction showed nonsignificant associations with the literacy outcomes at 6 years.

To investigate the developmental relationships between the constructs, a multi-group (control/ family-risk) longitudinal path model, predicting word-level literacy and reading comprehension at age 6, was constructed using maximum likelihood estimation in MPlus. The model was run on composite variables, which were standardised within the groups. We expected to find a series of indirect relationships: SES → HLE → precursor skills → literacy outcomes. Successive iterations were run with nonsignificant pathways (e.g., SES → parental literacy instruction) being deleted; direct pathways from SES and HLE to literacy outcomes were also tested.

The most parsimonious path model that gives an adequate fit to the data is shown in Figure 2. The unstandardized coefficients shown are equivalent to standardized coefficients, because all measures were standardized within groups before fitting the model. Path weights were initially constrained to be equivalent across groups; the adequacy of these constraints was tested by relaxing each one iteratively and observing changes in fit. This procedure showed that one path (storybook exposure → phoneme awareness) differed significantly, hence this path was freely estimated for the two groups. The resulting model provides a good fit to the data.

The model broadly confirms our hypotheses. For both groups, SES was positively associated with storybook exposure but not significantly related to oral language when the effect of storybook exposure was accounted for (i.e., full mediation). Literacy instruction was associated with phoneme awareness and emergent decoding to a similar degree in both groups. Storybook exposure also predicted emergent decoding in both groups. However, phoneme awareness was significantly related to storybook exposure only in the family-risk group. Phoneme awareness and emergent decoding were significant predictors of word-level literacy 1 year later (and to a similar degree in both groups). Finally, reading comprehension was strongly predicted by earlier oral language and concurrent word-level literacy. The model explained 67% of the variance in word-level literacy and 74% of the variance in reading comprehension at age 6 in the family-risk group (control group = 65% and

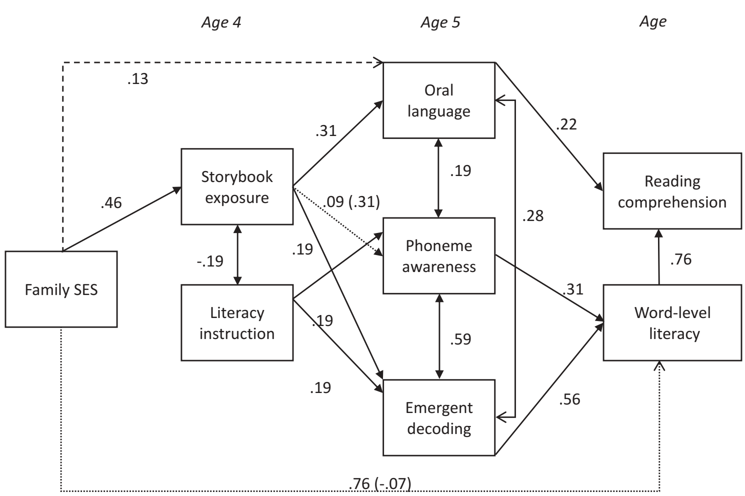

Figure 2. Two-group longitudinal path model predicting word-level literacy and reading comprehension.
Note. Dashed line represents nonsignificant pathway; dotted line represents pathway that is significant in one group only (coefficients for control group outside brackets; coefficients for family-risk group inside brackets). $\chi^2(38) = 48.24$, $p = .123$; root mean square error of approximation = .054, 90% confidence intervals [.00, .10], comparative fit index = .98, Tucker–Lewis index = .98. SES = socioeconomic status.

Table 5. Indirect effects for two-group path model predicting word-level literacy and reading comprehension at age 6.

