Author(s): Torppa, Minna; Lyytinen, Paula; Erskine, Jane; Eklund, Kenneth; Lyytinen, Heikki

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Running head: Language development and literacy skills

Abstract

Discriminative language markers and predictive links between early language and literacy skills were investigated retrospectively in the Jyväskylä Longitudinal Study of Dyslexia in which children at familial risk for dyslexia have been followed from birth. Three groups were formed on the basis of 198 children's reading and spelling status. One group of children with reading disability (RD, n = 46) and two groups of typical readers from non-dyslexic control (TRC, n = 84) and dyslexic families (TRD, n = 68) were examined from age 1.5 years to school age. The RD group was outperformed by typical readers on numerous language and literacy measures (expressive and receptive language, morphology, phonological sensitivity, RAN, and letter knowledge) from 2 years of age onwards. The strongest predictive links emerged from receptive and expressive language to reading via measures of letter naming, rapid naming, morphology, and phonological awareness.

Keywords: dyslexia, longitudinal study, reading development, early language development

Reading ability requires the coordination of a number of component skills, each of which has developed over many years before reading skill itself can emerge. Several studies (e.g., Pennington & Lefly, 2001; Puolakanaho, Ahonen, Aro et al., 2007, 2008; Scarborough, 1990, 1998; Snowling, Gallagher, & Frith, 2003) confirm that school beginners who have weaker verbal abilities and literacy knowledge at an early age are much more likely to experience difficulties in learning to read than their classmates. The problems of disabled readers usually manifest as difficulties in the acquisition of basic reading sub-skills such as word identification and phonological (letter-sound) decoding (Vellutino, Fletcher, Snowling, & Scanlon, 2004). Previous findings have revealed that, the strongest early predictors of subsequent poor reading are phonological awareness and letter knowledge (e.g. Lyytinen, Aro, Eklund, et al., 2004; Pennington & Lefly, 2001; Puolakanaho et al., 2007)..In addition to phonological awareness and letter naming, also other early skills has been shown to differentiate poor readers from typically-achieving readers, such as rapid serial naming (e.g. DeJong & Van der Leij, 2003; Lyytinen, Erskine, Tolvanen, et al.,2006; Wolf, Bowers, & Biddle, 2000), vocabulary (e.g. Scarborough, 1990), verbal learning (e.g. Carroll & Snowling, 2004), verbal memory e.g. Lyytinen, Aro, Eklund, et al., 2004; Snowling et al., 2003), and pseudoword or non-word repetition (e.g. Lyytinen, Aro, Eklund, et al., 2004; Snowling et al., 2003; van Alphen et al., 2004).

Reading disability or dyslexia runs in families (e.g., Hallgren, 1950; DeFries & Gillis, 1993; Olson & Byrne, 2005) and by conducting a prospective study of children who are at high risk of dyslexia due to family history, we can effectively examine the role of oral language development in reading disabilities. Scarborough 's (1990) study was the first prospective dyslexia investigation in which English language development was followed from the age of 2.5 years until the age at which the children's reading status could be confirmed. In Scarborough's study, 65% of those children from families with genetic risk of dyslexia could be classified as reading-disabled by age 8. Syntactic and speech production abilities differentiated the groups at 2.5 years and vocabulary skills from 3 years onwards. By age 5, children who went on to receive a diagnosis of dyslexia had poor letter knowledge, and poorly developed phonological awareness and expressive language skills. The findings presented by Pennington & Lefly (2001), Puolakanaho et al., (2007, 2008), and Snowling et al. (2003) also showed that children born to dyslexic families have an increased risk of literacy problems and that delays in their language development predicts dyslexia diagnosis at school age. In this paper, we provide information on those language markers that can discriminate between Finnish-speaking children who later became reading disabled and typical readers, as early as 1.5 years of age up to school age. The earliest comparable prospective studies have reported predictive connections to reading acquisition from 2.5 (Scarborough, 1990, Lyytinen, Eklund, & Lyytinen, 2005 and Smith, Roberts, Smith, Locke & Bennett, 2006) or 3-4

(Pennington & Lefly, 2001; Puolakanaho et al., 2007, 2008; Snowling et al., 2003) years of age.

We included six language and literacy domains that have previously been shown to be related to reading development: letter naming, phonological sensitivity, morphological skills, rapid naming, receptive language, and expressive language. Since reading requires an ability to connect letters or graphemes to the sounds or phonemes of spoken language, it is not surprising that the most consistent predictors of reading development are letter knowledge (e.g., Byrne, 1998; Gallagher, Frith, & Snowling, 2000; Lyytinen, Erskine, Tolvanen, et al., 2006; Lyytinen, Ronimus, Alanko, & Poikkeus, 2006, Torppa, Poikkeus, Laakso et al., 2006) and phonological sensitivity.(e.g., Byrne, 1998; Gallagher et al., 2000; Pennington & Lefly, 2001; Snowling et al., 2003;Vellutino et al., 2004). The phonological deficit, which is widely tendered as a causal explanation for reading failure in individuals with dyslexia is thought to be a result of poorly specified phonological representations and processing skills whereby limitations are placed on the establishment of those mappings between letter strings and phonology that are critical for learning to read (e.g., Elbro & Jensen, 2005; Ramus, 2001; Snowling, 1998; Vellutino et al., 2004). There are, however also findings that phonological abilities are not necessarily the best or sole predictors of future reading ability among beginners in English (Scarborough, 2005). Likewise, this is not the case with transparent orthographies such as German, Italian or Finnish (Cossu, 1999; Lyytinen, Aro, Holopainen, et al., 2006; Ziegler, Perry, MaWayatt, Ladner, & Schulte-Körne, 2003) in which grapheme-phoneme correspondences are more consistent than in English (Seymour, Aro, & Erskine, 2003). In comparison to several other languages, Finnish is a purely phonemic orthography with full consistency between letters and phonemes in both directions (Aro, 2006). While 23 letter-sound associations suffice in Finnish, the comparable number of consistent associations (requiring varying sizes of units) is more than 1500 in English. The transparency of Finnish easily facilitates the acquisition of basic decoding skill. More than 1/3 of Finnish children read before they have received any formal instruction and more than 95 % easily acquire accurate reading skill during the first year of formal instruction at the age of 7 years (see e.g. Holopainen, Ahonen & Lyytinen, 2001). At the end of the second grade Finnish children with typical reading skills read relatively fluently and accurately any word or pronounceable nonword (Lyytinen, Aro, Holopainen et al., 2006). The difficulties in reading are not as salient in reading accuracy as they are in reading fluency. Consequently, it is not surprising that one of the strongest predictors of reading fluency in Finnish and other transparent languages is rapid serial naming, RAN (e.g. Holopainen, Ahonen, & Lyytinen, 2001; Korhonen, 1995; Puolakanaho et al., 2007, 2008, Wolf, 1984; Wolf & Bowers, 1999).

