JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH
574

Kenneth Eklund

School-aged Reading Skills of Children with Family History of Dyslexia

Predictors, Development and Outcome

JYVÄSKYLÄN YLIOPISTO

JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH 574

Kenneth Eklund

School-aged Reading Skills of Children with Family History of Dyslexia

Predictors, Development and Outcome

Esitetään Jyväskylän yliopiston kasvatustieteiden ja psykologian tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston Historica-rakennuksen salissa H320
helmikuun 17. päivänä 2017 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Education and Psychology of the University of Jyväskylä,
in building Historica, hall H320, on February 17, 2017 at 12 o'clock noon.

UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2017

School-aged Reading Skills of Children with Family History of Dyslexia

Predictors, Development and Outcome

JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH 574

Kenneth Eklund

School-aged Reading Skills of Children with Family History of Dyslexia

Predictors, Development and Outcome

UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2017

Editors
Timo Suutama
Department of Psychology, University of Jyväskylä
Pekka Olsbo, Sini Tuikka
Publishing Unit, University Library of Jyväskylä

Cover picture by Kenneth Eklund

Permanent link to this publication: http://urn.fi/URN:ISBN:978-951-39-6963-9

URN:ISBN:978-951-39-6963-9
ISBN 978-951-39-6963-9 (PDF)

ISBN 978-951-39-6962-2 (nid.)
ISSN 0075-4625

Jyväskylä University Printing House, Jyväskylä 2017

ABSTRACT

Eklund, Kenneth
School-aged reading skills of children with family history of dyslexia – predictors, development and outcome
Jyväskylä: University of Jyväskylä, 2017, 66 p.
(Jyväskylä Studies in Education, Psychology and Social Research
ISSN 0075-4625; 574)
ISBN 978-951-39-6962-2
ISBN 978-951-39-6963-9 (PDF)

In this research I focused on reading skill development in school-age children with family history of dyslexia. I was interested in the effects of children's cognitive skills (language, phonological awareness, rapid serial naming, verbal short term memory, and letter knowledge), and gender in addition to family risk for dyslexia as predictors of children's reading development. In addition, I examined whether shared reading with parents, time spent reading alone, or task-focused behaviour could serve as potential protective factors against reading disability. One of my aims was to find out whether there exist subgroups of children who have different developmental trajectories, and to characterize these subgroups according to their own and their parents' cognitive profiles. Finally, I examined the literacy readiness of adolescents to meet the challenges of future societies abundant in printed material by administering them the PISA reading literacy task. All participants were drawn from the Jyväskylä Longitudinal Study of Dyslexia (JLD) in which 200 children have been followed from birth. The development of approximately 100 children with a family risk for dyslexia was compared to the development of a similar number of control children without such risk. In line with earlier studies, it was found that family-risk children, boys in particular, showed deficient cognitive and reading skills throughout their first 15 years. Moreover, the associations between early cognitive skills and reading literacy skills were strong, suggesting high developmental predictability for this group of children. However, children with family risk for dyslexia did not form a single homogenous group. First, for approximately 55% of these children their reading skill development followed that of their peers, showing no clear signs of difficulties during primary and secondary school. Second, a substantial proportion of the family-risk children, despite having high early cognitive risk on top of family risk, were able to avoid reading disability in Grade 2. Those children were characterized by not avoiding challenges at school. Third, reading disability in Grade 2 did not inevitably lead to similar status in Grade 8, although in Grade 8 this group of children on average lagged approximately five years behind their peers in their reading skill development: 38% of the children with family risk and reading disability in Grade 2, mainly girls, had been resolved by Grade 8. Finally, especially among boys with family risk for dyslexia, early cognitive skills proved to be a good predictor of deficient reading literacy skills at the end of secondary school, a finding which opens up possibilities for intervention and early support.

Keywords: dyslexia, family risk, development, longitudinal study

Author's address Kenneth Eklund
Department of Psychology
P.O. Box 35
FIN – 40100 University of Jyväskylä
Kenneth.M.Eklund@jyu.fi

Supervisors Professor Timo Ahonen
Department of Psychology
University of Jyväskylä

Docent Minna Torppa
Department of Teacher Education
University of Jyväskylä

Professor Heikki Lyytinen
Department of Psychology
University of Jyväskylä

Reviewers Professor Marja Vauras
Department of Teacher Education
University of Turku

Professor Charles A. Perfetti
Learning Research & Development Center
University of Pittsburgh

Opponent Professor Marja Vauras
Department of Teacher Education
University of Turku

TIIVISTELMÄ (FINNISH ABSTRACT)

Eklund, Kenneth
Kouluiän lukutaito lapsilla, joilla on suvussa kulkeva lukivaikeusriski – ennustajat, kehitys ja lopputulema
Jyväskylä: Jyväskylän yliopisto, 2017, 66 s.
(Jyväskylä Studies in Education, Psychology and Social Research
ISSN 0075-4625; 574)
ISBN 978-951-39-6962-2
ISBN 978-951-39-6963-9 (PDF)

Tutkimuksessani keskityin tarkastelemaan kouluiän lukutaidon kehitystä lapsilla, joilla on suvussa kulkeva lukivaikeusriski. Olin kiinnostunut siitä, miten kognitiiviset taidot (kielitaito, fonologinen tietoisuus, nopean sarjallisen nimeämisen taito, kielellinen lyhytkestoinen muisti ja kirjaintuntemus), ja sukupuoli suvussa kulkevan lukivaikeuden lisäksi ennustaisivat lukutaidon kehitystä alaluokkien jälkeen. Lisäksi halusin selvittää, voisivatko lapsen lukemiseen käyttämä aika (itsenäisesti tai vanhemman kanssa) tai lapsen sinnikkyys keskittyä ponnistelemaan haastavissakin tehtävissä toimia lasta lukivaikeudelta suojaavina tekijöinä. Pyrin myös selvittämään, olisiko lukutaidossa löydettävissä erilaisia kehityksellisiä alaryhmiä ja minkälaiset kognitiiviset profiilit, lasten omat tai heidän vanhempiensa, olisivat näille alaryhmille tyypillisiä. Olin kiinnostunut myös siitä, minkälaiset ovat näiden lasten lukutaidolliset valmiudet yläkoulun lopussa 15 vuoden iässä. Osallistujat kuuluivat Jyväskylän yliopistossa toteutettuun Lapsen kielen kehitys ja suvussa kulkeva lukivaikeus –hankkeeseen. Noin 100 lapsella oli suvussa kulkeva lukivaikeusriski ja heidän kehitystään verrattiin samansuuruiseen kontrollilasten joukkoon, joilla ei tällaista riskiä ollut. Havaittiin, aiempien tutkimusten mukaisesti, että lukivaikeusriskilasten (erityisesti poikien) kognitiiviset taidot sekä luku- ja kirjoitustaidot olivat verrokkilapsia heikommat ensimmäisen 15 vuoden aikana. Varhaislapsuuden kognitiiviset taidot olivat voimakkaasti yhteydessä myöhempiin lukemisen taitoihin luoden kohtuullisen synkät kehitysnäkymät osalle näistä lapsista. Toisaalta, lukivaikeusriskilapset eivät muodostaneet yhtä yhtenäistä ryhmää, jossa kaikilla olisi samanlainen kehityskulku. Ensiksi, noin 55 prosentilla näistä lapsista lukutaito kehittyi kouluiässä odotusten mukaisesti ilman selviä merkkejä ongelmista. Toiseksi, osa näistä lapsista vältti lukemisen ongelmat huolimatta perinnöllisestä riskistä ja heikoista kognitiivisista valmiuksista ennen kouluikää. Näille lapsille oli tyypillistä, että he jaksoivat ponnistella koulussa haastaviakin tehtäviä kohdatessaan. Kolmanneksi, vaikeudet lukemaan opettelemisessa kahdella ensimmäisellä luokalla eivät väistämättä johtaneet lukivaikeuteen kahdeksannella luokalla. Vaikka lasten, joilla sukuriskin lisäksi oli toisen luokan lopussa luokiteltu olevan lukivaikeus, lukutaito oli keskimäärin noin viisi vuotta jäljessä verrokkilasten lukutaitoa kahdeksannella luokalla, niin 38 prosentilla heistä (enimmäkseen tyttöjä) lukutaito kehittyi lähes ikätovereiden veroiseksi. Lopuksi, lukivaikeusriskipojat joiden lukutaitovalmiudet yläkoulun lopussa olivat heikot, näyttäisivät olevan helposti tunnistettavissa varhaislapsuuden kognitiivisten taitojen perusteella. Tämä mahdollistaa yritykset puuttua heidän kehitykseensä tukemalla heidän kielellisten ja fonologisten taitojensa kehitystä.

Avainsanat: lukivaikeus, sukuriski, kehitys, pitkittäistutkimus

ACKNOWLEDGEMENTS

I would like to start by thanking the supervisors of my thesis, Prof. Timo Ahonen, Dr. Minna Torppa, and Prof. Heikki Lyytinen for their encouragement and support during the process. I am also grateful for the reviewers of my thesis, Prof. Marja Vauras and Prof. Charles Perfetti for their valuable comments. In addition, I want to thank the other co-authors of the individual papers, Prof. Mikko Aro, Prof. Paavo Leppänen, Prof. Elsje van Bergen, Dr. Sari Sulkunen, and Prof. Pekka Niemi, for their effort.

This dissertation was done as part of the Jyväskylä Longitudinal Study of Dyslexia (JLD), in which I was fortunate to be hired to help in screening of the families in autumn 1992. During the past 24 years I have had the opportunity to be part of the longest prospective follow-up study of dyslexia in the world. Through taking care of various tasks in the JLD, especially participating in the dissertation processes of several colleagues as well as co-authoring of the papers, I have gradually acquired the knowledge I have about reading and dyslexia, as well as about making science. The extraordinary spirit among the people who have been not only working together but also sharing their everyday life has enriched the lives of us all. Thank you Maana, Anna-Maija, Seija, Paavo, Ulla, Tomi, Johanna, Pirkko, Anne, Paula, Ritva, Minna, Tuija, Jarmo, Kaisa, Riitta, Annamaija, … and several others for sharing your companion, knowledge and time. Although our shared time is mostly in history, warm memories related to common experiences live forever! A special thanks goes to the 200 families followed in the JLD. Without the persistence and commitment of the families, we would not have succeeded in our endeavor.

