Author(s): Torppa, Minna; Eklund, Kenneth; van Bergen, Elsje; Lyytinen, Heikki

Title: Parental literacy predicts children's literacy: A longitudinal family-risk study

Year: 2011

Version:

Please cite the original version:

Torppa, M., Eklund, K., van Bergen, E., & Lyytinen, H. (2011). Parental literacy predicts children's literacy: A longitudinal family-risk study. Dyslexia, 17(4), 339-355. https://doi.org/10.1002/dys.437

PARENTAL LITERACY PREDICTS CHILDREN'S LITERACY: A LONGITUDINAL FAMILY-RISK STUDY

Torppa, M., Eklund, K., van Bergen, E., Lyytinen, H. (2011). Parental literacy predicts children's literacy: A longitudinal family-risk study. *Dyslexia, 17,* 339-355.

Abstract

This family-risk (FR) study examined whether the literacy skills of parents with dyslexia are predictive of the literacy skills of their offspring. We report data from 31 child-parent dyads where both had dyslexia (FR-D) and 68 dyads where the child did not have dyslexia (FR-ND). Findings supported the differences in liability of FR children with and without dyslexia: the parents of the FR-D children had more severe difficulties in pseudoword- reading and spelling accuracy, in rapid word recognition, and in text-reading fluency than the parents of the FR-ND children. Finally, parental skills were found to be significant predictors of children's Grade 3 reading and spelling. Parental skills predicted children's reading and spelling accuracy even after controlling for children's preschool skills. Our findings suggest that the literacy skills of a parent with dyslexia might be valuable in assessing early on their child's liability to dyslexia.

Keywords: Dyslexia, Reading, Spelling, Family risk for dyslexia, Longitudinal study

Reading disability or dyslexia runs in families (e.g., Hallgren, 1950; DeFries & Gillis, 1993; Lyytinen et al., 2008; Olson & Byrne, 2005). Prospective family-risk (FR) studies where the development of children born to families with at least one parent with dyslexia is followed from early on, have demonstrated that FR children show a wide range of language and literacy problems, even prior to school entry (e.g. Elbro et al., 1998; Gallagher, Frith, & Snowling, 2000; Scarborough, 1990; Torppa et al., 2007a, 2007b). However, not all children with family risk for dyslexia face reading difficulties. In prospective studies of FR, depending on the diagnostic criteria applied, up to 66% of FR children are reported as dyslexic (e.g. Pennington & Lefly, 2001; Puolakanaho et al., 2007; Snowling, Gallagher, & Frith, 2003; van Bergen, de Jong, Plakas, Maassen, & van der Leij, in press). Studies comparing FR children with dyslexia (FR-D) and without dyslexia (FR-ND), demonstrate that FR-D children show poorer performance on numerous language and literacy skills at different ages than their FR-ND counterparts (Pennington & Lefly, 2001; Snowling, et al., 2003; Snowling, Muter, & Carroll, 2007; Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010; van Bergen, et al., in press; van Bergen, de Jong, Regtvoort, Oort, van Otterloo,& van der Leij, 2011). In addition to family risk, phonological awareness, RAN, and letter knowledge are relatively good predictors of dyslexia as early as age 3.5 years of age (e.g. Puolakanaho et al., 2008). This study aims to predict children's skill even earlier by examining whether we can predict FR children's liability for dyslexia from the skills of the parent with dyslexia. To be able to offer an FR child extra support when necessary, it is important to be able to assess their liability early on.

Of the studies reporting comparisons between FR children with and without dyslexia, only three have included examination of parental skills. Snowling et al. (2007) found no link between the skills of parents and their children whereas van Bergen et al (2011; in press) did and

consequently, replication is warranted. The two studies involving Dutch samples suggested that parental skills can predict children's liability for dyslexia in FR samples: the affected parents of children with dyslexia showed poorer performance than the affected parents of children without dyslexia in word- and pseudoword reading (van Bergen et al., 2011) and in word-reading and rapid automatized naming (RAN; van Bergen et al., in press). The present study compares a Finnish sample of FR children with and without dyslexia and extends previous studies by including a prediction of children's continuous reading and spelling skills from parental skills. Dyslexia is a heterogeneous disorder at the levels of both phenotype (see e.g. Leinonen, Müller, Leppänen, Aro, Ahonen, & Lyytinen, 2001) and genotype (see e.g. Raskind et al., 2000) and our purpose therefore is to include a more fine-grained analysis rather than simple prediction of whether a child has dyslexia or not. Assessment of parental skills can provide important predictive information on their children's skills if children tend to develop similar kinds of difficulties.

Parental assessment could be a valuable resource for the design of early individually-tailored support programs, particularly if parental skills can predict children's reading and spelling over and above children's preschool skills. Consequently, our analysis also controls for children's preschool language and literacy skills. We control for five language and pre-literacy skills that have previously been shown to be related to subsequent reading development: letter naming, phonological awareness, RAN, verbal short-term memory, and vocabulary. Of these measures, the most consistent predictors of reading development are letter knowledge (e.g., Byrne, 1998; Gallagher, et al., 2000; Lyytinen, et al., 2006; Torppa, et al., 2006) , phonological awareness (e.g., Byrne, 1998; Gallagher et al., 2000; Pennington & Lefly, 2001; Snowling et al., 2003; Vellutino et al., 2004), and RAN (e.g. de Jong & van der Leij, 1999;

Georgiou, Parrila, & Papadopoulos, 2008; Landerl & Wimmer, 2008; Pennington et al., 2001; Puolakanaho et al., 2008; Scarborough, 1998; Torppa, et al., 2010). Association has also been found between reading and vocabulary development (e.g., Catts, Fey, Zhang, & Tomblin 1999; Lyytinen, Eklund, & Lyytinen, 2005; Nation & Snowling, 2004; Scarborough, 1990) and verbal short-term memory (e.g. Scarborough et al., 1998), possibly due to its overlap with phonological skills (Pennington, 1991).