A number of researchers (Carlisle, 1995; Elbro & Arnbak, 1996; Mahony, Singson, & Mann, 2000) have suggested that, in addition to sensitivity to phonemes, sensitivity to the morphological structure of a language is also an important factor in reading acquisition. Despite the interesting connections shown in this domain, the role played by morphological skills as predictive indicators of reading acquisition has, to date, received comparatively little attention (e.g., Egan & Pring, 2004; Fowler & Liberman, 1995; Joanisse, Manis, Keating, & Seidenberg , 2000; Lyytinen & Lyytinen, 2004; Shu, McBride-Chang, Wu, & Liu, 2006). Finnish morphology is agglutinative in nature with very rich and complex sequential inflections and frequent stem variations (Lyytinen &

Lyytinen, 2004; Lyytinen, Aro, Holopainen, et al., 2006) - the proficiency of which is associated with word reading and writing skills in the early school years (Müller & Brady, 2001). Many of the morphological variations of the same words in Finnish often differ only by one phoneme (e.g., the inflections of the word talo (house) include forms such as talo*ssa* (in house) and talo*sta* (from house). In order to be able to use such inflections, children must have accurately specified phonological representations. Most of the children already have an implicit ability to manipulate such small phonological units by age 3 when they have acquired basic inflectional skills (Lyytinen & Lyytinen, 2004).

Association has also been found between vocabulary development and reading skills (e.g., Scarborough, 1990). The acquisition of new words induces children to process phonological sub-lexical units. This means that the lexicon is constantly restructured as a result of increasing vocabulary and growing awareness of the phonological similarities between words gained through experience with spoken language (Metsala & Walley, 1998). The role of receptive language is worthy of special attention, at least when the language skills of the children with familial risk of dyslexia are examined. Our previous findings (Lyytinen, Eklund, & Lyytinen, 2005) showed that late-talking toddlers (especially those belonging to a dyslexia risk group whose language development was delayed in both expressive and receptive language) performed at a significantly lower level than the controls, both on oral reading and spelling, as well as in reading comprehension when assessed at the end of second grade. Receptive language has earlier been proposed as a central precursor to reading disability (Lyytinen et al., 2003) on the basis of the observed role played by early speech perception (Richardson, et al. 2004) and speech processing in the brain (Leppänen, et al., 2004; Guttorm et al.,

(2005) in relation to word reading development, as followed in the Jyväskylä Longitudinal Study of Dyslexia (JLD).

The present paper adds to previous findings in three ways. Firstly, extending the retrospective analysis of early language development to the very early age of 1.5 years, secondly, by including morphological skills into the exploration of central reading fluency predictors, and thirdly, in the incorporation of a large sample of children (n = 198) learning a very transparent language. Two questions were addressed. First, what are the language markers which discriminate children who, at the end of the 2nd grade, were diagnosed as disabled readers from those who become typical readers and second, what predictive paths exist between language development and literacy skills among Finnish-speaking children?

METHOD

Participants

Participants were 198 children followed from birth in the Jyväskylä Longitudinal Study of Dyslexia (JLD). The families of this study were recruited with the help of maternity clinics of Central Finland. The children of the dyslexic families were born to families where one or both parents (plus one other close relative) were diagnosed as reading disabled. Parental risk status was confirmed with extensive individual assessment comprising reading/spelling, phonological and orthographic processing (see Leinonen et al., 2001). Information for the children's gender and IQs in the different age phases, and parents' dyslexia status and education are presented in Table 1.

<Table 1 here>

Language measures at 1.5, 2 and 2.5 years

Parents reported on their children's language skills at 1.5, 2, and 2.5 years by using the Finnish toddler version (Lyytinen, 1999) of the MacArthur Communicative Development Inventories CDI; (Fenson et al., 1994). The CDI provided information on the child's vocabulary production and maximum sentence length. The vocabulary score was computed from a 595-item checklist containing words from 20 semantic categories. The CDI also offered a good context in which to assess proficiency of inflectional morphology. Parents were asked to write down three of the longest utterances they had heard their child make recently. The scoring of these utterances was based on the mean number of morphemes. For example, the Finnish equivalent of the English expression "in our houses” would be talo/i/ssa/mme (house/plural marker/inessive case/possessive suffix) and contains four morphemes.

Children were also administered the Reynell Developmental Language Scales (RDLS; Reynell & Huntley, 1987) at 1.5 and 2.5 years. The RDLS provides separate measures of receptive and expressive language. In the verbal comprehension items at the age of 1.5 years the child was presented with an array of stimulus materials and asked to identify the specified object by pointing or picking it up (e.g., ”Which one is carrying something?”) or by responding with specified actions (e.g., ”Take two buttons out of the cup”). At the age of 2.5 years items with more demanding request were addedd (e.g. ”show me the *longest red* pen on the board”). Epressive languge included items from naming objects (e.g. cup, spoon, car) to describing concepts (e.g. ”Please, tell me all you know about the word *book*”) and pictures (e.g. ”Please, tell me what happens in this picture”).

Language measures at 3.5 years

Expressive language was assessed using the Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983). The Finnish version of the BNT contains 60 pictured items (in the order of mean difficulty) which the child is asked to name. Testing is continued until six consecutive errors are incurred. The score is based on the total number of items that are spontaneously correct plus the number of items correctly identified following a semantic stimulus cue.

