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Reading and emotional-behavioural development in Finnish children: a longitudinal study of associations

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Abstract

Poor reading has been linked to negative outcomes on a wide range of emotional-behavioural dimensions in children. However, little is known about the time course of these associations. In this study we analyse data from a sample of Finnish children (N = 199; 106 boys) which included measures of reading fluency in grade 1 (age 7 or 8), and emotional (anxiety, depression, and somatization) and behavioural (adaptability, aggression, attention, atypicality, hyperactivity, social skills, and withdrawal) development at ages 4, 5, 6 (pre-school) and 9 (school-aged). In a series of stepwise regression models that controlled for non-verbal IQ and family risk for dyslexia, we tested if pre-school emotional-behavioural measures were associated with school-aged reading fluency, and whether school-aged reading fluency was associated with later emotional-behavioural development. We also tested if these associations were moderated by reported gender. Consistent with previous longitudinal studies, we found that poorer attention before school was associated with poorer reading in the early school years which in turn was associated with higher levels of anxiety and inattention in children in middle school. None of these associations were moderated by gender.

Keywords Reading · Anxiety · Emotional health · Psychosocial development · Children

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Introduction

In literate countries around the world, a proportion of children have "persistent and unexpected difficulty in developing age- and experience-appropriate word reading skills" (Parrila & Protopas, 2017). This difficulty has had many names including developmental dyslexia, reading difficulty, reading impairment, or simply poor reading. In English, children can struggle with various word reading skills. They can find it hard to learn grapheme-phoneme correspondences (GPCs), to apply GPCs to read new words, to commit whole written words to memory, or read words fluently (Friedmann & Coltheart, 2018). It is noteworthy that most children with poor reading struggle with more than one of these skills (McArthur et al., 2013; Stuart & Stainthorp, 2015).

In Finnish, children with poor reading can struggle with the same word reading skills as in English. However, the number of children who struggle with learning and applying GPCs is much lower because Finnish orthography is much more transparent than English. That is, all written words in Finnish can be read accurately by learning and applying 29 single letter GPCs and one bigraph along with a few other phonotactic rules. As a result, most Finnish children can read new and known words and pseudowords accurately after just a few months of school. Thus, Finnish children with poor reading present primarily with difficulties in reading words and texts fluently (Aro & Wimmer, 2003; Eklund et al., 2015).

Traditionally, studies of poor reading have focused on possible causes, diagnostic assessment, and effective intervention. However, there is growing interest in the relationships that may exist between reading difficulties and emotional and behavioural development (hereafter "emotional-behavioural development") across the lifespan (for just a few examples, see Aro et al., 2024; Fishstrom et al., 2024; Li et al., 2024; Kargiotidis & Manolitsis, 2024; McArthur et al., 2024; Mekonnen et al., 2024; Vieira et al., 2024).

Studies have taken a variety of approaches including correlational and longitudinal approaches. The latter can provide stronger evidence for causal associations, though these should still be interpreted cautiously. To our knowledge, four studies have used seven longitudinal datasets to measure the strength of the relationships between reading ability and emotional-behavioural development before and after the onset of reading instruction. The earliest study (McGee et al., 1986), used a retrospective analysis of data for 476 English-speaking boys in New Zealand at ages 5, 7, 9, and 11 who were assessed for word reading skills at ages 7 and 11, and their emotional health (generalised anxiety, worry, depression) and behaviour (impulsivity, inattention, hyperactivity, antisocial, aggression) at all time-points. Using Bonferroni corrections, they found that boys with poor reading at age 7 had more behavioural problems (hyperactivity and aggression) at age 5 than typical readers. This was not the case for emotional problems for boys with poor reading at age 7 or 11. However, some differences would have emerged if the authors had used more powerful Holm-Bonferroni corrections leading to some ambiguity in the results.

It was 10 years before the next longitudinal study. Sanson et al. (1996) reported the results of a retrospective analysis of word reading and comprehension, and

emotional and behavioural development (a wide range of measures at different time points) provided by English-speaking Australian children and their families from birth to 7–8 years. The children were categorised as having poor reading (N = 36), poor behaviour (N = 41), poor reading and poor behaviour (N = 37), or no problems (typically developing; N = 42) at 7–8 years. At age 1–3 years the group with poor reading were rated as more difficult on a toddler temperament scale but not on other behavioural measures (a composite of crying, sleep problems, overactivity, dependency, temper tantrums, shyness, accident proneness, and mood swings) than typically developing children. At 3–4 years and 5–6 years, there were no longer differences between groups for any emotional or behavioural variables. These findings suggest that very early emotional development—but not behavioural development—may be related to later reading difficulties.

In 2015, Parhiala et al. did a retrospective longitudinal analysis of emotional (anxiety, depression and somatization), and behavioural (attention, hyperactivity, conduct, adaptability, social skills) factors in 199 Finnish-speaking children aged 4, 6, 8, and 9 in the Jyväskylä Longitudinal Study of Dyslexia (JLD; see Methods for more information). They found that children who struggled with word and non-word reading accuracy or fluency in grade 2 (N = 39) had poorer scores at age 4 and 6 years for three types of behaviour (attention, adaptability, social skills), but no aspects of emotion, compared to children with typical reading (N = 131). Of the earlier differences, only attention persisted at age 9. These results join those of McGee et al. in suggesting that problems with attention may both precede and follow from reading problems.