Finally, I would like to thank the closest persons I have had and have in my life. First, I am deeply grateful to my late mother for raising me up, alone without support, and giving me the opportunity for education, in spite of the shortage of money our family had. And second, my dearest, Kirsti: your warmth and love together with unquestionable faith and acceptance has enabled me to reach my potential. Thank you for the common journey, you have made it a much more enjoyable experience!

Jyväskylä 19.12.2016
Kenneth Eklund

LIST OF ORIGINAL PUBLICATIONS

I. Eklund, K. M., Torppa, M., & Lyytinen, H. (2013). Predicting reading disability: Early cognitive risk and protective factors. *Dyslexia, 19,* 1–10.

II. Eklund, K., Torppa, M., Aro, M., Leppänen, P. H. T., & Lyytinen, H. (2015). Literacy skill development of children with familial risk for dyslexia through grades 2, 3, and 8. *Journal of Educational Psychology, 107,* 126–140.

III. Torppa, M., Eklund, K., van Bergen, E., & Lyytinen, H. (2015). Late-emerging and resolving dyslexia: A follow-up study from kindergarten to Grade 8. *Journal of Abnormal Child Psychology, 431*, 1389–1401.

IV. Eklund, K., Torppa, M., Sulkunen, S., Niemi, P., & Ahonen, T. (2016). Early cognitive predictors of PISA reading in children with and without family risk for dyslexia. Submitted manuscript.

Taking into account the instructions given and comments made by the co-authors, the author of the thesis conducted the data analyses and wrote reports I, II, and IV. In report III, the author took part in planning the design, conducted the analyses, and wrote the first version of the results. He also organized the data gathering and storage in all four studies.

FIGURES

TABLES

CONTENTS

1 INTRODUCTION

While cognitive predictors of early reading skills and reading disability identified during the first grades have been widely studied in dyslexia research, much less attention has been given to following up reading skill development after the early grades. Knowledge on the early predictors and precursors of dyslexia enable early interventions not only through the identification of children in need of support but also by suggesting suitable targets for interventions, and hence a research emphasis on this issue is highly warranted. Notwithstanding, only long-term follow-ups can reveal how stable individual differences are, whether there exist subgroups of children with different developmental trajectories, and whether compromised early skills have long-term consequences on reading skills in adolescence. Due to the fact that half of the subjects in the sample studied in this research had a family history of dyslexia, the stability of dyslexia was of special interest. The purpose of this research was to cast light on these issues, i.e., the reading skills of school-age children with familial risk for dyslexia.

1.1 Basic concepts in reading and reading disabilities

Dyslexia is a specific learning disability, and individuals with dyslexia are "characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities" (Lyon, Shaywitz, & Shaywitz, 2003, p. 2). In research, dyslexia has long been considered as the lower tail of a continuous, normally distributed reading skill (Shaywitch, Escobar, Shaywitch, Fletcher, & Makuch, 1992), although this has not always been the case. The ultimate goal of reading is, of course, to capture the meaning of what is read. In dyslexia, problems in reading comprehension are usually seen as a secondary consequence of reduced reading because of compromised reading skills (Lyon et al., 2003). The term "reading disability" is often used interchangeably with the term "dyslexia", although, according to DSM–5, individuals with reading disability have difficulties in "understanding the meaning what is read" (American Psychiatric Association, 2013, p. 66), i.e., reading comprehension. Reading comprehension, on the other hand, has usually been seen as the product of two separate, although closely related skills, decoding and language comprehension (Simple View of Reading; Gough & Tunmer, 1986). Probably the most well-known international reading assessment is the OECD Programme for International Student Assessment (PISA), which has been conducted once every three years from the year 2000. PISA aims at assessing skills that go beyond decoding and reading comprehension, i.e., reading literacy, and that instead involve "an individual's capacity to: understand, use, reflect on and engage with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society" (OECD, 2009, p. 14). In the present research, the terms "dyslexia" and "reading disability" were used interchangeably, and without taking into account skills in reading comprehension. Keeping dyslexia and reading comprehension separate as constructs enabled to examine, first, the effects of early cognitive skills on reading skills and dyslexia, and second, the effect not only of both family risk for dyslexia and early cognitive skills but also reading skills on reading literacy.

Reading skills can be further divided into reading accuracy and speed or fluency. Reading research has, up to the last 10–15 years, largely focused on the reading accuracy of English-speaking readers (Share, 2008), for whom learning to accurately decode words is highly challenging because of the deep and complex orthography of the language (Seymour, Aro, & Erskine, 2003). In a transparent orthography, like Finnish, which has consistent mapping between letters and phonemes, reading accuracy is quickly acquired (Aro & Wimmer, 2003; Holopainen, Ahonen, Lyytinen, 2001; Seymour et al., 2003). In consistent orthographies, problems in reading speed (i.e., rate of decoding) or reading fluency (i.e., reading speed adjusted for accuracy) is commonly seen as characteristic of individuals with reading disability (e.g., Frith, Wimmer, & Landerl, 1998; Peterson & Pennington, 2012; Wimmer, 1993). Fluent reading requires the ability to decode even unfamiliar and long words with ease or the ability to automatically recognize large chunks of letters or even complete familiar words without effort, autonomously, unconsciously and fast (Kuhn, Schwanenfugel, & Meisinger, 2010). Sometimes, in addition to accuracy and speed, the ability to use appropriate prosody is also included in the term reading fluency (e.g., Hudson, Lane, & Pullen, 2005), although this is not usually the case in dyslexia research. Fluent reading ability supports comprehension of the material to be read, because well automatized word reading skills free up resources for higher-level processing (Perfetti, 1985; Perfetti & Hart, 2001). The terms "reading speed" and "reading fluency" have often been used interchangeably, especially in consistent orthographies, where reading accuracy is very high soon after reading acquisition, and therefore both operationalisations result in close to equal measures.

1.2 Multiple deficit model of dyslexia

The multifactorial and partly overlapping nature of the aetiology related to different disorders (e.g., reading disability, attention deficit, and language deficit) together with the inability of single-deficit models to explain the different phenotypes of dyslexia and higher than expected comorbidity between dyslexia and other disorders lead Pennington (2006) to postulate the multiple deficit model of dyslexia. In addition to the multifactorial and interactional nature of the aetiology in reading, the model proposes that 1) risk and protective factors (both either genetic or environmental) operate probabilistically, altering the development of the cognitive functions necessary for normal development, 2) no single factor is sufficient for any disorder, and 3) the liability of any disorder is continuous and quantitative rather than discrete and qualitative (Pennington, 2006). In reading research and family risk studies, the idea of multiple risk factors, some of which are also transmitted to offspring without dyslexia, is nowadays widely accepted (e.g., Bishop, 2009; Snowling, 2008; van Bergen, van der Leij, & de Jong, 2014).

The multiple deficit model proposes four levels of analysis on which a specific disorder, like dyslexia, can be studied: aetiological, neural, cognitive and behavioural (symptom) (Pennington, 2006). Interactions within and between each level exist, resulting in a complex model, which, however, allows the construction of hypotheses that can be tested in research (Pennington, 2006). Family-risk studies offer one possibility for such testing. If what is suggested by the multiple deficit model is true, children born to a family with dyslexia 1) will inherit at least some of the aetiological risk factors, and therefore 2) have a higher probability of ending up with dyslexia compared to control children, 3) will show deficiencies in several cognitive domains already before reading skill acquisition, and 4) even those who do not end up with dyslexia will show somewhat compromised performance in reading-related cognitive skills. In a further step, van Bergen et al. (2014) have recently proposed an intergenerational multiple deficit model, in which they extend the previous model by including two intertwined pathways (genetic and environmental) through which parents affect their child’s liability for reading disability.

Empirical findings have mainly provided support for the continuity of the genetic liability of dyslexia suggested by the multiple deficit model, at least with English- and Dutch-speaking children. Studies comparing three groups (i.e., family-risk children with or without dyslexia, and control children), have mainly shown that the three groups differ from each other such that the family-risk children with dyslexia have shown the poorest, and the control children the best performance, while the children with familial risk but without dyslexia have performed at a level in between the levels of the two other groups in language and pre-reading as well as in literacy skills both prior to and after school entry (Boets et al., 2010; Pennington & Lefly, 2001; Snowling, 2008; Snowling, Callagher, & Frith, 2003; van Bergen, de Jong, Plakas, Maassen, & van der Leij, 2012; van Bergen et al., 2011). However, in the Finnish JLD sample, no significant differences were found between family-risk children without dyslexia and typical readers from control families in reading-related pre-reading skills before school-age or reading/spelling skills in Grade 2 (Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010). Thus far, no studies have examined the differences between the three groups beyond Grade 2 in Finnish. In Study II, knowledge of the continuity of the genetic liability of dyslexia in Finnish was enhanced by studying literacy skill differences between the three groups at school-age. Nevertheless, some support for the continuity of the genetic liability of dyslexia have also been found in Finnish: all three groups differed from each other in brain responses to non-speech pitch change in sounds at birth (Leppänen et al., 2010) and in the ability to discriminate speech-stimuli with a barely perceivable difference in Grade 2 and in Grade 3 (Pennala et al., 2010). These findings suggest that in the case of Finnish a fine-grained measure is needed to capture a feature in which all three groups differ from each other.