		Control Group			Family-Risk Group		
		Compound Path Coefficient (SE)	95% CIs	p	Compound Path Coefficient (SE)	95% CIs	p
Indirect effects on word-level literacy	SES → storybook exposure → phoneme awareness → word-level literacy	.03 (.02)	[−.01, .07]	.135	.03 (.02)	[−.01, .07]	.135
	SES → storybook exposure → emergent decoding → word-level literacy	.17 (.06)	[.06, .25]	.002	−.00 (.05)	[−.10, .09]	.904
	Storybook exposure → phoneme awareness → word-level literacy	03. (.03)	[−.03, .09]	.353	.10 (.04)	[.05, .19]	.004
	Storybook exposure → emergent decoding → word-level literacy	.11 (.05)	[.01, .19]	.025	.11 (.05)	[.01, .19]	.025
	Literacy teaching → phoneme awareness → word-level literacy	.07 (.03)	[.01, .15]	.051	.07 (.03)	[.01, .15]	.051
	Literacy teaching → emergent decoding → word-level literacy	.10 (.05)	[.00, .19]	.026	.10 (.05)	[.00, .19]	.026
Indirect effects on reading comprehension	SES → oral language → reading comprehension	.03 (.02)	[−.01, .07]	.135	.03 (.02)	[−.01, .07]	.135
	SES → word-level literacy → reading comprehension	.17 (.06)	[.06, .25]	.002	−.00 (.05)	[−.10, .09]	.904
	SES → storybook exposure → oral language → reading comprehension	.03 (.01)	[.02, .06]	.007	.03 (.01)	[.02, .06]	.007
	SES → storybook exposure → phoneme awareness → word-level literacy → reading comprehension	.01 (.01)	[−.01, .04]	.372	.04 (.02)	[.02, .08]	.013
	SES → storybook exposure → emergent decoding → word-level literacy → reading comprehension	.04 (.02)	[.00, .07]	.042	.04 (.02)	[.00, .07]	.042
	Storybook exposure → oral language → reading comprehension	.07 (.02)	[.03, .12]	.004	.07 (.02)	[.03, .12]	.004
	Storybook exposure → phoneme awareness → word-level literacy → reading comprehension	.02 (.02)	[.03, .07]	.359	.04 (.02)	[.02, .08]	.013
	Storybook exposure → emergent decoding → word-level literacy → reading comprehension	.08 (.04)	[.01, .15]	.031	.08 (.04)	[.01, .15]	.031
	Literacy teaching → phoneme awareness → word-level literacy → reading comprehension	.05 (.03)	[.01, .12]	.058	.05 (.03)	[.01, .12]	.058
	Literacy teaching → emergent decoding → word-level literacy → reading comprehension	.08 (.04)	[.00, .15]	.031	.08 (.04)	[.00, .15]	.031

Note. SE = standard error; CI = confidence interval; SES = socioeconomic status.

67%, respectively; R^2 values for all outcome variables included in the model are presented in the appendix, Table A2).

Indirect effects from SES and the HLE via precursor skills to literacy outcomes were assessed, using bias-corrected bootstrapped confidence intervals (Preacher & Hayes, 2004). Significant indirect effects of SES and HLE on word-level literacy and reading comprehension were observed in both groups (see Table 5). SES indirectly predicted word-level literacy via storybook reading and emergent decoding; literacy instruction also predicted word-level literacy via emergent decoding. Multiple significant indirect effects on reading comprehension were observed from storybook exposure and parental literacy instruction, via oral language, emergent decoding, and word-level literacy. Finally, indirect effects of SES and storybook exposure via phoneme awareness were statistically significant in the family-risk group only.

It is notable that the effects of SES on reading comprehension were fully mediated by storybook reading in both groups (adding a direct path from SES → reading comprehension yielded no change in fit), $\Delta\chi^2(2) = 0.338$, $p = .844$. However, the effects of SES on word-level literacy were not fully mediated; there was a significant direct effect (SES → word-level literacy) in the control group only.

The effects of storybook exposure on reading outcomes were fully mediated by precursor skills at age 5; adding direct effects (storybook exposure → word-level literacy; storybook exposure → reading comprehension) gave no improvement in fit, $\Delta\chi^2(2) = 0.53$, $p = .766$, and $\Delta\chi^2(2) = 5.64$, $p = .056$, respectively. Similarly, the effects of literacy instruction on outcomes were fully mediated; adding direct effects (literacy instruction → word-level literacy; literacy instruction → reading comprehension) gave no improvement in fit, $\Delta\chi^2(2) = 0.36$, $p = .835$, and $\Delta\chi^2(2) = 0.39$, $p = .822$, respectively.