Finally, we also examine the influences of environmental and motivational factors on reading and spelling development. It is of interest to examine whether the home environment factor or children's interest in reading would differentiate the FR children with and without dyslexia. Previously, it has been shown that variation in the learning environments at home, shared reading in particular, (e.g., Senechal & LeFevre, 2002; Torppa et al., 2007a), and in children's motivation (e.g., Lepola, Poskiparta, Laakkonen, & Niemi, 2005; Onatsu-Arvilommi, Nurmi, Aunola 2002; Wigfield; Eccles, & Rodrigues, 1998) are linked to language and literacy skills.

In the present study we aim to answer the following questions:

1) Do children's skills, parental skills, children's interest in reading, or home literacy environment, discriminate between the groups of FR children with and without dyslexia?
2) Do parental skills predict FR children's Grade 3 reading and spelling skills?
3) Do parental skills predict FR children's Grade 3 reading and spelling skills after accounting for children's skills prior to school entry?

Method

Participants

Participants were 99 families, each containing a parent with dyslexia (FR group). Children were followed from birth as part of the Jyväskylä Longitudinal Study of Dyslexia (JLD, e.g. Lyytinen et al., 2008). Parents with dyslexia reported a history of difficulties in learning to read. Their dyslexia status was confirmed through extensive individual assessment comprising reading, spelling, and phonological and orthographic processing (see Leinonen, et al., 2001). In addition, all FR-group parents reported a close family member(s) with reading and spelling problems.

Procedure and Measures

Parental assessment

The FR-group parents with dyslexia were assessed on tests of reading and spelling before the child's birth. When the children were between 3 and 6 years old, we invited the parents for reassessments to measure phoneme deletion, RAN, verbal short-term memory, block design, and vocabulary. Because we were not able to reassess all parents with dyslexia, the sample size for these measures is somewhat lower than for the reading and spelling measures (i.e., n = 79 vs. n = 99).

Text-reading accuracy and fluency. Parents were asked to read aloud two passages (218 and 128 words, respectively) as fluently and accurately as possible. A measure of reading accuracy was calculated from the total number of reading errors occurring across both texts, with reading fluency as the average reading time for the two texts (s). Cronbach's alpha for reading fluency was .97.

Pseudoword-reading accuracy. Parents were asked to read a list of 30 pseudowords comprising two to four syllables. There was no time pressure. The number of correct responses was used as the measure of pseudoword-reading accuracy.

Rapid (pseudo)word recognition. The task included 40 words and 12 pseudowords as target stimuli, which were presented for 80 ms on a monitor. Immediately after each stimulus, a backward-masking stimulus was presented. Participants were asked to read aloud both the target and the masking stimulus. The next stimulus was presented after a response or after a five-second period of silence – whichever occurred first. Each masking stimulus had as many letters (4, 6 or 8) and syllables (2 to 4) as the target stimulus. Half of the target-masking pairs consisted of words and the other half consisted of pseudowords. The number of correctly read target words/pseudowords was the measure of rapid word recognition, making the maximum score 52.

Spelling Accuracy. Parents were asked to spell to dictation 10 pseudowords (delivered via headphones) containing 7 to 11 letters and of 2 to 4 syllables. There was no time limit to complete the task and, if necessary, participants could listen to each stimulus twice. The amount of spelling errors in pseudowords was derived as the measure.

Phoneme deletion. Parents were asked to pronounce a given word without the second phoneme. The task included 16 words (e.g., kaupunki ‘city’ became kupunki) of 4 to 10 letters with 2 to 4 syllables. Deletion of the second phoneme yielded a pseudoword. Stimuli were presented via headphones. A new stimulus was presented after a response or after a 20-secondperiod of silence. The number of correct responses was calculated.

Rapid Naming (RAN). On each of three tasks, participants were asked to name, as rapidly as possible, a matrix of 50 items comprising objects, digits, or a mixture of digits, objects, and letters. In the parental assessment, stimuli were presented on a computer screen. Total naming

time (in seconds) was used as the score. A mean composite score of the three standardized RAN scores was calculated for the prediction analyses. Cronbach's alpha for the RAN composite was .86.

Verbal short-term memory. The Digit Span subtest of WAIS-III (Wechsler, 1991) was administered with the requirement to repeat strings of digits, increasing in length, in both the forward and reverse directions.. Two sets of items, one for forward, the other for reverse, were used. Scaled scores were derived from the manual.

Vocabulary. In the Vocabulary subtest of WAIS-III (Wechsler, 1991), participants were required to define 35 words in his/her own words. Scaled scores were derived from the manual.

Block Design. This subtest of WAIS-III (Wechsler, 1991) included nine items which involved putting sets of blocks together to match patterns displayed in a booklet. Scaled scores were derived from the manual.

Home literacy environment and children's reading interest

When the children were 4, 5, and 6 years old, parents were asked to complete the Reading Models Questionnaire, which included questions concerning various features of the home literacy environment and children's interests. See a more detailed description in Torppa et al. (2007a).

Shared reading. To produce a composite score of shared reading, we obtained parental report of both frequency and time spent on children's reading activities in the home. Two items assessed the frequency: How often 1) mother reads with the child, and 2) father reads with the child. Two items covered the amount of time spent with print materials: 1) the typical duration of a reading episode (i.e., the child reads with an adult), 2) the total time per day the

child spends reading a book with an adult. Shared reading composites were derived by calculating the mean of these four item scores.