1.3 Genetic basis of dyslexia

Dyslexia runs in families. For children with a family history of dyslexia the risk for being affected is four- to ten-fold depending on the criteria used: 34%–66% of children born to families with dyslexia have been reported to have severe difficulties in reading and spelling acquisition during the first grades at school (Pennington & Lefly, 2001; Puolakanaho et al., 2007; Scarborough, 1990; Snowling et al., 2003; van Bergen et al., 2012), whereas the prevalence estimates in the population vary between 5% and 12% (Katusic, Colligan, Barbaresi, Schaid, & Jacobsen, 2001; Landerl & Moll, 2010; Shaywitz, S., Shaywitz, Fletcher, & Escobar, 1990). Slightly more males with reading problems have usually been reported both in clinical and research samples (Hawke, Olson, Willcutt, Wadsworth, & DeFries, 2009; Quinn & Wagner, 2015; Rutter et al., 2004). Studies in large enough population-based samples are scarce and cut-offs as well as the criteria according to which dyslexia is classified vary, and therefore little can be said about the universality of the prevalence rates of dyslexia. When the continuous nature of reading skills is taken into account, any cut-off dividing readers into those with and those without dyslexia will inevitably be somewhat arbitrary. However, the commonly used cut-offs in dyslexia research range from 1–1.5 standard deviations below the mean of the population-based sample, and are equivalent to 7–16% of the sample, assuming normality of the distribution in reading (e.g., Puolakanaho et al., 2007; Snowling et al., 2003; van Bergen et al., 2011).

Although learning to read depends on instruction, individual differences in reading skills are largely due to genetic inheritance from parents: estimates from heritability studies with mono- and dizygotic twins suggest that the heritability of reading skills ranges from 47% to 85% (Taylor, Roehrig, Hensler, Connor, & Schatschneider, 2010; Gayán & Olson, 2003, respectively) depending, amongst other things, on the reading outcome measure used (for a review of behaviour-genetic studies on reading, see Olson, Keenan, Byrne, & Samuelsson, 2014). It is important to notice, however, that these figures are informative only about the average aetiology of reading disability. For individual children, genetic influence can vary widely, and differences are also due to environmental effects, for example parental education (Olson et al., 2014).

Genetic linkage and behaviour-genetic studies on dyslexia have shown that several genes in different locations are involved, each accounting for a small proportion of the total genetic influence (e.g., Olson, 2006). So far, nine dyslexia gene loci with several candidate susceptibility genes have been found (Kere, 2014). However, several of these gene loci lack evidence of a specific gene, some of the genes found need replication, and "the combined genetic effects of the genes identified so far fall short of explaining the strong genetic background of DD" (developmental dyslexia) (Kere, 2014, p. 241). In addition, rather little is known about the mechanisms of the genes found, not to mention how they interact with the environment (Kere, 2014).

On the other hand, behaviour-genetic studies have shed light on the overlapping genetic and environmental aetiologies of reading disability and other developmental disorders. Empirical findings suggest that roughly 70% of the genes that are associated with reading disability also affect other learning disabilities (Kovacs & Plomin, 2007; Plomin & Kovacs, 2005). These so called generalist genes are also largely responsible for the variability between individuals in learning abilities and cognitive abilities per se, and not disabilities alone, suggesting that disabilities represent only the lower end of normally distributed skills (Kovacs & Plomin, 2007; Plomin & Kovacs, 2005). However, it is not only genetic components that are shared between different abilities: shared environmental effects also correlate highly between different learning abilities (Olson et al., 2014). Together, generalist genes and shared environmental effects between different learning abilities act in the same direction, causing individuals with different disabilities to more closely resemble each other. However, specialist genes also exist, causing a child to be better at one ability than another child, while nonshared environmental effects act in a similar direction (Kovacs & Plomin, 2007).

Putting together the facts presented above: several genes influence the variability between individuals' reading skills, as well as their reading ability and disability; the same genes that are involved in reading are also largely behind other learning abilities, for example mathematics; and shared environmental effects between, for example, reading and language-related skills are also highly correlated. These have several important implications for reading skills. First, (as already mentioned) reading skills are normally distributed; second, children with reading disability are more likely to have co-occurring deficiencies in other cognitive and academic skills; third, children with family risk for dyslexia will inherit different amounts and combinations of the influential genes leading either to dyslexia with or without other cognitive deficiencies, to other cognitive deficiencies "only", or to uncompromised or only slightly compromised development.

1.4 Cognitive predictors of reading skills and reading disability

Languages differ in their orthographic complexity or depth, i.e., the consistency of the mappings between letters and sounds. English has a deep/opaque orthography containing many inconsistencies and complexities, and a given letter or letter combination can be pronounced in several different ways. In Finnish, which lies in the other end of the orthographic depth continuum, consistency between letters and sounds is close to 100% in both directions: all the commonly used 20 letters have only one phoneme, and all 21 phonemes except one (/ŋ/) are marked with a single-letter grapheme (Aro, 2004). Orthographic consistency has been shown to be the key factor in determining the rate of learning to decode accurately in alphabetic languages, English, as the most complex orthography, taking the longest time, although the level of letter-sound acquisition was high after Grade 1 also in English in a comparison of thirteen European languages (Seymour, et al., 2003).

Despite differences in the difficulty of reading skill acquisition due to differences in orthographic complexity, the main predictors of reading accuracy and fluency (Landerl et al., 2012; Ziegler et al., 2010) and of growth in reading skills (Caravolas, Lervåg, Defior, Seidlová Málková, & Hulme, 2013) have been found to be rather universal. In their cross-sectional study with Grade 2 children from five different countries varying in orthographic consistency, Ziegler et al. (2010) showed, first, that phonological awareness was an important concurrent predictor of reading accuracy as well as of reading fluency in all the languages assessed; second, its weight was modulated by orthographic complexity showing the strongest effect in English, the most complex orthography; third, rapid automatized naming (RAN) was also a universal predictor, but its effect was smaller than that of phonological awareness and was restricted to reading fluency; fourth, verbal short-term memory had a small effect, especially in non-word decoding accuracy; and finally, vocabulary had a large significant effect, but only in Finnish. Letter knowledge was not included in Ziegler and his colleagues study. However, it has repeatedly been among the best predictors of later reading skills and disabilities in different orthographies, (e.g., Puolakanaho et al., 2007; Snowling et al., 2003; van Bergen et al., 2011), although its effect seems to be weaker in English (Caravolas et al., 2013). The similarity in the pattern of predictors in different orthographies suggests that the same mechanisms are involved in learning to read across alphabetic languages, although the relative strength of the different predictors seems to be modulated by orthographic depth (Landerl et al., 2012; Vaessen et al., 2010; Ziegler et al., 2010). Previous studies concerning the cognitive predictors of reading have mainly been carried out among children in early grades of school (e.g., Landerl et al., 2012; Puolakanaho et al., 2007; Vaessen et al., 2010; Ziegler et al., 2010).

Knowledge of the long-term predictive power of these cognitive skills on reading skills in upper grades is scarce, and therefore one of the foci of this research.

Phonological awareness refers to the conscious ability to perceive and manipulate the sound units of spoken words (e.g., Goswami & Bryant, 1990). These include the shortest and most basic speech units of language, phonemes, as well as larger units, such as syllables. There is a vast body of literature showing both concurrent and predictive associations between performances in phonological awareness and reading skills (see Castles & Coltheart, 2004, for a review). However, although it is suggested that learning to read itself alerts a beginning reader to the phonological units of words (Ehri, 1989) and that this has been confirmed empirically (e.g., Castles, Wilson, Coltheart, 2011; Perfetti, Beck, Bell, & Hughes, 1987), no firm conclusions can be drawn on the direction of the relationship between phonological awareness and reading acquisition. However, in dyslexia research the predominant view for many years has been that deficits in the phonological processing of sounds underlie the poor reading skills of individuals with dyslexia (e.g., Bradley & Bryant, 1983; Stanovich, 1988, 1998; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Consistent findings of deficient performance in children with family risk for dyslexia in tasks tapping phonological awareness (e.g., Boets et al., 2010; Pennington & Lefly, 2001; Snowling et al., 2003; Torppa et al., 2010; van Bergen et al., 2011, 2012) together with findings of compromised speech or even basic auditory processing skills resulting in inaccurate or fuzzy speech sound representations (for a review, see Hämäläinen, Salminen, & Leppänen, 2013) have supported this line of thinking. During the last 10–20 years, however, it has become evident that not all dyslexia phenotypes can be explained by phonological deficit and that not all children with phonological deficit will end up with dyslexia (Pennington, 2006).

In their "double-deficit hypothesis of developmental dyslexias", Wolf and Bowers (1999) suggested that, in addition to phonological deficits, deficit in rapid automatized naming (RAN) would be another, and largely independent source of reading difficulties. In the RAN task, developed by Denckla and Rudel (1976), individuals are instructed to name a series of familiar visual items (usually objects, colours, digits, or letters) as quickly as possible. It has been suggested that the task "invokes a microcosm of the later developing more elaborated reading circuit" (Norton & Wolf, 2012, p. 429), and that its performance involves several subcomponents, including attentional, visual, and integrational processes of orthographic, phonological as well as semantic information together with the motor activation leading to articulation (Norton & Wolf, 2012; Wolf & Bowers, 1999). Attempts have been made to reveal the crucial aspects of rapid naming that explain its predictive power for reading, inter-item pause time showing more promising results than articulation speed (Georgiou, Parrila, & Kirby, 2006; Georgiou, Parrila, Kirby, & Stephenson, 2008; Neuhaus, Foorman, Francis, & Carlson, 2001) leaving, however, unexplained what processes within or other than retrieval are activated during inter-item pause times. Despite not fully understanding the specific mechanism that relates rapid automatized naming to reading difficulties, it has been extensively shown to have both concurrent and predictive associations with reading (e.g., Kirby, Parrila, & Pfeiffer, 2003; Landerl & Wimmer, 2008; Papadopoulos, Georgiou, & Kendeou, 2009; Torppa, Georgiou, Salmi, Eklund, & Lyytinen, 2012; van Bergen et al., 2011). The relationships between RAN and reading fluency have tended to be stronger than those between RAN and reading accuracy (e.g., Georgiou, Parrila, & Kirby, 2009; Georgiou, Parrila, & Papadopoulos, 2008; Ziegler et al., 2010; for a meta-analysis, see Araújo, Reis, Petersson, & Faísca, 2015), and the relationship has been shown to strengthen along with reading skill development (Kirby et al., 2003; Vaessen et al., 2010).