Inflectional morphology was measured with the 20-item Berko-type test (Lyytinen & Lyytinen, 2004) that covers items of adjective inflection (comparative and superlative), verb inflection (present) and noun inflection (elative; i.e., from something). The test words were old, obsolete Finnish words which were unfamiliar to the children but adhered to the phonotactic rules of Finnish. The items were presented orally together with a colourful drawing and the child was instructed to generate the inflection of the target word. Scoring examined whether the child used the target word, what suffix was used and whether there were errors in the stem. Cronbach Alpha reliability for the BNT was .60 and .80 for the test of inflectional morphology.

Receptive language was measured with the Comprehension of Instruction sub-test belonging to the Developmental Neuropsychological Assessment by Korkman, Kirk and Kemp (1998; NEPSY). This was administered to assess the child's ability to process and respond quickly to verbal instructions of increasing complexity. The subtest involves a stimulus booklet with pictures of rabbits that vary in size, colour and facial expression. For each item, the examiner asks the child to point to the rabbit that matches the oral description (e.g., "Show me the rabbit that is big and blue and happy"). Cronbach Alpha reliability for this test was .62.

Phonological sensitivity was assessed at age 3.5 years with the subtest belonging to the NEPSY test by Korkman et al. (1998). Part A (14 items) was administered to assess the child's ability to identify a whole word from a part-word. Picture cards, each containing three pictures which were named by the experimenter (e.g., "pankki" (bank), "karkki" (candy) and "kortti" (card) were shown once only to the child with the instruction to identify the picture containing the target word's part (e.g. "kar"). Cronbach Alpha reliability for this test was .60.

Letter naming. Children were asked to name 16 capital letters in large font, each singly presented in a fixed series with the exception of presentation of the first letter representing the first letter of the child's own name. Letter names and/or sounds were coded as correct responses.

Rapid Serial Naming of objects (Denckla & Rudel, 1976) was administered in short form to the children (5 stimuli by 6 times random matrix). Children were instructed to name the objects as fast as possible without making errors, beginning with the top row and continuing to the bottom. Total matrix completion time (seconds) was used as a measure.

Language measures at 5 and 5.5 years

Expressive language was reassessed using the Boston Naming Test at 5.5 years.

Inflectional Morphology was reassessed at 5 years with the supplement to the assessment at 3.5 years of two inflectional forms (adverb and past tense; 10 items). Cronbach Alpha reliability for the inflectional morphology test was .91 and for the BNT was .78.

Receptive language was assessed at 5 years using the Peabody Picture Vocabulary Test-Revised (PPVT-R) (Dunn & Dunn, 1981) and the Comprehension of Instruction sub-test of the NEPSY (Korkman et al., 1998). Cronbach Alpha reliability for PPVT was .79.

Phonological sensitivity was assessed in the 5.5 year old children using parts A and B of Korkman's Developmental Neuropsychological Assessment (1998; NEPSY) Part B assessed the child's ability to identify and eliminate word segments at the syllabic-and phoneme levels (e.g. “Say the word “työ” (work) without |t|”, correct response “yö” (night)) . If the child asked, the items were repeated once.

Letter naming. Letter naming at age 3.5 years was supplemented at age 5.5 years to include an additional 8 capital letters. *Rapid Serial Naming* of objects (Denckla & Rudel, 1976) was re-administered at 5.5 years with similar methodology to the 3.5 year assessment.

Measures of reading at the end of 2nd grade

Reading skills were measured with *four separate lists* (three- and four-syllable words and non-words (10 items/ list, totalling 40 items) and *two oral text reading tasks* (a meaningful story, 124 words and a non-word story, 19 words). Word lists were presented in written form on the computer screen and the child was asked to read aloud one word at time. Reading fluency and accuracy were assessed separately for each word item in the list. Accuracy was scored as the number of correctly read items while fluency was computed as the mean response time (reaction time + response duration) to separately-presented and correctly-read items. The texts were printed on separate papers and the reading of each story was recorded. Percentage correct for words and non-words was used as a measure of accuracy. The score of fluency (read words and non-words/minute) was calculated by dividing the number of words and non-words read by the time spent reading. The children were also administered *the standardized Reading Test Lukilasse* (Häyrinen, Serenius-Sirve, & Korkman, 1999). This involved reading aloud a list of words of increasing length and difficulty. A standardised fluency score was derived as a function of the number of correctly-read items within a two-minute time period.

Spelling was assessed by asking the child to write four-syllable words (6 items) and non-words (6 items). Targets were presented via headphones twice before spelling (with one additional repetition at the child's request). Additional 6 four-syllable non-words were presented only once with no further repetition. The number of correctly written words was calculated separately from each of the three six-item lists, and the mean number of correctly-written items was used as an accuracy measure. Cronbach Alpha reliability for the composite score of literacy skills was .87.

Classification based on reading and spelling scores

The criteria for reading group classification were the following: (1) A cut-off point was calculated using the 10^{th} percentile of the JLD control group's performance on each of the eight above-mentioned outcome measures (word reading accuracy and speed, text reading accuracy and fluency, nonword text reading accuracy and fluency, Lukilasse word list reading fluency, and spelling accuracy). A child was considered to have deficient skills on each respective task if the score fell on or below the 10^{th} percentile. (2) To be classified with reading disability, the child's skills were at or below the 10^{th} percentile either a) on at least three of four accuracy or at least three of four fluency measures, or b) on two accuracy measures and on two fluency measures. Three groups were consequently formed from the reading and spelling data at the end of the second grade when the children's age varied between 8 and 9 years (M = 8 years 11 months, SD = 4 months). From the application of these criteria, the number of children with reading disability (RD) from dyslexic (n = 37, 35 %) and control families (n = 9, 10 %) and typical readers (TRC) from control (N = 84) and dyslexic (TRD) families (N = 68) resembled that of previous estimates by e.g. Pennington & Lefly (2001).