The first three studies all took a retrospective, group-comparison approach. McArthur et al. (2022) conducted the only general population correlational longitudinal analyses of reading and emotional-behavioural scores of English-speaking children around the time that they started reading instruction (i.e., ages 5–6, 7, and 9–11). They used data from four large-scale longitudinal datasets that all included measures of reading (word reading accuracy), emotion (anxiety, depression, poor reading self-concept) and behaviour (peer relationships, conduct, attention): the Millennium Cohort Study (N = 7870), the Early Childhood Longitudinal Study 1998 (N = 8001) and 2011 (N = 7160), and the Early Language in Victoria Study (N = 768). In line with McGee et al. (1986) and Parhiala et al., (2015), the results suggested that only early attention (age 5) was related to reading (age 7), while reading (age 7) was related to a number of facets of emotion (anxiety, depression, reading self-concept) and behaviour (attention, conduct, peer relations), at age 9. Poorer reading was also associated with being subject to more bullying behaviours by their peers.

In sum, the weight of evidence provided by previous longitudinal studies suggests that before children go to school, one aspect of their early behaviour—attention—consistently relates to their later reading ability at school (found in 6 of the 7 datasets), while reading in school is related to numerous aspects of later emotional (anxiety, depression, peer relationships—found in 4 of the 5 datasets with relevant measures) and behavioural problems (attention and hyperactivity in all 5 of the 5 datasets with relevant measures). It is important to note that while this evidence is not entirely unequivocal (cf. Sanson et al., 1996 who did not find an association

between early attentional difficulties and later reading), the preponderance of the evidence suggests these factors are the most closely associated with reading.

It is also important to note that one previous longitudinal study included gender in their retrospective analysis (Parhiala et al., 2015). The results indicated that one type of behaviour (social skills) improved in Finnish-speaking boys with reading problems (N = 19) but not girls with reading problems (N = 20) after starting school, while another type of behaviour (inattention) deteriorated in girls with reading problems (but not boys) after starting school. Though they did not report any significant interactions in their analysis, the means plots suggest that this may have been due to the power needed to for three-way interactions in the retrospective group-comparison design. The possibility that gender moderates the associations between reading and behavioural-emotional development finds some support in a cross-sectional study by Willcutt and Pennington (2000) who found a stronger association between reading difficulties and (1) behaviour (attention, hyperactivity, aggression) for 8-to-18-year-old English-speaking boys (n = 215) than girls (n = 186); and (2) emotional health (depression, somatic complaints, withdrawal) for girls than boys. Consistent with the latter result, Wang (2021) reported that reading difficulty was more closely associated with emotion (anxiety) in Mandarin-speaking girls (N = 29) than boys (N = 37) in grades 3–5. However, Ramirez et al. (2019) found that reading was more closely associated with emotion (reading anxiety) in English-speaking boys (N = 277) than girls (N = 330) in grades 1–2; and Parhiala et al. (2015) found a stronger relationship between reading difficulties and one type of emotion (somatic complaints) in Finnish-speaking boys (N = 132) than girls (N = 65 girls) aged between 7 and 13. To complicate these finding even further, at least three studies have failed to find an effect of gender on the association between reading ability and various types of emotion (Carroll et al., 2005; Hughes et al., 2013; Nelson & Gregg, 2012) or behaviour (Carroll et al., 2005; Hughes et al., 2013). Thus, the evidence for a moderating effect of gender on the relationships between reading and various emotional-behavioural measures is mixed – but it has yet to be examined in any longitudinal study treating reading ability as a continuous variable rather than dichotomously as poor vs typical reading (Nuzzo, 2019).

Aims and hypotheses

In sum, evidence from existing longitudinal analyses suggest that certain types of behaviour early in life—notably attention—may be related to later reading in early primary school, which in turn may be related to multiple aspects of later behaviour (attention, externalising behaviours, peer relationships) and emotion (depression, anxiety, reading self-concept) in middle primary. However, the strength of this evidence is limited by several factors. First, there remain only a small number of independent studies, particular with respect to the influence of reading performance on later emotional-behavioural development. Second, most studies have relied on retrospective group-comparisons which have less power for comparisons by dichotomizing continuous variables (Nuzzo, 2019). Third, with one exception (Parhiala

et al., 2015), studies to date have focused on children who speak English. With these limitations in mind, the current study had three aims.

Aim 1 was to determine if aspects of Finnish children's early emotion (anxiety, depression, somatization) or behaviour (attention, hyperactivity, atypicality, adaptability, aggression, social skills, withdrawal) at age 4, 5, and 6 years were related to their later reading ability in grade 1 (ages 7–8).[1] Given the results of previous studies, we predicted that certain aspects of behaviour at age 4–6 years—notably attention—would be related to reading in grade 1 (Kempe et al., 2011; McArthur et al., 2022; McGee et al., 1986; Parhiala et al., 2015; Sanson et al., 1996). This would not be the case for emotional factors.

Aim 2 was to determine if reading achievement in grade 1 in Finnish children was associated with later emotional and behavioural factors at age 9 years. The outcomes of previous research suggest that poorer reading scores at age 7–8 years would be related to certain types of emotion (i.e., anxiety and perhaps depression; Francis et al., 2019; McArthur et al., 2022; Ramirez et al., 2019) and behaviour (i.e., attention; McArthur et al., 2022; Parhiala et al., 2015). We could make no predictions about the remaining emotional (somatization) or behavioural (hyperactivity, atypicality, adaptability, aggression, social skills, withdrawal) factors since these have yet to tested individually in a relevant longitudinal study.

Aim 3 was to explore whether or not gender influences associations between poor reading and emotional-behavioural factors in early years of development. As outlined above, only one longitudinal study has investigated this issue, and it produced mixed behavioural findings for boys (social skills increased after starting school) and girls (inattention increases after starting school). Similarly, the results of other correlational studies have produced mixed results around this question. Consequently, the existing evidence provides no clear guidance for what to expect for this aim.