Letters serve fundamental functions in alphabetic writing systems, and the ability to associate the correct phonemes (letter sounds) with printed graphemes in a word, letter knowledge, is the basis for word decoding and reading skill acquisition (Byrne, 1989; Ehri, 1998). Contrary to phonological awareness and rapid naming, letter knowledge acquisition is dependent on parental or educational support (Gallagher, Frith, & Snowling, 2000; Piasta & Wagner, 2010; Torppa, Poikkeus, Laakso, Eklund, & Lyytinen, 2006). Letter knowledge is often measured with either or both of two different tasks, letter-sound knowledge and letter-name knowledge. Although both of these have some specific predictive power for reading achievement (McBride-Chang, 1995), they are highly correlated, letter-name knowledge typically being learnt earlier and therefore helping in the learning of letter sounds in cases where letter names give hints of their sounds (Share, 2004; Treiman, Tincoff, Rodriguez, Mouzaki, & Francis, 1998). The predictive role of letter knowledge for reading skill acquisition and reading disability is well established in the literature (e.g., Gallagher et al., 2000; Hammill, 2004; Pennington & Lefly, 2001; Puolakanaho et al., 2007; Torppa et al., 2006, 2010). However, the cognitive basis of letter knowledge is not well known, although phonological sensitivity has been shown to predict it both in children with and without family risk for dyslexia (Torppa et al., 2006). On the other hand, it has been suggested that the reason why letter knowledge is such a good predictor of further reading skills is its ability to enhance phonemic sensitivity (Foulin, 2005), supporting the idea of a reciprocal relationship between phonological sensitivity and letter knowledge (Burgess & Lonigan, 1998).

Reading itself and the cognitive skills children need for reading do not develop in a vacuum. At the same time as behaviour-genetic studies suggest strong heritability estimates, ranging from 47% to 85% (Gayán & Olson, 2003; Taylor et al., 2010), for reading skills, they mostly remain far from 100%, leaving a substantial proportion to be explained by the environment and gene-environment interaction. Children with family risk for dyslexia are often living with at least one parent who has compromised reading skills, a situation which, in principle, affords a less optimized home literacy environment (HLE) for a growing child, who may possibly be less read to, exposed to less printed material, or provided with a less positive reading model. However, although adults with dyslexia read less themselves (Leinonen et al., 2001; Scarborough, Dobrich, & Hager, 1991; Torppa et al., 2007) empirical studies have usually failed to show differences in the amount or quality of parents' shared reading with their children (Laakso, Poikkeus, & Lyytinen, 1999; Scarborough et al., 1991; Torppa et al., 2007; Torppa, Eklund, van Bergen, & Lyytinen, 2011; van Bergen et al., 2011). In addition, the direct associations with the HLE seem to be limited to language development, whereas more active involvement, such as teaching, is needed from parents to enhance their child's pre-literacy skills in such areas as letter knowledge or phonological awareness (Martini & Sénéchal, 2012; Mol & Bus, 2011; Sénéchal, 2006; Sénéchal & LeFevre, 2002; Torppa et al., 2006, 2007). Although there is some evidence to show that concurrently measured exposure to print explains more of the variance in the basic reading skills of schoolchildren with lower reading abilities compared to children with age-appropriate reading skills, 15% and 4%, respectively, (Mol & Bus, 2011), no effects of the early HLE on later reading achievement have been found in family-risk studies (Snowling, Muter, & Carroll, 2007; Torppa et al., 2007, 2011).

Behavioural genetic studies have shown that individual variation in the environments that one is exposed to is not solely induced passively (as described above); instead, depending on their genetic make-up individuals also actively select their environment and evoke different reactions from nearby humans (Plomin, DeFries, & Loehlin, 1977). Accordingly, a child's interest in reading has been shown to have a unique predictive power for his/her early literacy skills even after controlling for parental teaching, which serves as a partial mediator (Martini & Sénéchal, 2012). Parental teaching, on the other hand, seems to be associated with parents' beliefs and expectations about their child's skills and behaviour, e.g., task-focused behaviour (Martini & Sénéchal, 2012; Stephenson, Parrila, Georgiou, & Kirby, 2008). When comparing the effects of the HLE, parents' beliefs and expectations, and children's task-focused behaviour on emergent literacy and word reading, children's task-focused behaviour was found to be the most important factor. Moreover, it turned out to be the only one of these three factors with a significant direct effect (in addition to an indirect effect via emergent literacy) on word reading skill in Grade 1 (Stephenson et al., 2008). This was in line with earlier findings on the effect of task-focused behaviour on emergent reading skills in Finnish children (Lepola, Poskiparta, Laakkonen, & Niemi, 2005; Lepola, Salonen, & Vauras, 2000; Salonen, Lepola, & Niemi, 1998). No differences between family risk and control children were found in their reading interest before school-age (Torppa et al., 2007, 2011). Moreover, although the meta-analysis by Mol and Bus (2012) confirmed the widely held assumption of a bi-directional association between print exposure and reading skills, family-risk studies on this and on the longitudinal associations between task-focused behaviour and later reading skills are lacking. Therefore, their potential to serve as possible protective factors against reading difficulties in children with family risk is unclear. This question was addressed in Study I.

1.5 Development and stability of individual differences in reading skills

Skilled reading is often paralleled to accurate and fast word identification which happens with ease without noticeable effort, and this seems to be a universal feature irrespective of language or orthography (see Share, 2008). There is broad agreement that the learning of letter-sound correspondences and phonological recoding (decoding), i.e., translation of letter strings into sounds, are the first essential building blocks of reading acquisition across languages. In fact, according to the self-teaching theory of reading, phonological recoding is a sine qua non of successful reading acquisition insofar as "there can be no case of competent reading in the absence of functional decoding" (Share, 1995, p. 173). However, more is needed to acquire fluent reading skills. In addition to decoding words letter by letter, an alternative way of determining the correct pronunciation (and meaning) of a letter string is sight word recognition. According to the self-teaching theory, the development of an orthographic knowledge of words is based on the child's independent usage of grapheme-phoneme rules and analogies when confronting new words (Share, 1995). Repetitive exposure to familiar words and their successful identification is postulated to lead to their instant visual recognition with minimal phonological processing (Share, 1995). However, in light of the specific features of the Finnish orthography, the large amount of polysyllabic long words in Finnish and its agglutinative morphology, it is reasonable to assume that, to facilitate faster reading, direct connections exist between the written and spoken forms of words at the level of sublexical multiletter units as well as that of whole words (Huemer, 2009). From the information processing point of view reading development can be considered as a process of moving from accuracy requiring conscious attention to fluent automatic reading (LaBerge & Samuels, 1974).

The development of reading accuracy, which reflects the development of decoding skill, is highly dependent on the orthography of the language in question, being slow in the highly opaque orthography of English and faster in the more transparent orthographies: for example, in a comparative study, only half of the pseudowords assessed were correctly read at the end of Grade 1 in English, whereas in the more transparent orthographies the corresponding proportion was 80–90%, a level of accuracy that was not achieved by English readers before the end of Grade 4 (Aro & Wimmer, 2003). The ease with which accurate decoding skill is acquired in the more transparent orthographies has been confirmed by several studies (e.g., Frith et al., 1998; Holopainen et al., 2001; Seymor et al., 2003). In contrast to reading accuracy, the development of reading fluency across different orthographies follows a more similar pattern: after showing a steep rise in Grade 2, progression in reading speed gradually diminishes over the subsequent grades (Aro & Wimmer, 2003). Non-linear growth curves, reaching a plateau in adolescence, have been reported in English when reading was evaluated with a composite score comprising reading accuracy, fluency, and reading comprehension (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996; Shaywitz et al., 1999).

Stability in reading development can be studied in several ways: first, by examining the stability of the relative positions of individuals, i.e., strength of the associations between reading measures at different time points; second, by inspecting the stability of groupings of individuals; and third, by comparing developmental trajectories between groups identified at an early age. There is evidence from the few correlational studies extending beyond the early reading acquisition stage that the rank ordering of participants remains fairly stable up to adolescence in both reading accuracy (English-speaking) (e.g., Catts, Compton, Tomblin, & Bridges, 2012; Parrila, Aunola, Leskinen, Nurmi, & Kirby, 2005) and reading fluency (German-speaking) (Landerl & Wimmer, 2008). In addition, English-speaking children with familial risk for dyslexia and fulfilling the criteria for reading disability at age 8 years continued to show the poorest performance both in reading accuracy and fluency five years later (Snowling et al., 2007), supporting the idea of stability in the relative positions of individuals in reading skills. However, to my knowledge, there exist only one study in transparent orthography, i.e., the study by Landerl and Wimmer (2008), focusing on the stability of relative positions of individuals in reading fluency through a long follow-up period from early to upper grades. Therefore, more research on this issue is highly warranted and this question was examined in Study II, as well.

While in most of the studies with unselected samples relatively high proportions of the individuals with the lowest reading scores have remained in the same group throughout the follow-up period (Francis et al., 1996; Juel, 1988; Landerl & Wimmer, 2008; Schaywitch et al., 1999), contradictory findings have also been reported. In the study by Phillips and her colleagues (2002), only half of the children in the lowest reading group retained their position when followed from Grade 1 to Grade 6. Moreover, a subgroup of children with no difficulties in the early stage of reading acquisition but with evolving difficulties in Grade 4 or thereafter, i.e., children with late-emerging reading disability, has been reported among English-speaking children in several studies (Catts et al., 2012; Compton, Fuchs, Fuchs, Elleman, & Gilbert, 2008; Etmanskie, Partanen, & Siegel, 2016; Leach, Scarborough, & Rescorla, 2003; Lipka, Lesaux, & Siegel, 2006). While the prevalence rate of children with late-emerging RD is difficult to determine accurately due to inconsistencies in samples, measures and the grouping criteria used, the most recent studies estimate that approximately 40% of children classified as poor readers are late-emerging (Catts et al., 2012). In addition to late-emerging children, a group of children showing a different developmental path has also been detected. These children, described as children with resolving RD, manifested difficulties in early reading acquisition during the first grades but no longer in the later grades (Catts et al., 2012; Leach et al., 2003). The gender distribution in these subgroups has also varied from an equal distribution (Catts et al., 2012; Leach et al., 2003) to a slight predominance of girls in the resolving RD group (Phillips et al., 2002).