Exclusion criterion

An exclusion criterion of standard score below 80 in both Performance and Verbal IQ (WISC-III-R; Wechsler Intelligence Scale for Children, Wechsler, 1991) was applied to all participants**.** No subjects were excluded according to the exclusion criteria described above. The group comparisons of the Verbal and Performance IQ assessed at the different age phases (see Table 1) revealed that the average performance of the RD group on the Bayley Mental Development Index (Bayley, 1993) fell significantly below that of typical readers at age 2 ($F(2,186) = 6.44$, $p = .002$), on the Verbal quotient of the WPPSI-R (Wechsler, 1989) at 5 years ($F(2,191) = 12.76$, $p = .000$), and on the Verbal IQ of the WISC III (Wechsler, 1991) at 8.5 years ($F(2,191) = 6.70$, $p = .002$). In addition, at 8.5 years, the RD group performed less well than the TRC group on the WISC-III Block Design ($F(2,192) = 3.22$, $p = .042$). Outcomes on the Bayley Physical Development Index at 2 years, the Performance quotient at 5 years and other non-verbal subtests (except Block design at 8.5 years) did not discriminate between the groups. In the group comparisons, the contribution of the Performance IQ at age 8.5 years (selected here as the most reliable Performance IQ assessment) was controlled using covariance analyses (ANCOVA and MANCOVA).

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RESULTS

Reading and spelling outcomes by Groups

The means and standard deviations of the reading and spelling scores of the three Groups are presented in Table 2. One-way ANOVAs showed highly significant differences for all measures of reading accuracy and fluency. Dunnett T3 was deployed for paired comparisons because homogeneities of variances were unequal. Comparisons revealed that the children with reading difficulties (RD) scored significantly lower than the typical readers from the non-dyslexic (TRC) and dyslexic families (TRD) on all eight reading and spelling tasks. No significant differences were found between the TRC and TRD Groups. The effect sizes measured by Cohen's d (Cohen, 1988, with pooled standard deviation) were large for both Group comparisons varying from 1.17 to 2.57 between the RD and the TRC and from 1.18 to 2.36 between the RD and TRD groups (see Table 4). In both Group contrasts, the largest effect sizes occurred for the Standardized reading test Lukilasse (fluency of word list reading).

<Table 2 here>

Group differences in language and literacy skills

The means and standard deviations of language and literacy measures derived at five age points (1.5, 2-2.5, 3.5, 5-5.5 and 8.5 years) are presented in Table 3. The MANCOVA (controlling WISC III PIQ at age 8.5 years) Group comparisons were followed by univariate ANCOVA comparisons (controlling WISC III PIQ at age 8.5 years) on each measure. Effect sizes for Group contrasts were assessed using Cohen's 'd' (see Table 4).

<Table 3 here>

<Table 4 here>

MANCOVA of the language measures of 1.5 -year-old children revealed only one significant ($p < .05$) main effect (Wilks' Lambda criterion) of Group (see Table 3) but no significant main effect for the PIQ ($F(4,177) = 1.21$, p=.308). In Reynell Expressive, the RD group showed significantly lower scores than the typical readers. However, the p-value of both of the CDI measures, vocabulary production and maximum sentence length, fell just below the significance level (.063 and .051, respectively). All effect sizes between the Group contrasts of the RD, TRC and TRD were in the small or just in the medium range at this age (see Table 4).

MANCOVA of the language measures of 2-2.5 -year-old children revealed significant main effects of Group ($F(12,372) = 1.98$, $p = .025$) and also for the PIQ ($F(6,186) = 2.49$, p=.024). In the univariate ANCOVA analyses, significant Group effects were found for CDI Vocabulary production at 2 years, CDI maximum sentence length at 2 and 2.5 years, and Reynell Receptive score at 2.5 years, with the RD group showing lower scores than the other groups after controlling for the effect of Performance IQ (see Table 3). Effect sizes for the comparisons between RD and TRC groups were in the medium range on all measures except for Reynell Expressive score and CDI vocabulary production (see Table 4). Medium effect sizes were also found between the RD and TRD for vocabulary production at 2 years and for maximum sentence length at 2.5 years.

The MANCOVA of the language measures for 3.5-year-old children revealed significant main effects of Group ($F(12,372) = 3.11$. p=.000) and for the PIQ ($F(6,186) = 4.18$, p=.001). The univariate ANCOVA analyses revealed significant effects of Group for inflectional morphology, Boston Naming Test, phonological sensitivity, rapid naming and letter naming, with the RD group performing at a lower level than the TRC (see Table 3). Effect sizes for the RD and the TRC contrasts were in the medium range on all measures but RAN and for the RD and TRD contrast on letter naming tasks (see Table 4).

The MANCOVA of the language measures for 5-5.5 -year-old children revealed significant main effects of Group (F(14,346) = 3.82. p=.000) and for the PIQ (F(7,173) = 4.31, p=.000). The univariate ANCOVAs showed significant effects of Group for all language measures, with the RD group performing at a lower level than the TRC group (see Table 3). Effect sizes for the RD-TRC contrast were large on phonological sensitivity, rapid naming and letter naming tasks and in the medium range on other tasks. Medium effect size was found in the rapid naming and large effect size in letter naming tasks also for the RD and the TRD contrast (see Table 4).

Predictive paths of early language skills to reading accuracy and fluency

To investigate the developmental relations between children's language development and literacy skills, a longitudinal path model for measures from 2 years until second grade was constructed using Mplus 5.0 (Muthén & Muthén, 2004) with all children (n = 198). The reading groups were combined in this analysis to increase statistical power. The paired group differences in correlations among the 15 variables were tested (McNemar, 1969) and of the 315 comparisons only 23 were found significant. The comparisons showed that the within group correlations between the outcome reading measure and the predictors were similar in all groups. In the RD group, however, the RAN measures were not as strongly correlated with other language measures as they were in the TRC and

TRD groups. In addition within the TRC group the correlations among the vocabulary and phonological sensitivity measures were not as strong as among the other two groups. These differences are interesting and need further examination in larger datasets. However, because the differences were rather weak and rare and because of the strengths provided by the use of path modelling, we continued the analysis with the combined data. Path modeling allowed us to construct a model of the longitudinal connections among all assessed skills and to test the significance of all predictive paths simultaneously (that is, a series of simultaneous regression analyses). For the path model, a new composite variable of the 2 to 2-5 years expressive language was constructed by calculating the mean of the Reynell expressive scale at 2.5, CDI production at 2 and 2.5, and the maximum length of utterance at the 2 and 2.5 year assessments. The Reynell receptive scale at 2.5 years of age was included into the model as a receptive language measure. At the 3.5 and 5-5.5 years' phases, receptive language was measured by Comprehension of instructions (sub-test of the NEPSY) and expressive language by the Boston naming test.