Access to written language. The composite measure included six questions: three on library visits and one on membership of a book club, one on subscription to children's magazines, and one on the number of books at home.

Children's reading interest. Parents estimated their child's interest in various activities. Altogether, 11 different activities were listed. Of these, two concerned reading: 1) picture books and children's magazines, and 2) listening to storytelling. To estimate how interested a child was in reading compared to reported interest in general, we created an 'interest-preference score' by dividing the mean of the items concerning reading activities by the mean of the items concerning all listed activities.

Children's skill assessment

Children's letter knowledge was assessed at age 5 years, phonological awareness and vocabulary at age 5.5 years, and RAN objects and digit span at age 6.5 years. Reading and spelling were assessed in Grade 3 spring (mean age: 9.7 years). All assessments were conducted individually by trained testers.

Letter knowledge. Children named 23 capital letters presented one at a time. Testing always began by presenting the first letter of the child's first name. Subsequent letters were presented in the order in which letters are typically taught in Finnish schools. The number of correctly named letters was the letter knowledge measure.

Expressive vocabulary. The Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) contains 60 picture items which the child is asked to name. Testing is continued until six

consecutive errors are incurred. The score is the number of items that are spontaneously correct plus the number of items correctly identified following provision of a semantic stimulus cue.

Verbal short-term memory. Memory was assessed with forward and backward digit span (see Gathercole & Adams, 1994). The score was the number of correct repetitions.

Phonological awareness. Four measures of phonological awareness were assessed. The mean of the standardized scores formed the composite score. Cronbach's alpha for the composite score was .76. (1) *Segment identification*. The child was presented on a computer screen three pictures of objects with simultaneous pronunciation of the object's name The child was asked to identify the picture containing a specified sub-word level segment. The size of the segment to be identified varied from one to four phonemes (1-2 syllables). Segments came from the beginning, middle, or end of the word. There were 20 items. (2) *Blending*. The task was to blend segments into a word (e.g., *per-ho-nen* (butterfly)). The segments consisted of words, syllables, or phonemes. The segments were separated by 750 ms and were presented via headphones. One item consisted of a compound word, eight items required synthesis of syllables, and three items required the synthesis of syllables and phonemes. There were 16 items, and one point was awarded for each correct answer. (3) *Initial phoneme identification*. The child was shown four pictures of objects. Simultaneously, the object names were presented. Subsequently, a phoneme was given and the task was to select the picture of the object that starts with the phoneme. For examle: "Which word begins with /m/?". There were nine items, and one point was awarded for each correct answer. (4) *Initial phoneme production*. The experimenter showed a picture to the child and asked what she/he saw in the picture. Next, the child was asked to listen to the tester pronouncing the word and to articulate the initial sound. The number of correct initial sounds or

letter answers out of eight items formed the score. For details of the phonological tasks, see Puolakanaho, Poikkeus, Ahonen, Tolvanen, & Lyytinen (2003).

RAN of objects. Children were asked to name as rapidly as possible, a matrix of 50 items made up from five different pictures of objects: a car, a house, a fish, a pencil and a ball. All the Finnish names for these objects are two-syllabic high-frequency words. Total naming time (in seconds) was used as the score.

Pseudoword/word reading. Children read 20 (10 x three syllable, 10 x four syllable) pseudowords and 20 four syllable words presented successively on a computer screen. The number of correctly read words and pseudowords was used as a measure of pseudoword/word word -reading accuracy. In addition, the time from the appearance of the pseudoword/word to the end of articulation (i.e. reaction time + response duration) was used as a measure of pseudoword/word-reading fluency.

Text reading. Children read a short passage (189 words) presented on a sheet of paper. The text is part of a nationally standardized assessment battery (Lindeman, 2000). Children were instructed to read as quickly and accurately as possible. The percentage of correctly read words was used as a measure of text-reading accuracy. Furthermore, the average number of words read correctly per minute was used as a measure of text-reading fluency.

Reading pseudoword text. In Grade 3, children read aloud a short passage comprising 38 pseudowords. The pseudoword text was generated from a story text by replacing 0-3 letters inside syllables so that the words and structure of the sentences resembled real Finnish in form but had no meaning. The percentage of correctly read pseudowords was used as a measure of pseudoword-text accuracy. The amount of pseudowords read in one minute was the measure of pseudoword-text reading fluency.

Spelling accuracy. Spelling to dictation was assessed for 10 words and 24 pseudowords. All 34 items contained four syllables and were presented separately via headphones. The number of correctly written items was used as a measure of spelling accuracy. Cronbach's alpha was .71.

Word-list reading fluency. A nationally standardized reading test 'Lukilasse ' (Häyrinen, Serenius-Sirve, & Korman, 1999) was used as the fourth measure of reading fluency. The child was asked to read aloud a list of words of increasing difficulty, printed on a sheet of paper. The number of correctly read words within two minutes was transformed into a standard score according to the manual.

Results

The distributions of all measures were examined prior to analyses. Children's accuracy of text and pseudoword reading showed somewhat skewed distributions. There was, however, variation at the lower end of the distributions that we consider informative to the identification of dyslexia and consequently, the measures were included into analyses. A few outliers were identified in children's RAN-scores and also in parents' spelling, reading fluency, and reading accuracy. These outliers were moved to the tails of the distributions.