Two obvious discrepancies or limitations in the previous research on the stability of groupings complicate the drawing of firm conclusions. First, children have been grouped according to different skills and cut-offs in different studies. Grouping has been based either on word identification accuracy (Lipka et al., 2006), reading comprehension skills (Phillips et al., 2002) word identification accuracy together with reading comprehension skills (Catts et al., 2012; Etmanskie et al., 2016), a combination of word identification accuracy, word reading fluency and reading comprehension skills (Compton et al., 2008), or having separate groups for each compromised skill (word reading, reading comprehension, or both) (Leach et al., 2003). The key question in grouping is whether to retain in a single measure, for example, word identification, and accept its limited capacity to fully cover reading skills in the later grades, or whether, using several measures, to accept that they do not necessarily all have the same weight at different assessment ages (Bast & Reitsma, 1998; Compton et al., 2008). While the use of several measures has been recommended owing to the higher reliability and stability of the grouping outcome, the fact that such a design hinders study of the effects of the componential skills of reading is also recognized (Compton et al., 2008). From the point of view of mapping the stability of dyslexia status, the grouping criterion is highly relevant, as children with dyslexia are not primarily expected to have problems in reading comprehension (Lyon, 2003). Therefore, in studies focusing on the stability of dyslexia, the diagnostic criterion for grouping can be expected to be based on either reading fluency (transparent orthographies) or reading fluency and accuracy (opaque orthographies). Second, all the studies so far have been carried out with English-speaking children. As a consequence, the results are not directly applicable to transparent orthographies like Finnish, where learning to decode is rapid in comparison to English (Aro & Wimmer, 2003). In Study III, the existence of different developmental subgroups, as well as gender differences in them were examined among Finnish-speaking children to figure out the universality of this phenomenon across orthographies.

Both correlational and grouping stability analyses fail to show what happens to the differences between groups over time: do they increase, decrease or remain stable? Since Stanovitch (1986) suggested applying the "Matthew effect" to describe the reading development of subgroups with different states of reading readiness, that is, that differences between individuals will increase in accordance with their earlier skills, several attempts have been made to demonstrate the validity of the concept in practice. Of special interest has been the comparison of the development of children with poor pre-reading skills to that of children with good cognitive readiness for reading acquisition, as this forms a natural research design for testing the hypothesis that reciprocal relationships exist between early cognitive and later reading skills. The results have been mixed: Shaywitz et al. (1995) found no evidence of the Matthew effect for reading, although they speculated that this might be due to the limited measures of reading skills used, i.e., including mainly measures of word decoding accuracy. In a Dutch sample, Bast and Reitsma (1997, 1998) found evidence for the Matthew effect in decoding fluency, but not in reading comprehension. Finally, Parrila et al. (2005) found that, in their Canadian sample, individual differences mainly decreased over time, whereas, in their Finnish sample, differences in word identification increased, individual differences in oral reading fluency remained stable, and no clear pattern emerged in reading comprehension. Unfortunately, the follow-up of the Finnish sample only lasted until the end of Grade 2 (Parrila et al., 2005), and therefore nothing can be said about the subsequent development of individual differences in later grades. In Study II more light was shed on this issue, as the follow-up was continued to Grade 8.

1.6 From learning to read to learning by reading

In the national core curriculum for basic education (Finnish National Board of Education, 2016) the aims set for the teaching of reading skills change with ascending grades. While in Grades 1 and 2 learning the basic techniques of reading, becoming aware of the importance of practice in reading, and learning to observe oneself as a reader are the main objectives, in Grades 3 to 6 the emphasis is on establishing fluency in reading, learning different strategies for reading comprehension, and learning to evaluate various kinds of texts and oneself as a reader. Moreover, in secondary school (Grades 7–9) pupils should be encouraged to further develop their skills in comprehending, evaluating and interpreting different kind of texts to be able to act as active and participating citizens and to manage in further education and working life.

While the aims laid down for reading instruction in the national core curriculum for basic education follows the development of reading skills from basic reading to reading comprehension and applying reading in learning new things, the challenges set for individual pupils also increase with ascending grades. Of special interest from the perspective of this research is how children with family risk for dyslexia are to be prepared for the new challenges accompanying these new demands, for example those related to reading comprehension. Efficient decoding has generally been seen as a necessity for reading comprehension, as well-automatized word reading skills are thought to free up resources for higher-level processing (LaBerge & Samuels, 1974; Perfetti, 1985). According to the lexical quality hypothesis, the other cornerstone of reading comprehension is a large, high quality lexicon (Perfetti & Hart, 2001), and numerous empirical studies have shown a strong link between vocabulary and reading comprehension (e.g., Muter, Hulme, Snowling, & Stevenson, 2004; Nation & Snowling, 2004; Storch & Whitehurst, 2002; Torppa et al., 2007; Verhoeven & van Leeuwe, 2008). Children with a family history of dyslexia are known to be at high risk for encountering difficulties with decoding and word identification, as summarized earlier in this introduction. In addition, family-risk children with dyslexia have been shown to have deficient skills in early receptive and expressive vocabulary (e.g., Snowling et al., 2007; Torppa et al., 2010) and verbal short term memory (Boets et al., 2010; Pennington & Lefly, 2001; for a recent meta-analysis of oral language development, see also Snowling & Melby-Lervåg, 2016) already before school age, potentially further hindering their reading comprehension skills. Therefore, it is no surprise that English-speaking family-risk children with dyslexia have been shown to have lower reading comprehension skills than their peers at 12–13 years of age (Snowling et al., 2007). However, the study by Snowling and her colleagues (2007) is, to my knowledge, so far the only one concentrating on reading comprehension skills of children with family risk for dyslexia, and therefore, more research on this issue is warranted. In Study IV, in addition to examination of the associations between family risk and reading comprehension, I also focused on the relative importance of early cognitive skills and reading fluency in school-age in predicting reading comprehension at the end of secondary school.

The aims set down by the Finnish National Board of Education for secondary school (see above) bear a very close resemblance to what the OECD Programme for International Student Assessment (PISA) aims to assess at the age of 15 years in Grade 9, i.e., reading literacy, which involves "an individual's capacity to: understand, use, reflect on and engage with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society" (OECD, 2009, p. 14). The skills needed for success in the PISA reading task include decoding, knowledge of words, grammar and other linguistic skills, textual structures and features, and metacognitive knowledge (OECD, 2009), i.e., they go beyond basic reading and reading comprehension skills. However, research on cognitive prerequisites of PISA reading literacy is very limited. A recent study by Arnbak (2012), showed that concurrently measured word identification and vocabulary explained approximately 40% of PISA reading literacy, but nothing is known about the early cognitive predictors of PISA reading performance. Nevertheless, the PISA reading task serves as an excellent outcome measure that can help to answer an important question: What are the literacy capabilities of children with family risk for dyslexia to succeed in further education and subsequently as members of society?

1.7 Aims of the research

The focus of this research was the school-age reading skill development of children with family risk for dyslexia, its predictability by cognitive skills, different developmental profiles of reading, and prediction of reading literacy outcome at the end of secondary school. Figure 1 illustrates the designs of Studies I–IV.

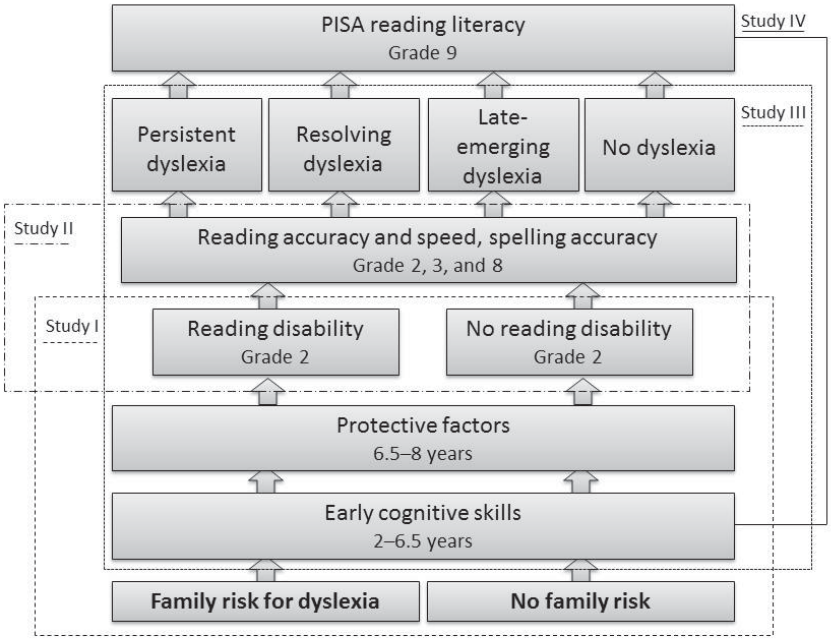


FIGURE 1 Designs of Studies I–IV

In Study I, it was examined how large a proportion of children with either a high or low early cognitive risk profile would end up manifesting reading disability at the end of Grade 2. In addition, I was interested in whether task-focused behaviour or reading habits (shared reading with a parent or reading alone) would differentiate children with different reading outcomes in Grade 2, i.e., with or without reading disability. Possible differences between the two outcome groups in these measures would suggest that they could serve as protective factors against early reading disability.

In Study II, the development of reading and spelling skills in two groups with family risk for dyslexia was examined; one with and one without reading disability in Grade 2. By comparing the development of these groups with that of children without family risk and with no reading disability through Grades 2, 3, and 8 I aimed to find out, first, to what extent are the differences between these three groups in reading and spelling skills stable throughout the follow-up period, second, whether evidence for the continuity of family risk for dyslexia could be found, and third, what reading-related processes might explain the slower reading speed of children with family risk for dyslexia and reading disability in Grade 2.