In the path modeling, we used a specific hierarchical estimation strategy to have stringent rules for obtaining unidirectional paths. That is, we first estimated the across-time paths between variables within each construct with repeated measurements. For the second step, we estimated the correlations between the variables across the constructs within age phase. Third, we estimated the across-time-across-domains paths. All statistically non-significant paths and covariances were removed within each step one by one, starting with the one with the closest to zero *t* value. The maximum likelihood with robust standard error estimation was used to estimate the paths. The final model fitted the data well ($\chi^2(65) = 66.41$, $p = .43$, RMSEA = .01, CFI = 1, TLI = 1). The standardized estimates of the final model are represented in Figure 1. By multiplying the standardized estimates by themselves, one obtains the percentage of explained variance of each predictor.

<Fig. 1 here>

The path model showed clearly the close relationships of the language measures across time already from the age of 1.5 years. Of the 2 – 2.5 years measures, receptive language made the widest contribution to other language skills. The largest effect of the early receptive language was found for the prediction of inflectional morphology at 3.5 years of age (.59 * .59 = 35 % of the variance explained). The early expressive language composite predicted expressive language, receptive language and letter naming at 3.5 years.

At 3.5 years, the close relationships among language measures were still evident. Receptive language was correlated with expressive language, phonological sensitivity and letter naming. In addition, phonological sensitivity correlated with inflectional morphology and letter naming. Whereas receptive language at age 2.5 had a wide impact on the 3.5 year olds' measures, its associations at age 3.5 to subsequent skills were limited to 5 year olds' receptive language, expressive language and inflectional morphology. Expressive language now made a wider contribution and it predicted all measures except inflectional morphology. Letter knowledge at 3.5 was connected to 5 year olds' letter naming, phonological sensitivity and RAN. Phonological sensitivity and RAN at 3.5 had a small but significant effect on 5 year olds' receptive language performance. The cross domain effects varied between 1 % and 12 % of variance explained.

At age 5 – 5.5 years, five modest correlations were found: Expressive language correlated with receptive language, inflectional morphology, and letter naming. Receptive language correlated with inflectional morphology and letter naming with phonological processing. Four direct early predictors of reading accuracy and fluency were identified; letter naming, rapid naming, inflectional morphology, and phonological sensitivity. Of the 5 to 5.5 year olds' measures, letter knowledge predicted 11.6 %, rapid naming 3.6 %, morphology 1.7 %, and phonological sensitivity 1.2 % of the variance in 2^{nd} grade reading accuracy and fluency. In addition, receptive and expressive language were also indirectly connected to reading skills through letter naming and inflectional morphology. In total, 25,8 % of the variance in 2^{nd} grade reading accuracy and fluency was predicted by this path model.

DISCUSSION

The goal of this study was to examine which early language markers discriminate between children who later became disabled readers and typical readers and to identify the existence of predictive paths between language development and literacy skills among Finnish-speaking children. Three groups of children were formed on the basis of their reading accuracy and fluency task performance at the end of 2nd grade (children with reading disability (RD), and two groups of typical readers, those from at-risk families (TRD) and those from the control families (TRC)) and their language development was followed from age 1.5 years until school age. As in previous retrospective analyses of language development in children with familial risk of dyslexia (Pennington & Lefly, 2001; Puolakanaho et al., 2007, 2008; Scarborough, 1990, 1998; Snowling et al., 2003), our results revealed a broad and consistent pattern of oral language impairment in children who later face reading disability.

The age of 1.5 years was too early to identify reading-related language difficulties (see also Westerlund, Berglund and Erikson, 2006). Note, however, that brain measures (event-related potentials to speech stimuli) recorded at age 3-5 days in the JLD data showed significant correlations to reading-related language development and early reading acquisition (Guttorm, et al., 2005). At 2 years of age, typical readers outperformed the group of children with reading difficulties (RD) in showing more mature expressive language (TRD and TRC groups) and accompanied by longer maximum sentence lengths (only TRC). From 2.5 years onwards, all measures except expressive language at age 2.5 differentiated the RD group from the TRC group.

Differences between the two groups of children with familial risk of dyslexia (RD and TRD) were more subtle than those between RD and TRC, supporting the notion of dyslexia as a continuous phenomenon. When early language and literacy development is considered, the typical readers from families with dyslexia (TRD) outperformed the reading disabled children (RD) on only 6 of the 23 tasks. At least medium effect sizes were obtained for the contrast between RD and TRD on Vocabulary production at 2 years, maximum sentence length at 1.5 and at 2.5, rapid naming at 3.5 and at 5.5, and letter naming at 3.5 and at 5.5 years. It should be noted, however, that the contrast between the typical reading groups (TRD and TRC) showed only small effect sizes meaning that the typical readers resembled each other, irrespective of whether they came from dyslexic or non-dyslexic families. That is, although the results of the TRD group fell in between the RD and TRC groups, there were no significant differences between these two typical reading groups. Scarborough (1990) reported similar findings. Also, when the reading accuracy and fluency tasks at 2nd grade were considered, the performance of typical readers from dyslexic families was similar to typical readers of the control group, rather than the other children from dyslexic families.

Even though all of the assessed language skills differentiated the RD group from typical readers, the path analysis showed that only letter knowledge, rapid naming, inflectional morphology, and phonological processing were direct predictors of a reading accuracy and fluency composite. The effects of the tasks of receptive and expressive language tapping mainly vocabulary were indirect. Similar findings of the indirect effects from vocabulary to reading have also previously been reported (e.g. Cooper, Roth, Speece, & Schatschneider, 2002; Torppa, Poikkeus, Laakso et al., 2007). Receptive measures, particularly at a very early age and expressive measures particularly at 3.5 years, appear to tap the skills necessary to boost development of the acquisition of complex language skills, such as the ability to inflect words, or sensitivity to the phonological structure of spoken language.