Method

The JLD database

The JLD is a longitudinal study of 107 children from families with a history of reading difficulties (family-risk sample), and 92 controls matched on parental education level. This sample has provided data from infancy to early adulthood for a wide range of development outcomes relating to literacy, spoken language, emotion, behaviour, and physical development (see Lohvansuu et al., 2021, for details of all assessments and procedures). As outlined above, Parhiala et al. (2015) have already used data from the JLD to retrospectively compare the emotional and behavioural

[1] While the emotional-behavioural development scales were administered according to the children's age, the reading fluency assessments used here were evaluated in the spring of the children's grade 1 school year. Children in Finland enter school in the August of the calendar year they turn 7. Therefore, at the grade 1 spring assessment the students were either age 7 or 8. We will use grade 1 throughout the text for accuracy, but this can be read as "ages 7 or 8".

data of children with and without reading difficulties (assessed in grade 2). Though this approach is consistent with clinical settings where such group categorizations take place by necessity, dichotomizing continuous variables to create groups is known to reduce power (Nuzzo, 2019). Parhiala et al. also combined several measures into composite measures, potentially obscuring influences for some of the individual components. In contrast, our analysis takes a continuous view of reading ability by using reading fluency scores as the variable of interest, and consider each measure separately rather than creating composite scores. The two approaches are thus complementary – examining the questions in similar ways with different strengths.

Participants

The present study included a group of children (N = 199; 106 boys and 93 girls) who had complete data records at ages 4, 5, and 6 and 9 for emotional-behavioural development measures, and at the end of grade one (mean age: 7 years, 11 months; children in Finland enter school in August of the calendar year they turn seven) for reading measure/s. The children were originally recruited to form two cohorts: one was deemed to be at "family-risk" (FR) of dyslexia ($n = 107$; 53 girls and 54 boys), based on one or both parents having dyslexia (assessed by the researchers) *and* at least one other close relative having reported reading or spelling difficulties. The other cohort ($n = 92$; 40 girls and 52 boys) was a control group whose parents had no reading or spelling difficulties and reported no reading difficulties among close relatives. Parental dyslexia was assessed prior to the child's birth based on a self-reported history of reading problems combined with reading scores more than one standard deviation below a normative mean on at least two of eight reading tasks (see Lohvansuu et al., 2021 for further details).

The FR and control samples showed no difference in parental educational levels (see Lohvansuu et al., 2021), and the sample approximately represents the Finland educational structure according to Statistics Finland reports (2006). The percentage of parents with primary education was 7.5 for women (Finland: 11.6) and 13.2 for men (17.8); for secondary education, 32.7 for women (41.8) and 49.5 for men (52.7) and, for higher education, 59.8 for women (46.6) and 37.3 for men (29.4). All the children spoke Finnish as their native language and had no reported mental, physical or sensory impairments.

Measures

Emotional and behavioural development

Emotional and behavioural development was assessed using the Parent Rating Scale (PRS) of the Behaviour Assessment System for Children (BASC) (Reynolds & Kamphaus, 1992) when the children were aged 4, 5, 6, and 9 years old (these

were also collected at age 8, but those data were not used for the analysis presented here[2]). Items are rated on a four-point scale ranging from 'never' to 'almost always'. Because Finnish children enter school during the year in which they turn 7 years old, the PRS for pre-schoolers (PRS-P: 126 items) was used at ages 4, 5, and 6 years, while the PRS for children (PRS-C: 138 items) was used at age 9 years. Only the subscales that were included in both PRS-P and PRS-C were included. This included three emotional variables: anxiety (12 items; e.g., "fears of death"), depression (13 items; "easily starts to cry"), and somatization (14 items; "complains of dizziness"). There were also seven behavioural variables: adaptability (10 items; "adapts quickly to new teachers"), aggression (13 items; "breaks other children's things"), attention problems (7 items; "easily distracted"), atypicality (13 items; "has peculiar whims"), hyperactivity (15 items; "climbs all over the place"), social skills (13 items; "politely asks for help"), and withdrawal (9 items; "refuses to participate in group activities"). For each scale, preschool well-being was represented by the mean standardized score across ages 4, 5, and 6 (Cronbach's alpha reliability coefficients were high: 0.77–0.89). School-aged well-being was represented by the standardized score for age 9 (Cronbach's alpha reliability coefficients were again high: 0.80–0.87).

Reading fluency

As previously discussed, reading accuracy is very high for even very young Finnish children due to the transparency of the orthography. Thus, children's reading in grade 1 was represented by the mean standardized score calculated across four reading fluency tasks (descriptive statistics for the four tasks are available in the Appendix). Due to a lack of appropriate standardized tests, three of the tasks below were developed by the JLD researchers, with the word identification task based on a previously established measure. In the sample used here, the Cronbach's alpha reliability coefficient for this composite score was 0.92.

Text reading Children read aloud a short passage (124 words) presented on a sheet of paper. They were instructed to read aloud as quickly and as accurately as possible. Their score was the average number of words read correctly per minute.

Word reading Children were asked to read aloud 18 individual words presented on a computer screen as quickly and accurately as possible. Their score was the mean time (in msecs) from the onset of the word to the end of their articulation.

Pseudoword reading As in the word reading task, children read 27 made-up pseudowords as quickly as possible, with their articulation times recorded.

[2] In our initial analyses we used the arithmetic mean of the age 8 and 9 BASC scores. We are grateful to a reviewer for pointing out that the reading assessments could overlap considerably with the age 8 BASC scores. We redid the analyses with only age 9 to ensure that the later measures were, in fact, later. Results from the two analyses do not differ in any important ways. In the interest of transparency, our original modelling results are available at https://osf.io/8b2un/.

Word identification Children were tested in their classroom on an 80-item word-reading task that is a part of a nationally-normed reading assessment (ALLU; Lindeman, 2000). For each item, children were presented with one picture and four phonologically-similar words. They were asked to read the words silently, and then draw a line between the word that matched the meaning of the picture. Their score was the total number of correct lines drawn within 2 minutes.