In Study III, I switched the focus from inspecting continuous reading skill to examining the stability of dyslexia status categorically. I was interested in whether similar subgroups of children with different developmental profiles in reading could be found in the context of the Finnish orthography as earlier found in English. Moreover, the children's gender distribution, exposure to print and cognitive profiles, and the cognitive profiles of their parents in these subgroups were examined in seeking to characterize these groups.

Finally, in Study IV, the reading literacy outcome of children with family risk for dyslexia in Grade 9, at age 15, was examined. In focus was the predictability of the PISA reading literacy performance from early cognitive skills before school-age and reading fluency at school-age, and whether the findings were similar in boys and girls with and without family risk for dyslexia.

2 METHOD

2.1 Participants

All the participants were drawn from the Jyväskylä Longitudinal Study of Dyslexia (JLD) (e.g., Lyytinen et al., 2008), and were screened from among 9 368 newborns born in the province of Central Finland between April 1993 and July 1996. Participants were originally selected for one of two groups: individuals with family risk for dyslexia or without family risk for dyslexia, i.e., the control group. The selection was made following a three-stage procedure including 1) a short parental questionnaire on difficulties experienced by parents and their close relatives in learning to read and spell, 2) a detailed parental questionnaire on their own reading history and the persistence of reading and spelling difficulties, and 3) an assessment of the parents' reading and spelling skills.

For the child to be included in the family risk group (n = 108) at least one parent had to show deficient performance in oral text reading or spelling, and in phonological and orthographic processing. In addition, reported onset of literacy problems during the early school years and a first-degree relative with corresponding difficulties were required. In the control group (n = 92), both parents had to have no family history for dyslexia and a z-score above –1.0 in all the administered reading and spelling tasks. The IQ of all parents had to be equal to or above 80 (for full details on the recruitment procedure, see Leinonen et al., 2001).

All the children spoke Finnish as their native language, had no mental, physical, or sensory impairments, and attended regular classroom education. The attrition rate was very low in the assessments before school age and during school age up to the end of Grade 3 (age 10 years), the end point of the follow-up agreed with the child's parents when they gave their consent to participate. Practically all 200 children participated in all the assessments – only single, randomly distributed missing values exist in the data for these years. For the assessments in adolescence (Grades 7–9), 182 parents signed new consents, and 159 adolescents agreed to participate in the PISA reading literacy assessment in

Grade 9. Attrition in this assessment was similar to that in the family risk and control groups, at 18.5% and 22.8%, respectively. Moreover, no differences in cognitive skills before school age or reading skills during school age were found between children who participated vs. did not take part in Grade 9 assessment.

2.2 Criteria for classification of children with dyslexia

Children were classified having dyslexia in two different ways. In Study I and Study II, the classification was done at the end of Grade 2, and was based on reading speed and accuracy as well as spelling accuracy. In Study III, the classification was done in both Grade 2 and Grade 8, and was based solely on reading speed. There were two reasons for using only reading speed in the Study III dyslexia classification: first, hardly any variance remained in the reading and spelling accuracy measures in Grade 8 and, second, I wanted to use identical criteria in both assessments to be able to examine the stability of dyslexia status without the interference of possible confounding effects arising from the use of different criteria.

The classification of dyslexia used in Study I and Study II in Grade 2. Dyslexia was identified on the basis of the children's performance in five tasks: 1) oral word and pseudoword reading, 2) oral text reading, 3) oral pseudoword text reading, 4) oral word list reading, and 5) spelling words and pseudowords. Four measures of reading speed were calculated: the mean response time of the correctly read words and pseudowords presented one by one, the number of words read per minute in the Oral text reading task, the number of pseudowords read per minute in the Oral pseudoword text reading task, and the number of correctly read words during two minutes in the Oral word list reading task. Four percentage measures of reading and spelling accuracy were calculated: the percentage of correctly read words and pseudowords presented one at a time, correctly read words in the Oral text reading task, correctly read pseudowords in the Oral pseudoword text reading task, and correctly written words and pseudowords, presented one by one in a dictation task. For the identification of dyslexia, a two-step procedure was used. First, the cut-off criterion for deficient performance in each of the eight measures was defined as the 10th percentile of the performance of the control group. Second, a child was considered to have dyslexia if she/he scored below the criterion in at least three out of the four measures of reading speed and/or in at least three out of the four measures of reading and spelling accuracy. In addition, a child who scored below the criterion in both two speed and two accuracy measures was considered to have dyslexia.

Classification of dyslexia used in Study III in Grade 2 and Grade 8. The dyslexia criteria were based on the child's performance in the following three oral reading tasks: word list reading, text reading, and pseudoword text reading. Reading speed was operationalized as the number of words/pseudowords read per minute. For the identification of dyslexia, first, a cut-off criterion for deficient performance was defined for each measure, using the 10th percentile in the distribution of the control children. Subsequently, a child who scored below the criterion in at least two out of the three measures of reading speed was considered to have dyslexia.

2.3 Measures

The skill domains assessed and the children's ages at assessment s in Studies I–IV are presented in Table 1. To ensure high reliability, a composite mean score computed from the standardized values of the different measures was used whenever possible. For a detailed description of the specific methods used, please see the original articles.

TABLE 1 Skill domains and children's ages at assessment in Studies I–IV

Skill domain	Assessment age (years) /Grade	Study I	II	III	IV
Language skills	2.0–2.5				X
	3.5			X	X
	5.0–5.5	X		X	X
	Grade 2			X	
Verbal short term memory	3.5				X
	5.0–5.5				X
	6.5	X		X	X
	Grade 2	X		X	
	Grade 3			X	
	Grade 8			X	
Phonological awareness	3.5				X
	4.5			X	
	5.0–5.5			X	X
	6.5	X		X	X
	Grade 1	X			
	Grade 3			X	
	Grade 8			X	
Rapid serial naming	3.5				X
	5.0–5.5			X	X
	6.5	X		X	X
	Grade 2	X			
	Grade 3			X	
	Grade 8			X	

Skill domain	Assessment age (years) /Grade	Study			
		I	II	III	IV
Letter knowledge	3.5				X
	4.5			X	
	5.0–5.5			X	X
	6.5	X		X	X
	Grade 1	X			
IQ	5.0	X			
	Grade 2	X			
Book reading	4.0			X	
	5.0			X	
	6.0–6.5	X		X	
	Grade 2	X		X	
	Grade 3			X	
	Grade 7			X	
Task avoidance	6.5	X			
	Grade 1	X			
	Grade 2	X			
Reading accuracy	Grade 2	X	X		
	Grade 3		X		
	Grade 8		X		
Reading speed	Grade 1				X
	Grade 2	X	X	X	X
	Grade 3		X		X
	Grade 8		X	X	X
Spelling accuracy	Grade 2	X	X		
	Grade 3		X		
	Grade 8		X		
Reading literacy	Grade 9				X

3 OVERVIEW OF THE ORIGINAL STUDIES

3.1 Study I

Predicting reading disability: early cognitive risk and protective factors

In this study, I examined the reading outcome of two groups: children with a high and children with a low early cognitive risk profile. The children were classified into these two groups on the basis of a previously performed mixture modelling procedure, in which four subgroups with different developmental trajectories were identified (Lyytinen et al., 2006). The children classified having high cognitive risk were characterized either by significant difficulties in naming speed accompanied by poor performance in morphology, phonological awareness and letter knowledge (*Dysfluent)* or with a declining trajectory in all the assessed cognitive skills except memory skills (*Declining)*. In turn, the children with strong language skills but poor letter knowledge (*Unexpected)* and children with no difficulties in their early cognitive development (*Typical)* were classified as having a low cognitive risk profile.

I was interested in, first, to what extent children with a low early cognitive risk profile and those with a high cognitive profile would end up with reading disability (RD) at the end of Grade 2, and second, whether I would find any factors that would distinguish children with different reading outcomes despite a similar cognitive background (see Figure 2). The specific research questions were: 1) What proportion of the children in the four subgroups had RD at the end of Grade 2? 2) Why did some of the children classified as having a high early cognitive risk profile for RD exhibit RD while others did not? And, further, why did some of the children end up with RD despite having a low cognitive risk? 3) To what extent were print exposure and task-focused behaviour protective factors against RD?

The participants comprised 198 children (106 at risk for familial dyslexia, 92 controls) for whom complete data were available and ranged from age 5 years to age 8 years 10 months at the end of Grade 2. Receptive and expressive language, morphology, letter knowledge, phonological awareness, rapid serial naming, memory, and IQ were used to assess the children's cognitive skills. Candidate protective factors possibly moderating the reading outcome were shared reading with parents, task-focused behaviour (rated by parents, teacher, and tester), and reading alone (parent report).

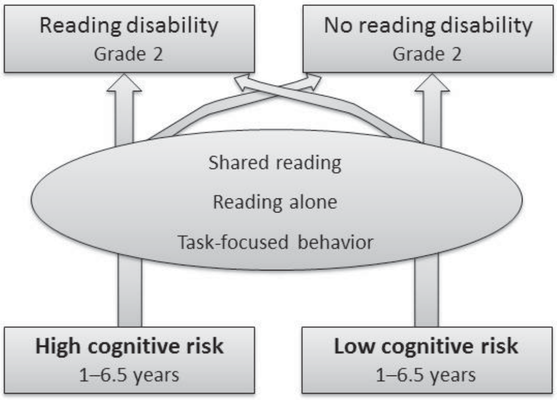


FIGURE 2 Design of Study I

The results suggested that although reading disability was identified in both groups, i.e., with high and low early cognitive risk profiles, it was more common in children with high early cognitive risk. The largest proportion was found in the Dysfluent subgroup, despite the fact that the classification of RD was based on both reading accuracy and fluency. The large majority of the children with RD in each subgroup had family risk for dyslexia. Cognitive skills before school-age did not differ between the children with high early cognitive risk but different reading outcome (RD vs. no RD); however, after one year of schooling, the children who ended up with RD had poorer phonological skills. In addition, the children with high cognitive risk but no RD were, according to their teachers, more task-focused even when faced with demanding tasks. On the other hand, the amount of shared reading provided to children with high cognitive risk and RD grew more between ages 6 and 8 when compared to that provided to children with a similar cognitive background but different reading outcome, i.e., no RD at the end of Grade 2. Finally, comparisons between the children with low early cognitive risk suggested that poorer cognitive skills, task avoidance and less time spent reading were significant risk factors for RD.