From all of the early assessments (2 -2.5 years), receptive language contributed most to subsequent development. The strongest direct connection, shown by receptive language at 2.5 years, was to inflectional morphology at 3.5 years. We concur with Bates and Goodman (2001) that emergence of grammar is highly dependent upon vocabulary size. At a later age, the direct predictive links from receptive language were smaller in size and limited to expressive and receptive language and to inflectional morphology.

The path model revealed how both expressive and receptive language skills are also associated with the development of naming fluency at different stages of language development. Among Finnish readers, compromised naming fluency is a direct predictor of the most common reading problems, ie., fluent reding. In order to attain ability to read demanding texts with comprehension a sufficient fluency must be achieved. The present results are consistent with the earlier findings showing that dysfluent naming is a reliable predictor of persistently slow reading among Finnish readers (Korhonen, 1995) and complement our own previous findings concerning the predictive role of early delays of language development (P. Lyytinen et al., 2005) according to which, both reading fluency and reading comprehension developed more poorly among children who were late talkers, especially if the delay in receptive language co-occurred with that of expressive language.

The importance of letter knowledge and rapid naming in relation to reading acquisition has been well known for many years (e.g., Pennington & Lefly, 2001; Snowling et al., 2003; Manis, Seidenberg, & Doi, 1999; Vellutino et al., 2004; Wolf, 1984; Wolf & Bowers, 1999) and consequently, their role as predictors and discriminators was no surprise. The best predictor of reading accuracy and fluency at 2nd grade was letter knowledge at age 5. In a transparent and consistent language such as Finnish, knowledge of the letter names almost parallels text decoding itself because the initial sound of these letter names consistently corresponds to the associated phoneme. Thus, knowledge of the sounds of letters facilitates accurate reading (phoneme by phoneme) of almost any word (irrespective of its familiarity) and this is what most Finnish first-graders are able to achieve before the end of the first semester of reading instruction. Had the reading measure been solely one of reading fluency, then RAN would probably have shown a stronger predictive association to the reading composite.

By taking into account the agglutinative nature of the Finnish language which contains a large number of exceptional inflections that are comprehended by children by school entry age, then children should be very oriented towards the details of spoken language in order to contrast words with very small (single phonemic) differences. Such an orientation to small phonemic variations makes the connection between Inflectional morphology and reading accuracy and fluency understandable. The connection between morphological skills and reading has also been reported earlier, both in our Finnish sample (Lyytinen & Lyytinen, 2004; Lyytinen, Aro, Holopainen, et al., 2006a) and in other languages (Carlisle, 1995; Egan & Pring, 2004; Elbro & Arnbak, 1996; Fowler & Liberman, 1995; Joanisse et al., 2000; Mahony et al., 2000; Shu, McBride-Chang, Wu, & Liu, 2006). In the present analyses, morphological skills played a dual role as a significant discriminator of the RD group and typical readers at 3.5, and 5, and as a significant predictor of reading accuracy and fluency composite in the path model. The path model also supported our theoretical expectation about the association between inflectional skills and phonological sensitivity which show co-development at age three years (a time when Finnish children show their fastest development of inflectional skills). This association between morphological skills and later reading is in line with findings reported by Silven, Poskiparta, Niemi and Voeten (2007) using a different sample of Finnish children.

The role played by phonological sensitivity was rather small in our analysis (predicted only 1.2 % of variance in reading accuracy and fluency composite) in contrast to what could be expected on the basis of previous literature (e.g., Byrne, 1998; Gallagher et al., 2000; Pennington & Lefly, 2001; Puolakanaho et al., 2007, 2008; Snowling et al., 2003;Vellutino et al., 2004). This may follow from the fact that the phonological sensitivity data was based on the results provided by one test (NEPSY by Korkman et al., 1998 chosen because of its wide availability), which deals with larger than single phoneme sized units. Phonological sensitivity also shares variance with the other, stronger, language predictors of reading accuracy and fluency (Puolakanaho et al., 2007, 2008), which in part explains the rather low unique prediction power in the regression calculations. It was also interesting that phonological sensitivity at age 5 years was not predicted by phonological sensitivity at age 3.5 years. Instead, the growth of letter knowledge supported the development of phonological sensitivity. This is easy to understand in the context of direct and consistent connections between letters and phonemes in Finnish. Phonological sensitivity did discriminate the groups well at both 3.5 and 5.5 years, with the RD group obtaining lower scores than the typical readers of the control group.

Overall, our analyses support the notion that early language development forms the basis of the development of reading accuracy and fluency. This is in keeping with earlier analyses by e.g. Scarborough (1990), Smith, Roberts, Smith, Locke and Bennett (2006) and also by ourselves (Lyytinen et al., 2005; for the most recent extensive review of the JLD-results, see Lyytinen, Erskine, Ahonen, et al., in press) using different methodological means. Because manifestation of dyslexia has been widely examined from the perspective of children learning to read in English, it was interesting to ascertain that the markers of dyslexia and the predictors of literacy skills were more similar than different among Finnish and English-speaking children, whose languages are, however, quite opposite in terms of their orthographies. Orthographic differences appear predominantly to emerge, not in predictors of reading skill per se, but in the rate of reading acquisition and in the characteristics of typical reading difficulties exhibited by children in various languages (Aro, 2006). Because of the low burden exerted by highly regular writing systems such as Finnish on children learning to read, we may presuppose that any reading difficulties observed among readers of such orthographies must represent the core problems associated with reading acquisition. Therefore, the predictors are also likely to represent developmental markers which play a core role - independent of the complexity of the writing system.

As with previous analyses, it should be noted that the predictive path model of the present study shows a distribution spanning a wide variation in skill - from impaired to advanced performance. In such data, for some individuals or sub-groups of individuals, it is probable that there are unnaturally strong developmental difficulties within the confines of relatively narrow skill sectors (see Lyytinen, Erskine, Tolvanen, et al., 2006). Such a narrow developmental deficit may, however, be critical for the acquisition of reading skill. For example, seriously compromised receptive skills (observable in a relatively small sub-group) may play an important role in hindering reading acquisition. One of its direct influences may be via perceptual difficulties associated with the differentiation of phonemes from each other. This is fundamental to the learning of phoneme-letter connections (see Lyytinen et al., 2007) in the initial stage of reading acquisition.