Control variables and moderators

Intelligence We included a measure of children's intelligence as a control variable because it is known to influence reading scores. The Wechsler Intelligence Scale for Children—Third Edition (WISC-III, Wechsler, 1991) was administered at the age of 8 years (close in age to the reading assessments). Four performance quotient subtests (Picture Completion, Block Design, Object Assembly, and Coding) and five verbal quotient subtests (Similarities, Vocabulary, Comprehension, Series of numbers, and Arithmetic) were administered, and the full Intelligence score was estimated according to the manual guidelines.

Family-risk status Family-risk status was also included as a control variable when predicting reading fluency. A dichotomous variable indicated whether or not the children's family had a history of reading difficulties. The identification was based on skill assessments, questionnaires, and interviews (see Lohvansuu et al., 2021).

Gender Gender was included as a moderator variable to address Aim 3. Gender was contrast coded (− 1 = girls, 1 = boys) and included in interaction terms for all of the analyses.

Missing data

Full data was available for the pre-school emotional-behavioural development measures and for reading fluency measures in grade 1 leaving us with N = 199 for those analyses. Eight participants were missing data in the school-age (age 9) emotional-behavioural measures and one participant was missing an intelligence measure, leaving us with N = 191 for those analysis. Little's MCAR test suggested no evidence that missingness was systematic $\chi^2(28) = 20.470$, $p = 0.847$.

Data analysis

We addressed our aims by fitting two hierarchical linear regression models for each emotional or behavioural development variable. For each measure, the first model examined the relationships between each early emotional and behavioural independent variable (ages 4–6) and the later reading fluency dependent variable (grade 1). We entered the independent variables in three steps: (1) gender and

intelligence (age 8); (2) the specific emotional or behavioural variable; (3) the interaction term between that variable and gender.

The second model for each variable used the same reading fluency measures as the independent variable and the emotional and behavioural variable at age 9 as the critical dependent variable. Once again, a three-step process was used: (1) gender and intelligence; (2) reading fluency; and (3) the interaction between reading fluency and gender.

For both sets of models, our tests of the associations between reading and emotional-behavioural development were one-tailed since previous research predicts that poorer scores on measures of emotion and behaviour should be related to poorer reading fluency scores and not the reverse and we know of no theories or data that suggest the reverse pattern in young children.

Results

Descriptive statistics are reported in Table 1. Distributions of all variables were found to approximate the normal distribution, all absolute values of skewness being < 2. In the distributions of grade 1 reading fluency and most of the emotional-behavioural development scores there were one to five outlier values that were situated more than three standard deviations from the mean. Therefore, we fitted all of the models with unadjusted and adjusted outliers (replacing outliers with values at the tail of the distribution). As the results were not affected by the outlier adjustments, we report the results based only on the unadjusted data.

Simple bivariate correlations between all study variables are reported in Table 2. Child's gender was associated with pre-school aggression and attention scores, as well as school-age hyperactivity and social skills scores. Boys were found to have somewhat more problems with attention, aggression, and hyperactivity and poorer social skills. Family risk status was moderately associated with reading fluency and weakly associated with school-age adaptability, anxiety, atypicality, depression, and somatization scores. Children with family risk for dyslexia read less fluently and showed poorer school-age emotional-behavioural well-being. A moderate correlation was found between Intelligence and grade 1 reading fluency with higher intelligence associated with better reading fluency. Moreover, Intelligence was weakly associated with both pre-school and school-age attention: fewer symptoms of attention problems were found to be related to higher intelligence scores. Finally, weak associations were found between grade 1 reading fluency and pre-school attention scores; and school-age anxiety, attention, and atypicality scores, where better reading fluency was found to be related to better outcomes on all measures.

Next, the hierarchical linear regression analyses were performed to reveal the unique effects of the independent variables when analysed simultaneously with the control variables and to examine gender interactions more closely.

Table 1 Descriptive statistics

	Min	Max	Mean	SD	Skew (SE)	Kurt (SE)
Age[a]	7.37	8.81	7.91	0.28	0.24 (0.17)	−0.42 (0.34)
Intelligence[b]	77	130	99.81	10.45	0.13 (0.17)	−0.48 (0.34)
Reading fluency[c]	−5.36	1.50	−0.48	1.27	−1.11 (0.17)	1.80 (0.34)
Pre-school emotional-behavioural development[d]						
Adaptability	−2.55	2.50	−0.07	0.73	−0.04 (0.17)	0.61 (0.34)
Aggression	−1.96	2.31	−0.04	0.86	0.30 (0.17)	−0.22 (0.34)
Anxiety	−1.76	4.32	0.12	1.01	0.97 (0.17)	1.67 (0.34)
Attention	−2.69	3.53	0.02	1.01	0.23 (0.17)	1.04 (0.34)
Atypicality	−1.57	2.81	0.01	0.92	0.68 (0.17)	0.12 (0.34)
Depression	−1.93	2.44	0.06	0.84	0.24 (0.17)	−0.17 (0.34)
Hyperactivity	−2.38	2.93	−0.00	0.96	0.41 (0.17)	0.29 (0.34)
Social skills	−2.26	2.37	−0.06	0.82	0.18 (0.17)	0.15 (0.34)
Somatization	−1.72	3.16	0.11	0.88	0.70 (0.17)	1.05 (0.34)
Withdrawal	−1.74	2.77	−0.02	0.83	0.69 (0.17)	0.43 (0.34)
School-age emotional-behavioural development[e]						
Adaptability	−3.96	1.85	−0.26	1.09	−0.31 (0.18)	−0.18 (0.36)
Aggression	−2.11	3.97	0.05	1.01	0.89 (0.18)	1.47 (0.36)
Anxiety	−1.63	4.74	0.32	1.14	0.98 (0.18)	1.40 (0.36)
Attention	−1.90	3.66	0.14	1.12	0.51 (0.18)	−0.07 (0.36)
Atypicality	−1.13	7.16	0.29	1.44	1.75 (0.18)	4.38 (0.36)
Depression	−1.58	6.49	0.33	1.38	1.53 (0.18)	3.54 (0.36)
Hyperactivity	−1.85	4.17	0.12	1.14	0.94 (0.18)	0.89 (0.36)
Social skills	−2.75	2.67	−0.06	1.10	0.09 (0.18)	−0.39 (0.36)
Somatization	−1.80	6.67	0.21	1.26	1.06 (0.18)	3.20 (0.36)
Withdrawal	−1.41	3.75	0.09	1.01	0.84 (0.18)	1.06 (0.36)