It may be concluded from the first study that poor cognitive skills before school-age and family risk for dyslexia elevate the risk for having reading disability after two years of schooling, even when the high vs. low early cognitive risk profiles were examined categorically. However, the associations do not appear to be straightforward. Maintaining children's interest in educational and literacy-based tasks seems to protect them from reading disability even among those whose pre-reading skills are not optimal for reading acquisition. Fortunately, the children with high early cognitive risk and RD at the end of Grade 2 were not left alone with their difficulty. Parents seemed to react by increasing their amount of shared reading with these children during the early school years.

3.2 Study II

Literacy skill development of children with familial risk for dyslexia through grades 2, 3, and 8

In Study II, I compared the development of reading speed, reading accuracy and spelling across three groups of children classified according to their family background and reading skills at the end of Grade 2. The children with family risk for dyslexia were divided in to two groups, with RD vs. no RD, and were compared to children with no family history of dyslexia and no RD at the end of Grade 2. The development of the three groups was followed through Grades 2, 3, and 8 (see Figure 3).

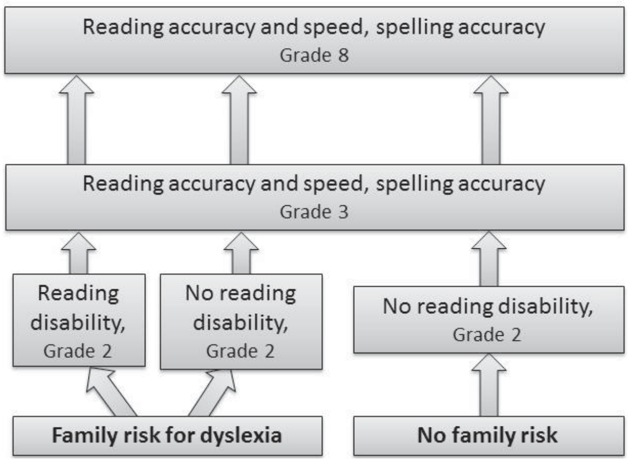


FIGURE 3 Design of Study II

I was interested, first, in how stable the relative positions of individuals were across this six-year period after the early reading acquisition phase, second, in whether I would find evidence for continuity in family risk for dyslexia in the Finnish orthography, and third, in whether I would find any explanations for the deficient reading speed of children with family risk and RD. The specific research questions were: 1) What is the stability of reading and spelling skills after the early reading acquisition phase? 2) What is the effect of family risk for dyslexia on the development of reading and spelling? 3) Are reading speed differences in the different reading tasks and materials used (word list, text and pseudoword text) similar across the three groups of participants and across Grades 2, 3, and 8?

Altogether, 173 children participated in this study. Nine children with RD but without family risk at the end of Grade 2 were excluded from the study because of the small group size and to retain comparability with other studies examining the continuity of the genetic risk for dyslexia. In addition, 18 of the 200 screened and followed children refused to take part in the 8th grade assessments. Composite scores of the three oral reading tasks (text, pseudoword text, and list of words) were used to measure reading accuracy and speed. Spelling accuracy was assessed with a pseudoword spelling task.

The results indicated high stability in reading speed, whereas in reading and spelling accuracy, the level of stability was slightly lower. The children with family risk and RD showed deficient reading and spelling skills throughout the six-year follow-up, although in this group slightly better progress was found in reading speed between Grade 2 and Grade 3, in reading accuracy between Grade 3 and Grade 8, and in spelling accuracy throughout the follow-up, when compared to the children with no RD irrespective of their family background. The latter two groups differed from each other in only one of the 21 measures of reading and spelling. Examination of reading speed in the three tasks showed that the children with family risk and RD were still reading the words on the wordlist and the pseudowords in the pseudoword text at the same speed in Grades 2 and 3, while, in Grade 2, the children in the other two groups were already reading the words on the wordlist and in the text faster than the pseudowords in the pseudoword text.

I may conclude from this study, first, that the mean level of reading and spelling skills of children with family risk and RD at the end of Grade 2 is substantially lower than the skills of children without RD, and that in Grade 8 the developmental lag is approximately 5 years. Second, these differences tend to remain throughout the primary and secondary grades, and third, the deficient reading speed of these children seems to be a consequence of a stronger reliance on letter-by-letter decoding or difficulties in usage of their lexicon disabling fast word recognition, or both. In addition, weak support for the continuity of family risk for dyslexia was found.

3.3 Study III

Late-emerging and resolving dyslexia: a follow-up study from kindergarten to Grade 8

In Study III my main focus was on the stability of dyslexia status. I compared four groups of children, formed according to the children's reading status in Grade 2 and Grade 8: dyslexia in both grades (*Persistent dyslexia*), dyslexia in Grade 2 but not in Grade 8 (*Resolving dyslexia*), no dyslexia in Grade 2 but dyslexia in Grade 8 (*Late-emerging dyslexia*), and no dyslexia in either grade (*No dys-*

lexia). The four groups were compared in their cognitive skills (vocabulary, verbal short-term memory, phonological awareness, rapid naming, and letter knowledge) and print exposure (amount of book reading). Differences between the four groups in parental reading fluency (text reading) and cognitive skills related to reading (vocabulary, verbal short-term memory, phonological awareness, and rapid naming) were also examined (see Figure 4).

I was interested first, in how large a proportion of children classified as having dyslexia in Grade 2 would also be classified as having dyslexia in Grade 8, indicating persistent difficulties in reading, and second, in whether I would find subgroups of children with changing dyslexia status, i.e., children with resolving or late-emerging dyslexia, as have been found earlier in English. I was also interested in whether the four groups would differ in their cognitive skills, exposure to print, or parental reading fluency or cognitive skills. The specific research questions were: 1) What is the instability of dyslexia between Grade 2 and 8? 2) Do the four groups differ in a) the development of reading speed b) the development of language and cognitive skills c) the amount of book reading d) gender or e) parental reading and reading-related cognitive skills?

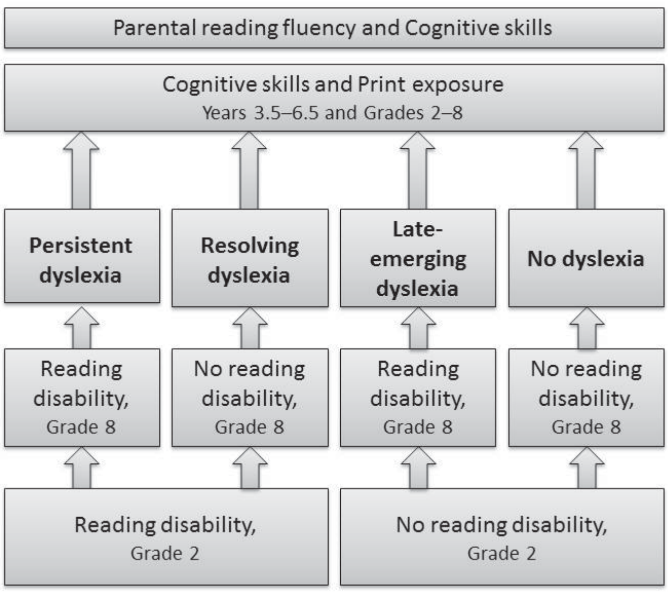


FIGURE 4 Design of Study III

All 182 JLD children who participated in the Grade 8 assessments were included in this study. According to their dyslexia status in Grade 2 and 8 they were divided into four groups: dyslexia in both grades (*Persistent dyslexia*, n = 22), dyslexia in Grade 2 but not in Grade 8 (*Resolving dyslexia*, n = 15), no dyslexia in Grade 2 but dyslexia in Grade 8 (*Late-emerging dyslexia*, n = 18), and no dyslexia in either grade (*No dyslexia*, n = 127). Children's cognitive skills were assessed both before and at school age (3.5–6.5 years and Grades 2 and 8). Parental text reading fluency was assessed before the child's birth, and parent's reading-related cognitive skills when the children were 3–6 years old.

I found, first, that for 60% of the children who had dyslexia at either of the two time points (Grade 2 or 8) their dyslexia status changed. This change occurred more frequently than predicted by the unreliability of the tests used in the group classification. Second, reading speed development in the four groups, which were formed according to performance in the individually administered tasks, was validated in the large-scale group assessments, which included also the classmates of the follow-up children. Third, both family risk for dyslexia and gender were unevenly distributed in the groups: children with family risk were overrepresented in the Persistent, Late-emerging and Resolving dyslexia groups and underrepresented in the No dyslexia group, whereas girls were overrepresented in the Resolving dyslexia group and boys in the Late-emerging group. Fourth, clear differences between the four groups were found in their cognitive profiles but not in the amount of book reading. Finally, the parents of the Late-emerging and Persistent groups were slow in rapid naming whereas the parents in the Resolving and No dyslexia groups were not.

In line with the earlier studies conducted in English, children with change in their dyslexia status, i.e., the resolving and late-emerging groups, were also found in Finnish. However, the number of resolving children was much larger than those found in the earlier (English-language) studies, probably due to either the easier orthography of Finnish when compared to English or the ability of the Finnish education system to support the learning of children starting their school career with deficient pre-reading skills. Interestingly, the majority of the resolving children were girls. All the dyslexia groups showed difficulties in cognitive skills; however, these difficulties were limited to most well-known pre-reading skills. Of special interest was the similarity between the children and parents among the Late-emerging and Persistent dyslexia groups: slowness in rapid naming was in accordance with the known bottleneck of reading in Finnish, i.e., reading fluency, and rapid naming being its best predictor.