Group Comparisons of Children with and without Dyslexia

Table 1 reports the means and standard deviations and the ANOVA group comparisons of the FR-D and FR-ND groups for the child measures. The MANOVA group comparisons of both the Grade 3 measures ($F(8, 82) = 22.54$, $p < .001$, $\eta^2 = .69$) and preschool measures ($F(5, 86) = 6.16$, $p < .001$, $\eta^2 = .26$) indicated group differences. As expected, the measures used for diagnosis differed between the FR-D and FR-ND groups. With respect to preschool measures, the FR-D

performed poorer than FR-ND group in phonological awareness, RAN, verbal short-term memory, and letter knowledge. Their vocabulary, however, did not differ significantly.

Table 2 reports the means and standard deviations and the ANOVA group comparisons of the parental skills. The MANOVA group comparisons of parental reading skills ($F(5, 93) = 2.61$, $p < .05$, $\eta^2 = .12$) but not of cognitive skills ($F(7, 68) = 1.70$, $p > .05$, $\eta^2 = .15$) indicated group differences The affected parents of the FR-D group scored significantly lower than the parents of the FR-ND in pseudoword reading and spelling accuracy, in rapid word recognition, text-reading fluency, and vocabulary. There were no significant differences between the FR-D and FR-ND groups on parental text-reading accuracy, phoneme deletion, RAN, verbal short-term memory, or block design.

The MANOVAs comparing the home literacy environment at ages 4, 5, and 6 revealed no group differences in shared reading ($F(3, 88) = .79$, $p > .05$, $\eta^2 = .02$), access to print materials ($F(3, 87) = .63$, $p = .60$, $\eta^2 = .02$), or children's interest in reading ($F(3, 87) = .1.55$, $p > .05$, $\eta^2 = .05$). Because of the lack of significant group effects, no follow-up analyses were performed for these measures.

Prediction of Children's Skills

Next, we examined the associations between children's skills and parental skills in order to examine whether we could use the skill profile of the affected parent to predict that of the child. Note that for the correlations and regression analyses all scores were transformed so that higher scores correspond to better performance than lower scores.

Table 3 reports the correlations between the measures. Multiple stepwise regression analysis was used to predict children's skills from parental skills. Because text- and pseudoword-reading accuracy were slightly skewed, these were log-transformed prior to regression analyses.

Table 4 reports the regression analyses for the prediction of children's reading and spelling accuracy and Table 5 reports the results for reading fluency. All parental measures were entered using the stepwise method, which adds significant predictors one by one, starting with the strongest predictor.

The results show that between 10 and 25% of the variance in children's reading and spelling accuracy, and between 8 and 16% of the variance in children's reading fluency can be predicted by the skills of their parent with dyslexia. The strongest predictor of children's accuracy in text-reading, pseudoword reading, and spelling was parental spelling. The strongest predictor of children's pseudoword text accuracy was, however, parental pseudoword reading accuracy. The parental predictors of children's Grade 3 reading fluency (see Table 5), varied across measures. The strongest predictor of text-reading fluency was parental digit span, the strongest predictor of pseudoword text fluency was parental RAN, and the strongest predictors of list reading fluency were phoneme deletion and rapid word recognition. Pseudoword reading fluency was not significantly predicted by any of the parental measures.

Next, we examined whether parental skills predict children's reading and spelling, even after accounting for children's preschool skills. Regression analyses using the stepwise method were used with children's skills entered in Step 1 and parental skills in Step 2. The results for the accuracy and fluency measures are presented in Tables 6 and 7, respectively. Interestingly, the parental measures were significant predictors of the children's accuracy scores in text, pseudoword text, and spelling, but not in pseudoword-reading accuracy or any of the fluency measures, after controlling for the children's preschool skills. Letter knowledge at age 5 was the strongest predictor of all Grade 3 skills except pseudoword text-reading fluency, which was predicted only by children's RAN. After accounting for children's preschool skills, parental

spelling predicted children's Grade 3 spelling and text-reading accuracy and parental pseudoword-reading accuracy predicted children pseudoword text-reading accuracy.

Discussion

Although having a parent with dyslexia is a strong risk factor for dyslexia (e.g. Elbro et al., 1998; Pennington & Lefly, 2001; Puolakanaho et al., 2007; Snowling, et al., 2003; van Bergen et al., 2011, in press), not all children with a family risk (FR) develop dyslexia. The present study examined the possibility of using measures obtained from the parent with dyslexia to predict their children's skills. Group comparisons of children with and without dyslexia (diagnosed in Grade 3) showed firstly, that the FR children with dyslexia were impaired across all language and literacy skills prior to school entry. Secondly, FR-D group parents showed significantly poorer reading and spelling than FR-ND group parents. Third, the regression analyses showed that children's reading and spelling skills can be predicted by parental skills. Reading and spelling accuracy were predicted significantly by parental reading and spelling accuracy measures, even after accounting for children's language and literacy skills prior to school entry. Finally, there were no differences between the groups with and without dyslexia in gender of the child or the parent with dyslexia, parental education, home literacy environment, or in children's reading interest.

Our findings thus showed that the cognitive, reading, and spelling difficulties of the FR-D children were linked to their dyslexia status: the FR-D children were impaired across all literacy-related skills. Group differences in Grade 3 reading and spelling were expected by definition, and group differences in reading precursors (letter knowledge, phonological awareness, RAN, and verbal short-term memory) were consistent with previous findings of these measures being good predictors of reading development (e.g. Byrne, 1998; de Jong & van der

Leij, 1999; Pennington & Lefly, 2001; Puolakanaho et al., 2008; Snowling et al., 2003; Landerl & Wimmer, 2008). The FR-D and FR-ND groups did not, however, differ in vocabulary at age 5.5 years of age. This finding concurs with our previous findings in the same sample concerning the very early language development of children with and without dyslexia in Grade 2 (*AUTHORS*), but differs from the findings of Snowling et al. (2003) who showed that the FR children without reading disabilities had better oral language skills than the FR children with reading disabilities . They suggested that good oral language may have operated as a compensatory mechanism. The definition of reading disabilities in Snowling et al. (2003) was, however, based on a composite measure that also included comprehension, which may explain why there was a significant difference in vocabulary.