[a]Assessment age at grade 1

[b]Full intelligence estimated using the wechsler intelligence scale for children—third edition, WISC-III, (Wechsler, 1991)

[c]Grade 1 reading fluency, an arithmetic mean from the standardized scores of four reading tasks

[d]Pre-school emotional-behavioural development scores are arithmetic means from the standardized scale scores of the parent rating scale of the behavior Assessment system for children, BASC (Reynolds & Kamphaus, 1992) at 4, 5, and 6 years

[e]School-age emotional-behavioural development scores are the standardized scale scores of the parent rating scale of the behavior assessment system for children, BASC (Reynolds & Kamphaus, 1992) at 9 years

Early emotional-behavioural development influences on reading

Our first aim was to examine which early (ages 4–6) emotional and behavioural variables associated with grade 1 reading fluency, and whether or not they differed by gender. Omnibus tests of the hierarchical regression models predicting grade 1 reading fluency were all significant (see Table 3). In most cases, this was driven by

Table 2 Pearson correlations between the predictors and dependent measures used in the regression models

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Gender[a]	−.04	.06	.03	−.13[w]	.15[x]	.02	.20[y]	−.02	−.13[w]	.07	−.11	.01	.03	−.05	.08	−.12	.02	−.09	−.00	.11	−.16[x]	.04	−.04
2. Intelligence[b]		.11	.30[z]	.08	−.02	−.05	−.17[x]	−.02	.06	−.04	.05	−.07	.05	.02	−.01	−.04	−.21[y]	−.12	−.06	−.08	.03	−.11	−.04
3. FR status[c]			.34[z]	.11	.03	−.12	−.02	−.01	−.07	.00	.08	−.12[w]	.01	.23[y]	−.05	−.27[z]	−.13[w]	−.20[y]	−.23[y]	−.10	.06	−.16[x]	−.08
4. Reading fluency[d]				.07	.00	−.06	−.17[x]	−.04	−.08	−.04	.13[w]	−.04	.13[w]	.05	−.02	−.23[y]	−.23[y]	−.19[x]	−.12	−.05	−.03	.04	−.02
Pre-school emotional-behavioural development[e]																							
5. Adaptability					−.40[z]	−.30[z]	−.33[z]	−.20[y]	−.33[z]	−.19[y]	.63	−.23[z]	−.45[z]	.47[z]	−.30[z]	−.15[x]	−.29[z]	−.27[z]	−.30[z]	−.20[y]	.49[z]	−.25[z]	−.40[z]
6. Aggression						.30[z]	.50[z]	.44[z]	.53[z]	.66[z]	−.25[z]	.22[y]	.07	−.29[z]	.68[z]	.15[x]	.42[z]	.28[z]	.41[z]	.49[z]	−.33[z]	.10	.16[x]
7. Anxiety							.37[z]	.52[z]	.69[z]	.32[z]	−.07	.43[z]	.30[z]	−.27[z]	.28[z]	.61[z]	.22[y]	.40[z]	.54[z]	.23[y]	−.09	.34[z]	.22[y]
8. Attention								.49[z]	.42[z]	.67[z]	−.30[z]	.13[w]	−.05	−.33[z]	.44[z]	.27[z]	.60[z]	.39[z]	.49[z]	.56[z]	−.32[z]	.09	.09
9. Atypicality									.58[z]	.57[z]	−.12[w]	.26[z]	.14[x]	−.27[z]	.33[z]	.35[z]	.38[z]	.50[z]	.44[z]	.40[z]	−.19[x]	.27[z]	.18[x]
10. Depression										.46[z]	−.08	.35[z]	.18[x]	−.30[z]	.49[z]	.47[z]	.31[z]	.36[z]	.60[z]	.36[z]	−.14[w]	.24[y]	.20[y]
11. Hyperactivity											−.10	.18[x]	−.05	−.27[z]	.51[z]	.22[y]	.49[z]	.37[z]	.42[z]	.66[z]	−.18[x]	.14[w]	.11
12. Social skills												−.09	−.37[z]	.35[z]	−.18[x]	−.03	−.32[z]	−.25[z]	−.20[y]	−.18[x]	.61[z]	−.07	−.31[z]
13. Somatization													.18[x]	−.17[x]	.14[w]	.25[z]	.15[x]	.23[y]	.25[z]	.15[x]	−.13[w]	.52[z]	.16[x]
14. Withdrawal														−.12	−.02	.05	−.04	.09	.02	−.10	−.24[z]	.15[x]	.66[z]
School-age emotional-behavioural development[f]																							
15. Adaptability															−.47[z]	−.40[z]	−.42[z]	−.43[z]	−.52[z]	−.36[z]	.57[z]	−.18[x]	−.32[z]
16. Aggression																.36[z]	.52[z]	.42[z]	.63[z]	.65[z]	−.41[z]	.11	.14[w]
17. Anxiety																	.33[z]	.43[z]	.63[z]	.30[z]	−.11	.27[z]	.26[z]
18. Attention																		.55[z]	.51[z]	.65[z]	−.47[z]	.22[y]	.20[y]