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Table 1. Demographic information for parents and their children with and without dyslexia

	Disabled readers (RD) from dyslexic and control families		Typical readers (TRC) from control families	Typical readers (TRD) from dyslexic families
Number of children	37	9	84	68
Gender boys: girls	18:19	6:3	46:37	34:34
Number of cases with dyslexic				
mother	17	0	0	36
father	19	0	0	30
both parents	1	0	0	2
Education[a)]				
mother	3.93 (1.51)		4.57 (1.31)	4.33 (1.48)
father	3.60 (0.90)		3.82 (1.46)	3.73 (1.41)
Children's IQs [a)]				
Bayley MDI (2 years)	95.73 (11.64)		103.16 (12.26)	103.61 (13.00)
Bayley PDI (2 years)	97.33 (12.54)		98.31 (10.71)	101.13 (11.33)
WPSSI-R [a)]				
VIQ (5 years)	98.74 (14.06)		112.29 (11.81)	107.79 (17.71)
PIQ (5 years)	100.23 (16.31)		102.28 (13.10)	102.25 (13.89)
WISC-III [a)]				
VIQ (grade 2)	94.41 (9.87)		101.72 (11.16)	101.10 (11.72)
PIQ (grade 2)	97.15 (13.53)		103.21 (13.45)	100.81 (11.89)

[a)]Note: Means and standard deviations (in parenthesis)

Table 2. Reading and spelling outcome scores by groups at the end of the second grade

Measures	Reading disability group (RD) from dyslexic and control families		Typical readers (TRC) from control families		Typical readers (TRD) from dyslexic families			
	Mean	SD	Mean	SD	Mean	SD	F[a]	Paired comparisons
Reading Accuracy								
Word and Nonwords	30.24	5.43	36.86	2.29	36.15	2.84	58.72***	RD< TRC,TRD
Meaningful Text	85.76	9.84	94.74	4.60	94.57	3.74	37.20***	RD< TRC, TRD
Nonword Text	61.90	20.37	85.48	10.53	83.37	14.60	41.13***	RD< TRC, TRD
Reading Speed								
Words and Nonwords [b]	4.25	1.78	2.28	0.59	2.40	0.47	66.12***	RD< TRC, TRD
Meaningful Text [c]	32.24	14.85	73.41	21.86	67.19	19.86	68.14***	RD< TRC, TRD
Nonword Text [c]	17.67	6.58	34.40	11.71	31.27	8.70	45.66***	RD< TRC, TRD
Lukilasse: Standardized Reading Test	5.22	1.87	11.04	2.60	10.38	2.47	93.82***	RD< TRC, TRD
Spelling Accuracy								
Words and Nonwords	8.74	5.09	14.70	2.43	14.28	2.73	52.21***	RD< TRC, TRD

[a]The degrees of freedom vary between 2,186 and 2,190 because of missing data on the single measures

[b]Mean duration for individual words/nonwords

[c]Words/minute

*** $p < .001$

Table 3. Group means, standard deviations, and ANCOVA results for language measures

Measures	Reading disability group (RD) from dyslexic and control families		Typical readers (TRC) from control families		Typical readers (TRD) from dyslexic families		ANCOVA
	Mean	SD	Mean	SD	Mean	SD	F [a)]
1.5 years							
Vocabulary Production (CDI)	39.56	47.34	73.26	80.52	70.38	79.21	2.81
Maximum Sentence Length (CDI)	1.28	0.72	1.87	1.51	1.88	1.44	3.02
Reynell Receptive	14.28	5.38	15.50	5.55	15.74	5.45	0.77
Reynell Expressive	10.02	2.95	11.83	4.42	12.10	4.33	3.13*
2 years							
Vocabulary Production (CDI)	198.76	135.63	285.49	160.19	296.24	159.04	5.31**
Maximum Sentence Length (CDI)	4.40	2.32	5.92	3.01	5.36	2.53	3.50*
2.5 years							
Vocabulary Production (CDI)	403.53	144.39	461.77	105.64	443.31	137.51	2.62
Maximum Sentence Length (CDI)	7.12	3.35	9.02	3.18	8.99	3.72	3.20*
Reynell Receptive	34.20	5.27	37.86	5.76	36.64	6.80	3.82*
Reynell Expressive	32.52	7.22	34.41	6.10	34.46	6.31	0.88
3.5 years							
Comprehension of Instruction	10.39	3.55	12.17	3.38	11.95	3.55	2.77
Inflectional Morphology Test	11.42	7.01	16.76	8.14	14.49	8.75	5.22**
Boston Naming Test	16.20	5.05	20.49	5.78	18.10	5.86	6.47**
Phonological sensitivity, NEPSY	5.44	3.22	7.47	2.76	6.60	2.86	7.07**

Rapid Naming (time)	80.66	28.65	68.32	23.86	69.45	21.45	4.31*
Letter Naming	0.36	1.04	3.00	4.70	2.70	4.16	5.97**
<u>5 years</u>							
Peabody Picture Vocabulary Test	62.32	22.39	76.44	21.44	68.56	27.21	4.74*
Inflectional Morphology Test	43.13	20.09	57.29	16.59	50.93	17.32	7.55**
<u>5.5 years</u>							
Comprehension of Instruction	17.69	2.84	19.58	2.62	18.65	2.99	4.46*
Boston Naming Test	32.02	6.66	36.30	5.42	34.15	6.84	5.60**
Phonological sensitivity, NEPSY	10.42	2.20	12.45	2.85	11.59	3.35	4.97**
Rapid Naming (time)	54.25	17.16	41.69	8.44	44.68	14.76	11.53***
Letter Naming	7.22	6.47	15.73	6.18	13.37	8.04	17.27***

[a)] The degrees of freedom vary between 2, 180 and 2, 191 because of missing data on the single measures

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

Table 4. Effect sizes (Cohen's d's with pooled standard deviations) for group comparisons