Discussion

In this study, we aimed to evaluate the HLE and its association with early literacy development in a group of children at high risk of dyslexia. The HLE was conceptualised as informal and formal home-based literacy interactions. We measured the HLE of 4-year-old children at family-risk of dyslexia and children not at risk, comparing levels of storybook exposure and reported literacy instruction in the home between these groups. We found group differences in storybook exposure between the risk groups but no differences in reported literacy instruction, but these differences were largely accounted for by SES differences between the groups. Variations in the HLE were related to later measures of language and literacy skills in both groups. Despite lower mean levels of SES, storybook exposure, language, and literacy in the family-risk group, the developmental relationships between the variables were highly similar in the two groups.

Children in the family-risk group experienced less exposure to storybooks than children in the control group, but there was no evidence for greater variance in the at-risk families (with the exception of the number of children's books in the home). The group difference in storybook exposure stands in contrast to the results of previous studies (Elbro et al., 1998; Torppa et al., 2007). It is plausible that the observed group difference is associated with the relatively lower SES of the families in the family-risk group in our study, given that storybook reading in the home has often been shown to vary with family SES (e.g., Niklas et al., 2015). There were no group differences in parental education level in Torrpa et al.'s (2007) study, and maternal education (though not parental occupational status) was also equivalent in the family-risk and control groups in Elbro et al.'s (1998) sample. In the current study, group differences in parent-reported frequency of shared reading and number of children's books in the home were no longer statistically significant when family SES was controlled, although there remained a small effect of risk group on the checklist measures of storybook exposure after controlling SES. However, within-group differences were also associated with levels of storybook exposure: Where the primary caregiver met research criteria for dyslexia, storybook exposure was lower than in children with a first-degree dyslexic relative who was not the primary caregiver. This may suggest that dyslexic parents are more likely to avoid reading storybooks with their children (an example of passive gene–environment correlation). It is also possible that dyslexic parents may read as widely with their children but may not retain information about storybooks and hence score relatively less well on the checklist measures. Similarly, children at family-risk who met the research criteria for language impairment had lower levels of storybook exposure than those whose language was developing typically. It is likewise possible that this pattern reflects an underlying evocative gene–environment correlation, that is, children with relatively poor language levels may find engaging with the linguistically rich medium of storybooks difficult, and/or parents may choose to focus on repeated readings of a narrow range of literature to scaffold language development. Taken together, these findings suggest that differences between children in storybook exposure are associated with a number of child, caregiver, and family characteristics.

We observed no differences in the mean frequency or variance of reported parental literacy instruction at age 4 between the family-risk and control groups. This variable was more weakly correlated with children's letter- and word-related skills than has been reported in previous studies (e.g., Torrpa et al., 2006). This may be in part explained by limited sensitivity in our measure (three parent-report items from the family interview); however, it is likely that the differential relations between this formal aspect of home literacy and children's developing skills also reflect cultural differences in school-starting age. The measure of letter-sound knowledge taken when children were 5 years old in the current study was subject to ceiling effects in the family-risk and control groups (in contrast to the findings of Torppa et al., 2006, in a Finnish sample). Children in the United Kingdom typically start full-time school in the September following their fourth birthday, and systematic synthetic phonics tuition during the reception year is a statutory requirement in state schools (Department for Education, 2014). The primary influence of parental literacy instruction in the UK context may therefore be on children's letter knowledge at school entry, an earlier stage of development than was captured in the current study.

The key finding from this study is that developmental relationships between the HLE and children's language and literacy skills are similar for children with and without a family-risk of dyslexia. Multiple indirect pathways from the HLE at age 4 to literacy at age 6 were observed, and the effects of informal and formal HLE on literacy outcomes were fully mediated by earlier precursor skills (oral language, phoneme awareness and emergent decoding). The only notable difference between the groups was a direct pathway from storybook exposure to phoneme awareness in the family-risk group only. Storybook reading in the home may primarily benefit children's oral language skills, which in turn are critical foundations for the development of phoneme awareness (Sénéchal & Lefevre, 2002; Torppa et al., 2007). Alternatively, shared reading may support phonological awareness directly when it is in ascendancy, because children's storybooks are often rich in rhyme and alliteration. Given that children at family-risk of dyslexia can be expected to exhibit delays in the development of phonological awareness (Pennington & Lefly, 2001; Snowling, Gallagher, & Frith, 2003), the stronger association between storybook exposure and phoneme awareness may be explained by a less advanced stage of development in this group. Oral language and phoneme awareness were measured concurrently in this study, and therefore we do not make claims about the direction of causality between development in the two domains.