Table 2 (continued)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
19. Atypicality																			.53[z]	.55[z]	−.36[z]	.38[z]	.36[z]
20. Depression																				.54[z]	−.37[z]	.26[z]	.24[y]
21. Hyperactivity																					−.35[z]	.21[y]	.13[w]
22. Social skills																						−.20[y]	−.47[z]
23. Somatization																							.19[y]
24. Withdrawal																							

[a]0 = girl, 1 = boy

[b]Full intelligence estimated using the wechsler intelligence scale for children—third edition, WISC-III, (Wechsler, 1991)

[c]1 = family risk for dyslexia, 2 = no family risk

[d]grade 1 reading fluency, an arithmetic mean from the standardized scores of four reading tasks

[e]Pre-school emotional-behavioural development scores are arithmetic means from the standardized scale scores of the parent rating scale of the behavior assessment system for children, BASC (Reynolds & Kamphaus, 1992) at 4, 5, and 6 years

[f]School-age emotional-behavioural development scores are the standardized scale scores of the parent rating scale of the behavior assessment system for children, BASC (Reynolds & Kamphaus, 1992) at 9 years

[w]$p < .10$

[x]$p < .05$

[y]$p < .01$

[z]$p < .001$

Table 3 Results of the hierarchical linear regression analyses predicting grade 1 reading fluency. Separate analysis was performed for each pre-school emotional-behavioural development scale as predictor

	Emotional-behavioural development (ED) scale														
	Adaptability			Aggression			Anxiety			Attention			Atypicality		
	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig
Step 1	.20		***	.20		***	.20		***	.20		***	.20		***
Gender[a]		.02			.02			.02			.05			.02	
Intelligence[b]		.29	***		.30	***		.30	***		.28	***		.30	***
FR status[c]		.30	***		.31	***		.30	***		.30	***		.30	***
Step 2	.00			.00			.00			.01		+	.00		
ED scale score[d]		.04			−.01			−.02			−.13	+		−.04	
Step3	.02		*	.00			.00			.00			.00		
Gender × ED scale		−.13	*		.05			.03			−.04			−.02	
Total R^2	.22		***	.20		***	.20		***	.22		***	.20		***
	F(5,191) = 10.66			F(5,191) = 9.83			F(5,191) = 9.71			F(5,191) = 10.65			F(5,191) = 9.74		

	Emotional-behavioural development (ED) scale														
	Depression			Hyperactivity			Social skills			Somatization			Withdrawal		
	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig
Step 1	.20		***	.20		***	.20		***	.20		***	.20		***
Gender[a]		.01			.02			.03			.00			.02	
Intelligence[b]		.30	***		.30	***		.28	***		.28	***		.28	***
FR status[c]		.30	***		.30	***		.30	***		.30	***		.31	***
Step 2	.00			.00			.01			.00			.01		+
ED scale score[d]		−.07			−.03			.10			.01			.10	

Table 3 (continued)

	Emotional-behavioural development (ED) scale														
	Depression			Hyperactivity			Social skills			Somatization			Withdrawal		
	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig
Step3	.00			.00			.01			.03		**	.00		
Gender × ED scale		.00			− .03			− .09			.18	**		.05	
Total R^2	.21		***	.20		***	.22		***	.23		***	.22		***
	F(5,191) = 9.98			F(5,191) = 9.75			F(5,191) = 10.64			F(5,191) = 11.53			F(5,191) = 10.51		

Standardized betas reported according to the final model, where all independent measures are included in the model

[a]0 = girl, 1 = boy

[b]Full intelligence estimated using the wechsler intelligence scale for children—third edition, WISC-III, (Wechsler, 1991)

[c]1 = family risk for dyslexia, 2 = no family risk

[d]An arithmetic mean calculated from the standardized scale scores of the Parent Rating Scale of the Behavior Assessment System for Children, BASC (Reynolds & Kamphaus, 1992) at 4, 5, and 6 years

[+]p < .10, * $p < .05$, ** $p < .01$, *** $p < .001$

strong influences of intelligence and family-risk status on reading fluency. Child's gender showed no significant unique effect on grade 1 reading fluency in any of the models. Of the pre-school emotional-behavioural development scores, there was a significant (one-tailed) main effect of attention whereby more attention problems led to poorer reading outcomes. No other pre-school indices of emotional-behavioural development produced significant associations.

Early reading influences on later emotional-behavioural development

Our second aim was to examine which later emotional and behavioural variables at age 9 were associated with grade 1 (typically age 7 or 8) reading fluency. Hierarchical regression models using reading fluency to predict emotional-behavioural development scores at age 9 years are reported in Table 4. Omnibus tests indicate that only the models with anxiety, attention problems, and social skills scores were significant. School-age adaptability, atypicality, depression, somatization, and withdrawal scores were not reliably associated with grade 1 reading ability, gender, or intelligence. We note that boys did tend to report somewhat higher rates of aggression and hyperactivity, though both of these were only significant one-tailed and the omnibus tests of the step 1 models did not support that structure.

We found only one reliable link from early reading to later emotional-behavioural development. Grade 1 reading fluency was found to explain 4.6% of the variance in school-age anxiety score, so that better reading fluency in grade 1 predicted lower anxiety scores later. Neither intelligence, gender, nor familial risk status were significant predictors; and the association remained significant after controlling for pre-school anxiety scores ($\beta = -0.19$, $p = 0.023$).