The comparison of reading and spelling skills of the affected parents of the FR children with and without dyslexia showed that the parents of the FR-D children were significantly poorer than those of the FR-ND children in pseudoword-reading accuracy, rapid word recognition, spelling accuracy, and text reading fluency. These parental differences indicate that the FR-D children have a higher liability for dyslexia than the FR-ND children, which is very interesting given that all of these parents have dyslexia. The FR-D and FR-ND group parents did not, however, differ to a significant degree in text reading accuracy, phoneme deletion, RAN, verbal short-term memory, vocabulary, or block design. Two previous studies have also found parental skill differences between FR-D and FR-ND groups: van Bergen et al. (in press) in word-reading fluency and RAN and van Bergen et al. (2011) in word- and pseudoword-reading fluency. The van Bergen et al. studies used a fluency-based dyslexia diagnosis, which may explain why they found differences only in parental fluency measures. In

contrast, in the present study, there were differences in both parental accuracy and fluency measures.

Our second and third questions concerned the prediction of children's reading and spelling from parental skills. The regression analyses showed that children's Grade 3 reading and spelling skills were significantly predicted by parental skills. Children's accuracy measures were predicted by parental accuracy measures, even after accounting for children's language and literacy skills prior to school entry. Children's fluency measures, on the other hand, were predicted by parent's cognitive skills and rapid word recognition. However, parental measures did not explain additional variance in children's reading fluency after accounting for children's preschool language and (pre)literacy skills. It is worth noting that knowing how well an expectant parent with dyslexia can spell ten pseudowords is predictive of their child's reading and spelling accuracy ten years later, even after controlling for children's phonological awareness, RAN, letter knowledge, verbal short-term memory, and vocabulary at age 5 to 6.5 (0-2 years prior to school entry). It should also be noted that these associations between the skills of the parents with dyslexia and their children are not likely to be due to differences in children's home environment or reading interest because the children with and without dyslexia did not differ on these variables. Overall, our findings suggest that the use of parental skills in families with a history of dyslexia may be of assistance when evaluating whether and which literacy difficulties their children may face. Early anticipation of children's liability for literacy difficulties may provide important opportunities to offer the children at highest risk preventive support programs to minimize the challenges during early school age (e.g. Lyytinen, Erskine, Kujala, Ojanen, & Richardson, 2009; Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2011).

Table 1

Descriptive Statistics of Children's Measures by Children's Grade 3 Dyslexia Status

	No Dyslexia			Dyslexia				
	n	*M*	*SD*	*n*	*M*	*SD*	ANOVA (*F*)	|*d*|
Preschool measures								
Phonological awareness 5.5 y								
Segment identification	65	13.34	3.47	30	11.30	2.09	9.50**	.71
Blending	64	6.45	2.48	29	5.38	2.41	3.79	.44
Initial phoneme identification	65	6.78	2.01	29	5.03	2.32	15.64***	.81
Initial phoneme production	63	2.98	2.81	26	1.31	2.02	8.03**	.68
Letter knowledge 5 y	66	11.03	8.05	30	4.37	4.22	17.56***	1.04
RAN objects 6.5 y (s.)	65	72.75	21.11	30	91.22	29.49	12.11**	.72
Verbal STM 6.5 y	67	5.49	1.31	30	4.50	1.33	12.33**	.75
Vocabulary 5.5 y	63	34.65	6.81	29	31.62	6.77	3.70	.45
Grade 3 accuracy								
Text reading accuracy (%)	63	95.77	2.93	30	85.01	7.58	97.31***	1.87
PW/Word-reading accuracy	62	29.11	5.20	28	18.50	5.89	73.84***	1.91
PW Text-reading accuracy	61	87.04	11.72	28	66.30	14.48	51.65***	1.57
Spelling accuracy	68	24.96	4.29	31	16.74	5.25	67.69***	1.71
Grade 3 fluency								
Text-reading fluency (s.)	68	156.77	45.71	31	256.91	80.44	61.99***	1.53
PW/Word-reading fluency (s.)	68	2.75	.68	31	3.67	1.02	28.18***	1.06
PW Text-reading fluency (s.)	63	34.40	10.59	29	26.95	9.00	10.78**	.76
List-reading fluency	68	9.87	2.32	31	5.16	2.10	92.98***	2.13

Note. $*p < .05$. $**p < .01$. $***p < .001$. PW = Pseudoword, STM = short-term memory, *d* = Cohen's *d* (absolute value)

Table 2

Descriptive Statistics of Parental Measures by Children's Grade 3 Dyslexia Status

	No Dyslexia			Dyslexia				
	n	*M*	*SD*	*n*	*M*	*SD*	ANOVA (*F*)	|*d*|
Reading and Spelling								
Text-reading accuracy	68	20.01	13.74	31	25.84	19.69	2.22	.34
Text-reading fluency (s.)	68	190.29	39.87	31	210.90	55.61	3.93*	.43
PW-reading accuracy	68	51.12	6.40	31	46.77	10.05	6.36*	.52
Rapid word recognition	68	19.90	11.07	31	12.94	12.51	7.75**	.59
Spelling accuracy	68	4.22	2.69	31	6.07	4.21	6.67*	.52
Cognitive Skills								
Phoneme deletion	53	9.45	2.00	24	8.25	2.82	3.78	.49
RAN objects (s.)	53	15.53	2.83	24	16.71	29.59	2.78	.41
RAN digits (s.)	53	10.13	2.66	24	10.76	24.19	1.49	.25
RAN mixed (s.)	53	14.08	3.71	24	14.82	26.99	.76	.23
Verbal STM	52	11.94	2.71	24	10.63	3.23	3.43	.44
Vocabulary	53	50.47	6.33	24	45.92	10.71	5.45*	.52
Block design	53	38.53	7.72	24	39.50	6.95	.28	.16