The effect of SES on reading comprehension was completely explained by storybook exposure in both groups. It appears that families of higher SES tend to read a broader range of literature with their children (demonstrated by the moderate correlation between family SES and the composite measure of storybook exposure), which benefits language and emergent literacy and, later in development, word-level literacy and reading comprehension. In the control group, the effect of SES on word-level literacy was not completely explained by the HLE. This is perhaps accounted for by the greater proficiency of children in this group; arguably, once word-level skills are established, a new set of predictors associated with SES (e.g., access to resources for independent reading, teacher expectations) may come into play. Further, the role of genetic heritability in explaining the association between parental education level/occupational status and children's reading attainment cannot be ruled out.

This study has several limitations. In common with much previous research, indirect measures of the HLE were used, which may be vulnerable to social desirability bias. Checklist measures of storybook exposure may disadvantage dyslexic respondents due to the inherent memory load, although the correlation between checklists and self-reported frequency of storybook reading in this group (r = .40, p < .01) provides an indication of convergent validity. Potentially important aspects of the home environment were not measured in this study; for example, previous research indicates that parental attitudes toward and beliefs about reading influence both literacy-related interactions with children and children's reading development (Machida, Taylor, & Kim, 2002; Weigel, Martin, & Bennett, 2006). Each construct was measured at one time point only, and therefore the complex transactions between home environment and child through development are not captured; thus it is clearly impossible to give an unambiguous causal interpretation to the reported results, as demonstrated by the associations of primary caregiver reading status and child language status with levels of storybook exposure in the home.

The role of the HLE in the language and reading development of typically developing children has been well documented. The contribution of the current study is to show similar developmental relationships in an English-speaking sample of children at family-risk of dyslexia, suggesting that such children are able to take advantage of rich literacy interactions to a similar degree to other children. Shared storybook reading and parental teaching of literacy skills at age 4 predict word-level literacy and reading comprehension 2 years later, via foundational skills for reading at age 5 in our sample. Thus home literacy may be a suitable target for early intervention for children with a known family history of dyslexia to support the development of a number of crucial foundational skills for reading, including oral language and print-related skills, to optimise children's chances of success in learning to read at school.

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Appendix

Table A1. Correlations between child outcomes at 5 and 6 years.

Age		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
5½ years old	1. Expressive vocabulary		.49***	.15	.13	.21	.24*	.17	.27*	.13	.09	.39***
	2. Sentence structure	.45***		.16	.14	.20	.19	.19	.17	.08	.03	.34**
	3. Phoneme isolation	.34***	.47***		.44***	.53***	.39***	.56***	.46***	.35**	.28*	.49***
	4. Phoneme deletion	.18	.28**	.55***		.62***	.56***	.42***	.46***	.49***	.40***	.46***
	5. Early word reading	.39***	.47***	.63***	.68***		.88***	.72***	.77***	.56***	.65***	.66***
	6. Single word reading	.40***	.40***	.49***	.67***	.90***		.54***	.72***	.58***	.63***	.53***
6½ years old	7. Early word reading	.28**	.44***	.68***	.61***	.81***	.67***		.78***	.54***	.54***	.81***
	8. Single word reading	.35***	.45***	.55***	.64***	.90***	.87***	.84***		.77***	.71***	.70***
	9. Nonword reading	.32***	.41***	.55***	.65***	.80***	.76***	.75***	.88***		.61***	.51***
	10. Spelling	.27**	.40***	.55***	.63***	.84***	.81***	.76***	.86***	.75***		.45***
	11. Reading comprehension	.49***	.58***	.55***	.56***	.83***	.78***	.79***	.87***	.80***	.78***	

Note. Control group is above the diagonal; family-risk group is below the diagonal.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A2. Proportion of variance explained (R^2) for each outcome variable in the longitudinal path model.

	Control	Family-Risk
Storybook exposure	.19	.23
Oral language at age 5	.15	.15
Phoneme awareness at age 5	.04	.10
Emergent decoding at age 5	.06	.06
Word-level literacy at age 6	.65	.67
Reading comprehension at age 6	.67	.74