There is one finding that warrants further discussion. The results for the model of the attention problems scale were sensitive to which variables were included. When only the three first-order terms were included (family risk, gender, intelligence, and reading fluency), only reading fluency was significant. When including the gender x grade 1 reading fluency term, reading fluency was no longer significant, nor was the interaction term. As a result, conclusions are sensitive to whether one chooses to consider the full model or the more parsimonious model without the interaction term. Thus, in the JLD sample the association between grade 1 reading fluency and later attention is sensitive to the model structure. Further, when controlling for earlier attention problems, the effect once again became non-significant ($\beta = -0.11$, $p = 0.065$, though significant one-tailed), suggesting that this may partly or largely reflect a continuation of the influence of early attention scores on reading.

Gender interactions

The literature to date on gender and the associations between reading and emotional-behavioural development are very mixed. Our third aim was to examine whether or not the JLD dataset could help shed light in this area.

Table 4 Results of the hierarchical linear regression analyses predicting emotional-behavioural development at age 9. Separate analysis was performed for each emotional-behavioural development scale and gender, and grade 1 reading fluency were used as predictors

	Emotional-behavioural development (ED) scale[a]														
	Adaptability			Aggression			Anxiety			Attention			Atypicality		
	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β	sig
Step 1	.00			.01			.02			.05		*	.02		
Gender[b]		−.06			.08			−.09			−.01			−.13	
Intelligence[c]		.00			−.00			.04			−.16	*		−.08	
Step 2	.00			.00			.05		**	.03		*	.02		*
Reading fluency[d]		.05			−.02			−.25	**		−.17	*		−.15	
Step 3	.00			.00			.00			.00			.01		
Gender × Reading		−.03			−.01			.05			−.06			−.13	
Total R^2	.01			.01			.07		*	.08		**	.06		*
	F(4,174) = 0.26			F(4,174) = 0.35			F(4,174) = 3.25			F(4,174) = 3.62			F(4,174) = 2.86		
	Emotional−behavioural development (ED) scale														
	Depression			Hyperactivity			Social skills			Somatization			Withdrawal		
	ΔR^2	std β	sig	ΔR^2	std β	sig	ΔR^2	std β		ΔR^2	std β	sig	ΔR^2	std β	sig
Step 1	.00			.02			.03		+	.01			.00		
Gender		−.02			.10			−.16	*		.06			−.03	
Intelligence[c]		−.03			−.07			.04			−.13			−.04	
Step 2	.01			.00			.00			.01			.00		
Reading fluency		−.10			−.03			−.04			.07			−.00	
Step 3	.00			.00			.00			.00			.00		
Gender × Reading		−.05			−.02			−.02			.07			.03	
Total R^2	.02			.02			.03			.02			.00		
	F(4,174) = 0.74			F(4,174) = 0.85			F(4,174) = 1.25			F(4,174) = 0.99			F(4,174) = 0.18		

Table 4 (continued)

Standardized betas reported according to the final model, where all independent measures are included in the model

[a]An arithmetic mean calculated from the standardized scale scores of the parent rating scale of the behavior assessment system for children, BASC (Reynolds & Kamphaus, 1992) at 9 years

[b]0 = girl, 1 = boy

[c]Full Intelligence estimated using the Wechsler Intelligence Scale for Children – Third Edition, WISC-III, (Wechsler, 1991)

[d]An arithmetic mean calculated from the standardized scores of four reading tasks (Text reading, Word reading, Pseudoword reading, Word identification).

$^{+}p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Gender and early emotional-behavioural development influences on reading

For the associations between pre-school developmental measures and grade 1 reading, gender had a significant moderating effect on the role of adaptability and somatization scores in predicting reading fluency.

To investigate these two gender interactions further, we conducted separate hierarchical linear regression analyses for boys and girls. These analyses suggested that the significant interaction between Gender and adaptability arose from two non-significant associations that went in opposite directions for boys (better reading fluency was associated with lower adaptability, $\beta = -0.095$, $p = 0.289$) and girls (better reading fluency was associated with higher adaptability, $\beta = 0.165$ for girls, $p = 0.079$). The analysis for somatization, on the other hand, revealed that a higher somatization score was associated with better reading fluency for boys ($\beta = 0.187$; $p = 0.036$). For girls the effect was reversed, though not statistically significant ($\beta = -0.168$; $p = 0.074$). Though they did not consider children with typical reading, Aro et al. (2022) also found that boys with reading difficulties reported less somatization than girls with reading difficulties.

Gender and early reading influences on later emotional-behavioural development

Gender did not moderate any of the associations between grade 1 reading fluency and later emotional or behavioural development measures.

Comparison to Parhiala et al. (2015)

Parhiala et al. (2015) also used the JLD to ask similar questions, though they adopted a retrospective group comparison approach (identifying groups of children with and without dyslexia at age 7 or 8). We have previously discussed how their methods differed from ours. While the two approaches converged on some results, they disagreed on others. Both studies find that attention problems in the pre-school years (ages 4–6) are associated with poorer reading ability in grade 1 (measured by fluency in our case, dyslexia in theirs); and both studies find that reading skill further influences later attention at age 9.

In contrast, Parhiala et al. (2015) found that their children with dyslexia had poorer scores on a composite measure of adaptability and social skills at ages 4 and 6, while we did not find that either measure was reliably associated with reading fluency in grade 1. It is notable that in the retrospective study, the differences did not persist into the school years—differences were absent by age 9.

The analyses also differed in whether or not they reported an association between poor reading in grade 1 and poorer scores on a later internalising measure. Parhiala et al. (2015) found no differences on a composite measure of internalising symptoms (anxiety, depression, and somatization) between their children with and without dyslexia, whereas our analysis finds that reading fluency is associated with later anxiety

scores (but not the other two). It's possible that had Parhiala et al. (2015) considered the measures separately, they would also have seen a difference in later anxiety.