Note. $*p < .05$. $**p < .01$. $***p < .001$. PW = Pseudoword, STM = short-term memory, *d* = Cohen's *d* (absolute value)

Table 3

Pearson Correlation Coefficients between the Measures

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22
Grade 3 measures																						
1. Text-reading accuracy																						
2. PW/Word reading acc.	.61																					
3. PW Text-reading acc.	.63	.72																				
4. Spelling accuracy	.58	.68	.59																			
5. Text-reading fluency	.53	.57	.59	.50																		
6. PW/Word reading fluency	.48	.40	.50	.37	.63																	
7. PW Text-reading fluency	.29	.33	.25	.29	.59	.62																
8. List-reading fluency	.58	.64	.65	.62	.86	.64	.62															
Preschool measures																						
9. Phonological aw. 5.5 y	.33	.38	.31	.41	.35	.13	.22	.37														
10. Letter knowledge 5 y	.36	.48	.44	.50	.45	.27	.18	.46	.63													
11. RAN objects 6.5 y	.25	.34	.24	.36	.37	.24	.30	.39	.32	.46												
12. Verbal STM 6.5 y	.36	.36	.33	.40	.43	.20	.21	.36	.38	.40	.19											
13. Vocabulary 5.5 y	.13	.19	.10	.31	.15	-.09	.04	.21	.50	.44	.42	.30										
Parental measures																						
14. Text-reading accuracy	.21	.12	.12	.26	.08	-.09	.04	.18	.17	.19	.09	.14	.20									
15. PW-reading accuracy	.31	.29	.28	.35	.15	-.01	.02	.21	.22	.24	.06	.13	.11	.70								
16. Rapid word recognition	.14	.21	.20	.39	.20	.08	.14	.26	.08	.27	.05	.23	.16	.44	.42							
17. Spelling accuracy	.32	.25	.16	.33	.12	-.08	.02	.20	.34	.27	.02	.18	.23	.62	.65	.28						
18. Text-reading fluency	.16	.22	.21	.29	.08	-.04	.03	.19	.17	.18	.23	-.04	.12	.53	.56	.44	.39					
19. Phoneme deletion	.22	.28	.22	.37	.21	.00	.16	.33	.39	.30	.19	.05	.24	.49	.58	.21	.59	.41				
20. RAN composite	.18	.22	.16	.15	.22	.19	.29	.22	.26	.23	.25	-.07	.05	.42	.48	.20	.30	.51	.33			
21. Verbal STM	.12	.12	.18	.26	.31	.15	.16	.23	.26	.32	.21	.27	.32	.32	.50	.44	.34	.35	.32	.41		
22. Vocabulary	.27	.07	.15	.29	.08	.05	.05	.14	.14	.09	.14	.11	.17	.41	.38	.26	.37	.43	.19	.22	.22	
23. Block design	.12	.03	-.01	-.06	.13	.10	.14	.10	.07	-.01	-.03	.05	-.07	.03	.15	-.02	-.02	.11	.17	.25	.04	.23

Note. For all *r*s > .37, $p < .001$; all *r*s > .25, $p < .01$; and all *r*s > .22, $p < .05$.

Table 4

Summary of the Stepwise Regression Analyses with Standardized β Values for Parental Skills Predicting Children's Grade 3 Reading and Spelling Accuracy

	Children's skills							
	Text-reading accuracy		PW reading accuracy		PW text-reading accuracy		Spelling accuracy	
	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
Parent's skills								
Text-reading accuracy								
PW reading accuracy					.33**	.11**		
Rapid word recognition							.28*	.07*
Spelling accuracy	.39**	.16**	.31**	.10**			.34**	.18***
Text-reading fluency								
Phoneme deletion								
RAN composite								
Digit span								
Vocabulary								
Block design								
Final model R^2	.16		.10		.11		.25	
Final model *F(df)*	(1,70) = 12.86***		(1,74) = 8.09**		(1,72) = 8.55**		(2,73) = 11.72***	

*$p < .05$, **$p < .01$, ***$p < .001$.

Table 5

Summary of the Stepwise Regression Analyses with Standardized β Values for Parental Skills Predicting Children's Grade 3 Reading Fluency

	Children's skills					
	Text-reading fluency		PW text reading fluency		List reading fluency	
	β	ΔR^2	β	ΔR^2	β	ΔR^2
Parent's skills						
Text-reading accuracy						
PW reading accuracy						
Rapid word recognition					.22*	.05*
Spelling accuracy						
Text-reading fluency						
Phoneme deletion					.28*	.11**
RAN composite			.29*	.08*		
Digit span	.31**	.09**				
Vocabulary						
Block design						
Final model R^2	.09		.08		.16	
Final model *F(df)*	(1,74) = 7.58**		(1,72) = 6.46*		(2,73) = 6.86**	

Note. The variance of children's pseudoword-reading fluency variance was not explained significantly by any of the parental measures.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 6

Summary of the Stepwise Regression Analyses with Standardized β Values for Parental Skills Predicting Children's Grade 3 Reading and Spelling Accuracy