Measures	RD vs TRC d	RD vs TRD d	TRC vs TRD d
1.5 years			
Vocabulary Production (CDI)	0.51	0.47	-0.04
Maximum Sentence Length (CDI)	0.50	0.53	0.01
Reynell Receptive	0.22	0.27	0.04
Reynell Expressive	0.48	0.56	0.06
2 years			
Vocabulary Production (CDI)	0.58	0.66	0.07
Maximum Sentence Length (CDI)	0.57	0.40	-0.20
2.5 years			
Vocabulary Production (CDI)	0.46	0.28	-0.15
Maximum Sentence Length (CDI)	0.58	0.53	-0.01
Reynell Receptive	0.66	0.40	-0.19
Reynell Expressive	0.28	0.29	0.01
3.5 years			
Comprehension of Instruction	0.51	0.44	-0.06
Inflectional Morphology Test	0.70	0.39	-0.27
Boston Naming Test	0.79	0.35	-0.41
Phonological sensitivity	0.68	0.38	-0.31
Rapid Naming (time)	-0.47	-0.44	0.05
Letter Naming	0.78	0.77	-0.07
5 years			
Peabody Picture Vocabulary Test	0.64	0.25	-0.32
Inflectional Morphology Test	0.77	0.42	-0.38
5.5 years			
Comprehension of Instruction	0.69	0.33	-0.33
Boston Naming Test	0.70	0.32	-0.35
Phonological sensitivity	0.80	0.41	-0.28
Rapid Naming (time)	-0.93	-0.60	0.25
Letter Naming	1.35	0.84	-0.33
2nd Grade			
Word and Nonword reading accuracy	1.59	1.36	-0.28
Meaningful Text, reading accuracy	1.17	1.18	-0.04
Nonword Text, reading accuracy	1.45	1.21	-0.17
Words and Nonwords, reading speed	-1.49	-1.42	0.22
Meaningful Text, reading speed	2.20	1.99	-0.30
Nonword Text, reading speed	1.76	1.76	-0.30
Lukilasse: Standardized Reading Test	2.57	2.36	-0.26
Spelling Accuracy	1.49	1.36	-0.16

Note. TRC = Typical readers from control group, RD = Reading disability group, and TRD = Typical readers from dyslexia at-risk group. Effect sizes ≥ .5 have been underlined

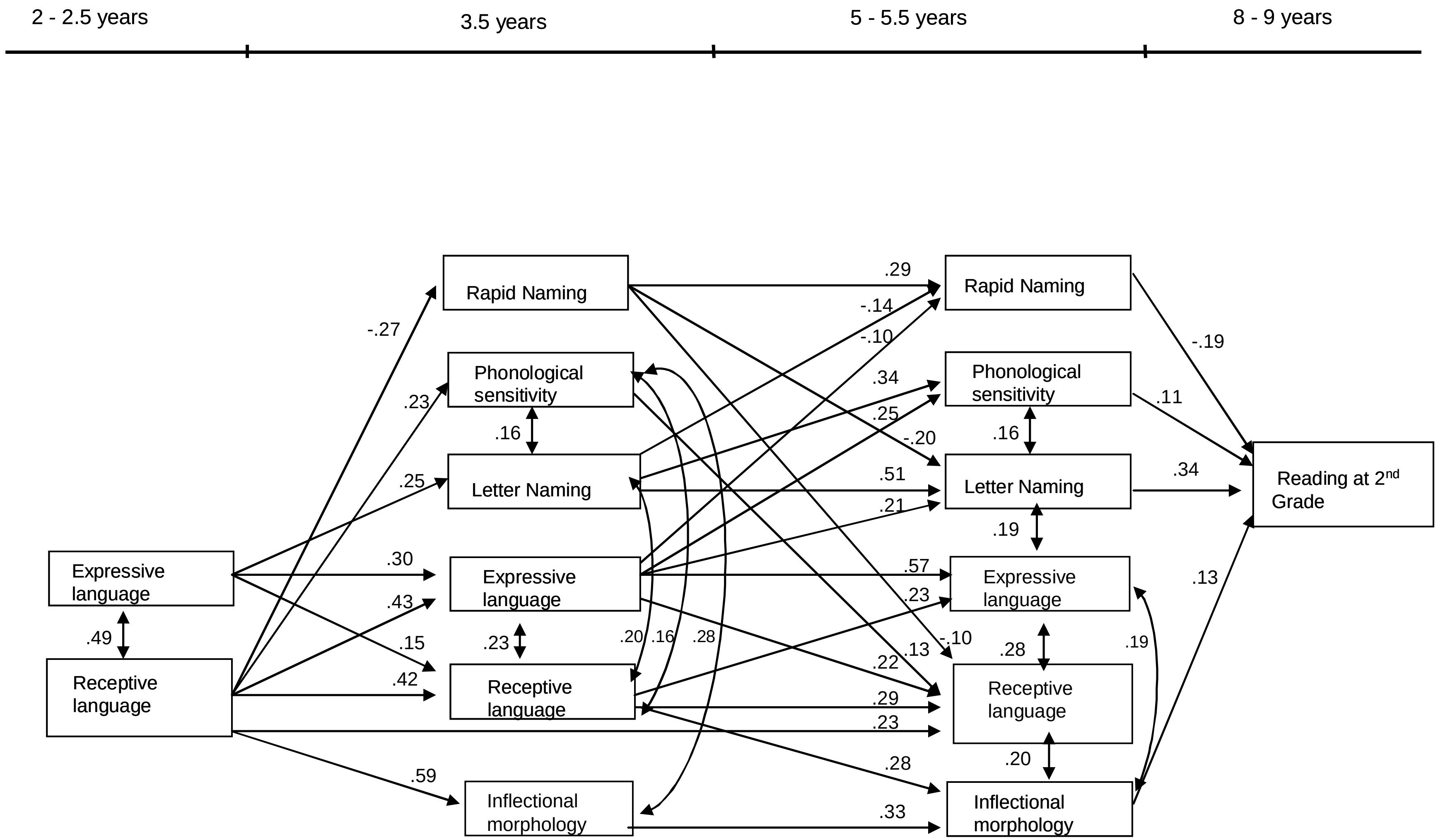

Figure 1. The longitudinal path model with standardized estimates.