Discussion

The first two aims of this study were to examine the relationship between early emotional-behavioural development and grade 1 reading, and the relationship between grade 1 reading and later emotional-behavioural outcomes. The longitudinal dataset used here allowed us to draw some inferences about the direction of causation: if an emotional-behavioural development measure in pre-school is associated with grade 1 reading, we can reasonably infer that it might be causal. Conversely, if the relationship only emerges in post-reading instruction measures of emotional-behavioural development, we can reasonably infer that poor reading might be a cause of the emotional-behavioural difficulties—particularly if it persists after controlling for the earlier measure of the same dimension.

For these two aims, we found some evidence that poorer pre-school attention scores are linked with poorer reading outcomes in this Finnish sample, and no other early measure of emotional-behavioural development contributed to grade 1 reading outcomes. We note, however that this relationship was only significant one-tailed, falling somewhere in between the four datasets that suggest this early influence of attention (McArthur et al., 2022; McGee et al., 1986; Parhiala et al., 2015) and one that didn't (Sanson et al., 1996). We also found that poorer reading in grade 1 was strongly associated with poorer outcomes on both anxiety and attention scores at a later time point. Both of these results persisted when controlling for earlier scores suggesting that they do not merely reflect continuation of earlier associations. These findings converge with those of McGee et al. (1986) and McArthur et al. (2022), but are inconsistent with findings from Parhiala et al. (2015). Reading did not predict outcomes on any other school-aged measures of emotional-behavioural well-being.

Our third aim was to test the possibility that girls and boys would differ in the ways that early reading measures are associated with emotional-behavior development. We found very little evidence for any such interactions, and where the interactions did appear (early somatization and adaptability), the patterns were difficult to interpret. In the absence of clearer results or converging evidence, we do not discuss these findings any further.

Implications for theory and practice

The results here are generally consistent with a McArthur's (2022) theory that aims to explain the association between reading difficulties and mental health. According to this theory, a student who starts to fall behind their peers in their reading may be at increased risk of experiencing negative feedback from

themselves or others, which will negatively impact their self-concept related to reading and school. This increases their risk of experiencing anxiety—particularly reading and social anxiety—which in turn increases the chance that they struggle to pay attention to reading classes, or engage in other behaviours to avoid the difficult learning situations. This reduces their opportunity to learn and practice reading, so they fall even further behind their peers, which begins a cycle between problems with reading, self-concept, anxiety, and inattention and avoidance behaviours.

While this theory proposes reading failure as the "starting point" for this negative cycle, it is possible that for some students, the starting point is problems with attention that exist before they start school which can affect their ability to learn to read. The results of this prospective longitudinal analysis align with both poor reading and inattention as a starting point since reading ability at one point in development (age 8) were related to both anxiety and attention at later point in development (age 9). The results align less strongly with inattention as a starting point since the relationship between early attention and later reading was somewhat unstable, depending on which variables were included in the model.

In practical terms, this analysis suggests that children whose reading skills are trailing their peers should be monitored for the development of anxiety and or attentional problems. Though it is much too early to propose specific interventions, research should continue to probe the association between poor reading and anxiety or attention and develop techniques to prevent and/or break the cycle.

Limitations

Due to sample size limitations, the present study has relatively limited power for examining the interactions with gender, particularly where those differences might be small. The oversampling of poor readers may limit the extent to which the magnitudes of these associations would generalise to a broader sample from the general population, though this is also a strength in that it ensures a wider range of reading skills without requiring a large sample. As in all other regression analyses, there is the possibility that unknown covariates would moderate the present results, or that relationships may be non-linear.

Conclusion

Converging with evidence from other large datasets (McGee et al., 1986; Parhiala et al. 2015; McArthur et al., 2022), we found that measures of attention in children before they start school are related to their later reading ability in early primary school. Also consistent with previous research (McGee et al., 1986; Parhiala et al. 2015; McArthur

et al., 2022; and Sanson et al., 1996), we found that no measures of early emotional development predicted later reading performance. Also, consistent with other studies, we find that reading ability in early primary school was related to later anxiety symptoms (McArthur et al., 2022) and attention (Parhiala et al. 2015; McArthur et al., 2022) scores in middle primary school. We found no evidence for a relationship between reading ability in early primary school and other measures of emotional (depression, somatisation) or behavioural (adaptability, aggression, atypicality, hyperactivity, social skills, withdrawal) development. Thus, pre-school attention appears to have a relationship to reading in early primary, which in turn has relationships to both later attention and anxiety outcomes in middle primary.

Few studies thus far have directly tested for effects of gender as a moderating influence on the associations between reading and emotional-behavioural development measures over time. Broadly speaking, we find that while parents report that girls have better social skills and boys tend to have more behavioural problems (aggression and hyperactivity), gender does not moderate how those measures are associated with reading ability. However, the data from the JLD does produce some interactions between gender and the association between pre-school measures of adaptability and somatization and later reading ability that will require further study to solidify or reject.

Appendix

See (Table 5).

Table 5 Descriptives of the four reading fluency tests that make up the reading fluency measure

	Min	Max	Mean	SD	Skew (SE)	Kurt (SE)
Text Reading	2.63	103.33	35.34	22.57	0.82 (0.18)	−0.05 (0.35)
Word Reading	760.33	7888.13	1918.03	1122.07	2.38 (0.17)	7.10 (0.35)
Pseudoword Reading	962.30	8348.62	2381.25	1220.81	1.84 (0.17)	4.05 (0.35)
Word Identification	8	80	43.51	19.74	0.35 (0.18)	−0.88 (0.35)

Unit of measurement varies according to task as follows: text reading = words read/minute, word reading and pseudowoord reading = mean time from the onset of the word to the end of the articulation in milliseconds, word identification = total number of correctly identified words within 2 minutes

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Declarations

Conflict of interest We have no known competing interests to disclose.

Ethical approval Ethics approval for the data used in this study was provided by the Ethical Board of the Central Finland Hospital District on 15.12.2004 (#66/2004).

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