	Children's skills							
	Text-reading accuracy		PW reading accuracy		PW text-reading accuracy		Spelling accuracy	
	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
STEP 1: Children's skills								
Phonological awareness 5.5 y								
RAN 6.5 y								
Letter knowledge 5 y	.27*	.19***	.56***	.31***	.46***	.26***	.42***	.25***
Verbal STM 6.5 y	.22*	.05*						
Vocabulary 5.5 y								
STEP 2: Parent's skills								
Text-reading accuracy								
PW reading accuracy					.21*	.04*		
Rapid word recognition								
Spelling accuracy	.27*	.07*					.31**	.09**
Text-reading fluency								
Phoneme deletion								
RAN composite								
Digit span								
Vocabulary								
Block design								
Final model R^2	.31		.31		.30		.34	
Final model *F(df)*	(3,64) = 9.68***		(1,70) = 32.11***		(2,76) = 14.78***		(2,69) = 12.19 ***	

*$p < .05$, **$p < .01$, ***$p < .001$.

Table 7

Summary of the Stepwise Regression Analyses with Standardized β Values for Parental Skills Predicting Children's Grade 3 Reading Fluency

	Children's skills							
	Text-reading fluency		PW reading fluency		PW text-reading fluency		List reading fluency	
STEP 1: Children's skills	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
Phonological awareness 5.5 y								
RAN 6.5 y					.38**	.15**		
Letter knowledge 5 y	.46***	.30***	.43***	.19**			.57***	.32***
Verbal STM 6.5 y	.22*	.04*						
Vocabulary 5.5 y								
STEP 2: Parent's skills								
Text-reading accuracy								
PW reading accuracy								
Rapid word recognition								
Spelling accuracy								
Text-reading fluency								
Phoneme deletion								
RAN composite								
Digit span								
Vocabulary								
Block design								
Final model R^2	.34		.19		.15		.32	
Final model *F(df)*	(1,69) = 17.89 ***		(1,73) = 16.88 ***		(1,68) = 11.67**		(1,70) = 33.60***	

*$p < .05$, **$p < .01$, ***$p < .001$.

ACKNOWLEDGEMENTS

-

References

Byrne, B. (1998). *The foundation of literacy: The child's acquisition of the alphabetic principle*. Hove, UK: Psychology Press.

Catts, H. W., Fey, M. E., Zhang, X., & Tomblin, J. B. (1999). Language basis of reading and reading disabilities: Evidence from a longitudinal investigation. *Scientific Studies of Reading, 3*, 331-361.

DeFries, J.C., & Gillis, J.J. (1993). Genetics of reading disability. In R. Plomin & G. McClearn (Eds.), *Nature, nurture and psychology* (pp. 121-145). Washington, DC: APA Press.

de Jong, P. F., & van der Leij, A. (1999). Specific contributions of phonological abilities to early reading acquisition: Results from a Dutch latent variable longitudinal study. *Journal of Educational Psychology, 91*, 450-476.

Elbro, C., Borstrøm, I., & Petersen, D. K. (1998). Predicting dyslexia from kindergarten: The importance of distinctness of phonological representations of lexical items. *Reading Research Quarterly, 33*, 36-60.

Gallagher, A. Frith, U., & Snowling, M. J. (2000). Precursors of literacy delay among children at genetic risk of dyslexia. *Journal of Child Psychology and Psychiatry, 41*, 203-213.

Gathercole, S. E., & Adams, A-M. (1994). Children's phonological working memory: Contributions of long-term knowledge and rehearsal. *Journal of Memory and Language, 33*, 672-688.

Georgiou, G., Parrila, R., & Papadopoulos, T. C. (2008). Predictors of word decoding and reading fluency in English and Greek: A cross-linguistic comparison. *Journal of Educational Psychology, 100*, 566-580.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *RASE: Remedial & Special Education, 7*, 6-10.

Hallgren, B. (1950). Specific dyslexia ("congenital word-blindness"): A clinical and genetic study. *Acta Psychiatrica et Neurologica Scandinavia, 65*, Suppl., 1–287.

Häyrinen, T., Serenius-Sirve, S., & Korman, M. (1999). *Lukilasse*. Helsinki, Finland: Psykologien Kustannus Oy.

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *The Boston Naming Test* (2nd ed.). Philadelphia: Lea & Febiger.

Kirby, J. R., Georgiou, G., Martinussen, R., & Parrila, R. (2010). Naming speed and reading: From prediction to instruction. *Reading Research Quarterly, 45,* 341-362.

Landerl, K., & Wimmer, H. (2008). Development of word reading fluency and spelling in a consistent orthography: An 8-year follow-up. *Journal of Educational Psychology, 100*, 150-161.

Leinonen, S., Müller, K., Leppänen, P. H. T., Aro, M., Ahonen, T., & Lyytinen, H. (2001). Heterogeneity in adult dyslexic readers: Relating processing skills to the speed and accuracy of oral text reading. *Reading and Writing, 14*, 265-296.

Lepola, J., Poskiparta, E., Laakkonen, E., & Niemi, P. (2005). Development of and relationship between phonological and motivational processes and naming speed in predicting word recognition in grade 1. *Scientific Studies of Reading,* 9(4), 367-399.

Lindeman, J. (2000). *Ala-asteen lukutesti: käyttäjän käsikirja*. [The comprehensive school reading test]. Oppimistutkimuksen keskus, Turun yliopisto. [Center for Learning Research, Turku University].

Lyytinen, P., Eklund, K., & Lyytinen, H. (2005). Language development and literacy skills in late-talking toddlers with and without familial risk for dyslexia. *Annals of Dyslexia, 55*, 166-192.

Lyytinen, H., Erskine, J., Kujala, J., Ojanen, E. & Richardson, U. (2009). In search of a science-based application: A learning tool for reading acquisition. *Scandinavian Journal of Psychology*, 50, 668-675.

Lyytinen, H., Erskine, J., Ahonen, T., Aro' M., Eklund, K., Guttorm' T., Hintikka' S.,, Hämäläinen, J., Ketonen' R., Laakso, M-L., Leppänen' P.H.T., Lyytinen, P., Poikkeus' A-M., Puolakanaho' A., Richardson' U., Salmi P., Tolvanen, A., Torppa, M. & Viholainen, H. (2008) Early identification and prevention of dyslexia: Results from a prospective follow-up study of children at familial risk for dyslexia. In *The Handbook Dyslexia*, Reid, G., Manis. F., Siegel, L.,& A. Fawcett. Sage Publishers.

Lyytinen, H., Erskine, J., Tolvanen, A., Torppa, M., Poikkeus, A.-M., & Lyytinen, P. (2006). Trajectories of reading development: A follow-up from birth to school age of children with and without risk for dyslexia. *Merrill-Palmer Quarterly, 52*, 514-546.

Nation, K., & Snowling, M. J. (2004). Beyond phonological skills: Broader language skills contribute to the development of reading. *Journal of Research in Reading, 27*, 342-356.

Olson, R. K., & Byrne, B. (2005). Genetic and environmental influences on reading and language ability and disability. In H. Catts & A. G. Kamhi (Ed.), *The connections between language and reading disabilities* (pp. 173-200). Mahwah, NJ: Erlbaum.

Onatsu-Arvilommi, T., Nurmi, J. & Aunola, K. (2002). The development of achievement strategies and academic skills during the first year of primary school. *Learning and Instruction*, 12 (5).

Pennington, B. F., & Lefly, D. L. (2001). Early reading development in children at family risk for dyslexia. *Child Development, 72,* 816-833.

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P., Poikkeus, A., Tolvanen, A., Torppa, M. & Lyytinen, H. (2007). Very early phonological and language skills: estimating individual risk of reading disability. *Journal of Child Psychology and Psychiatry*, 48 (9), 923–931.

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P., Poikkeus, A., Tolvanen, A., Torppa, M. & Lyytinen, H. (2008). Developmental links of very early phonological and language skills to second grade reading outcomes. *Journal of Learning Disabilities, 41 (4),* 353-370.

Puolakanaho, A., Poikkeus, A.-M., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2003). Assessment of three-and-a-half-year-old children's emerging phonological awareness in a computer animation context. *Journal of Learning Disabilities, 36,* 416-423.

Raskind, W.H., Hsu L., Berninger, V.W., Thomson, J.B. & Wijsman, E.W. (2001). Familial aggregation of dyslexia phenotypes. *Behavioral Genetics,* 30, 385–395.

Saine, N. L., Lerkkanen, M.-K., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2011). Computer-assisted remedial reading intervention for school beginners at-risk for reading disability. *Child Development*, 82, 1013-1028.

Scarborough, H. S. (1990). Very early language deficits in dyslexic children. *Child Development, 61*, 1728–1743.

Scarborough, H. S. (1998). Predicting the future achievement of second graders with reading disabilities: Contributions of phonemic awareness, verbal memory, rapid serial naming, and IQ. *Annals of Dyslexia, 48,* 115-136.

Sénéchal, M., & LeFevre, J. (2002). Parental involvement in the development of children's reading skill: A five-year longitudinal study. *Child Development* 73, 445-460.

Snowling, M. J., Gallagher, A., & Frith, U. (2003). Family risk of dyslexia is continuous: Individual differences in the precursors of reading skill. *Child Development, 74,* 358-373.

Snowling, M.J., Muter, V., & Carroll, J. (2007). Children at family risk of dyslexia: A follow-up in early adolescence. *Journal of Child Psychology and Psychiatry,* 48, 609–618.

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities,* 43, 308–321.

Torppa, M., Poikkeus, A.-M., Laakso, M.-L., Eklund, K., and Lyytinen, H. (2006). Predicting delayed letter name knowledge and its relation to grade 1 reading achievement in children with and without familial risk for dyslexia. *Developmental Psychology*, 42(6), 1128-1142.

Torppa, M., Poikkeus, A., Laakso, M., Tolvanen, A., Leskinen, E., Leppänen, P., Puolakanaho, A. & Lyytinen, H. (2007a). Modeling the early paths of phonological awareness and factors supporting its development in children with and without familiar risk of dyslexia. *Scientific Studies of Reading*, 11 (2), 73-103.

Torppa, M., Tolvanen, A., Poikkeus, A-M. Eklund, K., Lerkkanen, M-K., Leskinen, E., & Lyytinen, H. (2007b). Reading Development Subtypes and Their Early Characteristics. *Annals of Dyslexia,* 57, 3-32.

van Bergen, E., de Jong, P.F., Regtvoort, A., Oort, F., van Otterloo, S., & van der Leij, A. (2011). Dutch children at family risk of dyslexia: Precursors, reading development, and parental effects. *Dyslexia, 17,* 2-18.

van Bergen, E., de Jong, P.F., Plakas, A., Maassen, B., & van der Leij, A. (in press). Child and parental literacy levels within families with a history of dyslexia. *Journal of Child Psychology and Psychiatry.*

Vellutino, F. V., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): what we have learned in the past four decades. *Journal of Child Psychology and Psychiatry, 45*, 2-40.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children - Third edition*. San Antonio, TX: The Psychological Corporation.

Wigfield, A., Eccles, J.S., & Rodrigues, D. (1998). The development of children's motivation in school contexts. *Review of Research in Education,* 23, 73-118.