3.4 Study IV

Early cognitive predictor of PISA reading in children with and without family risk for dyslexia

The OECD Programme for International Student Assessment (PISA) was "set up to measure how well young adults near the end of compulsory schooling are prepared to meet the challenges of today's knowledge societies" (OECD, 2002, p. 3). Therefore, it is also an interesting outcome measure for children with family risk for dyslexia, as it gives an impression of the effects of family risk on students' preparedness to meet the challenges of education after secondary school and, even further, of living in a society abundant with printed material. In Study IV, I examined how well girls and boys with and without family risk for dyslexia performed in the PISA reading literacy assessments, and also how well their performance in PISA reading was predicted by their early cognitive skills before school age and reading fluency during school age (see Figure 5).

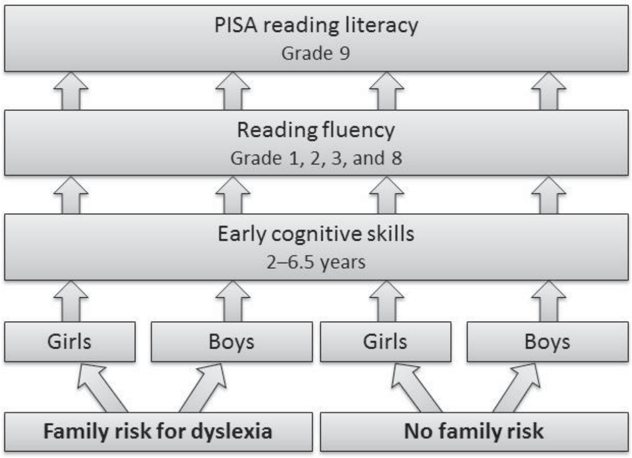


FIGURE 5 Design of Study IV

In this study, I was interested in PISA reading literacy measured at 15 years of age as a reading outcome for children with family risk for dyslexia. I examined the effect of family risk, gender, various cognitive skills (language skills, phonological awareness, verbal short term memory, rapid naming, and letter knowledge) from age 2 onwards, and reading fluency at school age (Grade 1, 2, 3, and 8) on PISA reading literacy. I addressed the following three questions: 1) What is the effect of family risk for dyslexia and gender on PISA reading and its cognitive predictors? 2) How well is PISA reading predicted by cognitive skills at 3.5 years of age? 3) Does reading fluency in school add to the explained variance of PISA reading beyond the effects of cognitive skills before school age?

Of the 200 participants followed from birth in the JLD, 158 took part in this study. One participant was excluded because of a serious inflammation in the central nervous system and 41 participants refused to take part in PISA reading assessments at school. Attrition was similar in the at-risk and control groups, 18.5% and 22.8%, respectively. Moreover, no differences in cognitive skills before school-age or reading fluency during school-age were found between the children who participated and those who did not take part in this study. For the purposes of this study, the children were further allocated into four groups according to their family risk status and gender: 1) *High-risk boys* (n = 42), 2) *High-risk girls* (n = 46), 3) *Low-risk boys* (n = 40), and 4) *Low-risk girls* (n = 30).

I found, first, that the High-risk boys performed significantly worse than the Low-risk girls in PISA reading, and also scored the lowest in the cognitive tasks and reading fluency. In this group, language skills, phonological awareness and letter knowledge at age 3.5 years explained 73% of the variance in PISA reading in Grade 9. Second, the High-risk girls scored lower than the Low-risk girls most clearly in phonological awareness, letter knowledge, and reading fluency. In PISA reading, their performance was between that of the High-risk boys and Low-risk girls, while their language skills at 3.5 years explained 34% of the variance in PISA reading, and their reading fluency in Grade 8 added 15% to the prediction. Third, among both Low-risk groups many fewer significant associations between early cognitive skills and PISA reading were found. In the Low-risk girls, language skills at 3.5 years explained 32% of the variance in PISA reading, whereas in the Low-risk boys none of the early cognitive predictors at age 3.5 years explained the variance in PISA reading. For them reading fluency in Grade 3 was the only predictor, explaining 11% of the outcome variance of PISA reading. It is noteworthy that the Low-risk boys showed subtle deficiencies in language skills, verbal short-term memory, phonological awareness, letter knowledge, and PISA reading literacy when compared to the Low-risk girls.

It can be concluded that in line with the earlier research children with family risk for dyslexia showed clear signs of deficiencies in the development of cognitive skills before school age as well as in reading fluency during school age. Moreover, boys seemed to be more vulnerable than girls, not only in the children with family risk for dyslexia but also in boys and girls without family risk, although to a lesser extent. A rather deterministic picture of the development of boys with family risk for dyslexia emerged, as no less than 73% of the variance in PISA reading literacy was explained by cognitive skills at age 3.5 years. In addition, it seemed that education was unable to reduce the inter-individual differences emerging before school start among these boys. However, because of the strong predictive associations between early cognitive skills and PISA reading literacy, it should be relatively easy to identify family-risk boys with heightened risk for poor reading literacy skills already in early childhood. Special emphasis should be placed on enhancing their language and phonological skills, as these play a crucial role in their later literacy development.

4 DISCUSSION

The main objective of this research was to illuminate the development of the school-age reading skills of children with family risk for dyslexia. The various perspectives taken resulted in a diverse overall picture. High stability in reading skills was found between Grades 2 to 8 in Study II, when reading skills were studied with continuous measures from the viewpoint of Grade 2. On the other hand, the examination of the children's categorical dyslexia status in Study III indicated substantial instability in reading development in the same time window. In addition, in Study IV, the family risk children, especially boys, were found to have compromised skills in several cognitive domains before school age. A high cognitive risk profile did not, however, inevitably lead to reading disability at the end of Grade 2, as found in Study I, although early cognitive skills were strongly associated with PISA reading literacy in Grade 9 at age 15 (Study IV). Both family risk and gender were found to be associated with performance in the PISA reading tasks.

4.1 Development and stability of individual differences in reading skills

In Study II, high stability in the rank ordering of individuals was found not only in reading speed but also in reading accuracy, although to a slightly lesser extent. High stability in individual differences was further confirmed by the stable differences found in reading development between the groups with and without reading disability at the end of Grade 2. At that time point, approximately 35% of the children in the family-risk group were classified as ending up with reading disability. On average, this group of children showed deficient reading skills throughout the whole six-year study period, from Grade 2 to Grade 8. In Grade 8, in reading speed development they were approximately 5 years behind the children with typical reading skills, i.e., their reading speed was being at the level of third graders. They seemed also to rely longer than their peers on letter-by-letter decoding, even in reading words, as no differences in reading speed were found between their reading of words and pseudowords, until Grade 8. Moreover, these children had not reached an overall reading accuracy of 90% until as late as by Grade 8, a level which the two other groups had already attained at the starting point of this follow-up, i.e., the end of Grade 2. It should be noted, however, that no assessments were conducted between Grades 3 and 8, and therefore, based on these studies, I do not know their developmental paths in reading during this interval. Reading pseudoword text with high accuracy was in Grade 8 still difficult for many family-risk children with dyslexia in Grade 2, although on average they read and spelled pseudowords with an accuracy of 82% at that time point. On the other hand, the children with family risk but typical reading skills at the end of Grade 2 mainly followed the developmental track of the control children, who had typical reading skills in both reading accuracy and fluency. These two groups with typical reading skills but different familial background differed from each other only in text reading accuracy in Grade 3. To conclude, the results of Study II would suggest that reading skills at the end of the early reading acquisition stage (Grade 2) seemed to provide clear guidelines regarding the further development of these skills for the two groups of children with family risk for dyslexia.

However, in Study III it was found that only 40% of the children with dyslexia in either Grade 2 or Grade 8 had dyslexia in both grades. In addition, two groups with contrasting developmental trajectories were found: children with late-emerging dyslexia, who only fulfilled the criteria for RD in Grade 8, and children with resolving dyslexia, who only showed reading disability in Grade 2. The existence of these groups with different developmental trajectories was validated in the large scale group assessments, which also included the classmates of the follow-up children. In addition, through a simulation analysis, I was able to confirm that the number of children who changed their position between grades 2 and 8 was significantly larger than could be expected by taking into account the reliabilities of the reading measures used to classify the children. In other words, these changes did not happen purely by chance due to use of cut-off scores instead of continuous variables. Contrary to the findings of Study II, the impression given by Study III is that a lot of changes occur in reading status after the first two grades.

Can these findings and interpretations, which at first sight seem to be inconsistent, be integrated and if so, how? The following technical and methodological differences between the two studies can partially help us to understand the different findings. First, the rather low percentage of individuals (40%, i.e., 22 out of 55) who were consistently classified as having dyslexia in Study III was calculated in relation to the number of children who showed reading disability in either Grade 2 or Grade 8. If we recalculate the number of children with persistent dyslexia in relation to grade 2 reading disability, the percentage rises to 60% (22 out of 37 individuals). In other words, if the results of Study III are reconsidered from the viewpoint of the children with reading disability in Grade 2, then the majority of these children continued to be struggling with reading in Grade 8. Second, family background was not taken into account in Study III when the children were classified into groups. While the vast majority of the children in all three groups with dyslexia had family risk, the group with the lowest percentage of these children was the resolving group (73.3% vs. 83.3% and 81.8%, Resolving vs. Late-emerging, and Persistent dyslexia, respectively). These figures suggest that a slightly larger proportion of the resolving children had no family background of dyslexia when compared to the two other groups with less positive developmental paths in reading. Third, the classification of the children with dyslexia in Study II was based on reading accuracy and fluency, whereas in Study III it was based solely on reading fluency. Although the effect of discrepant dyslexia criteria on the results of the two studies is difficult to disentangle, post hoc analyses conducted with the data used in both studies revealed that in Study II nine children with family risk were classified as having dyslexia in Grade 2 solely due to problems in reading accuracy. These children might have exerted a downward effect on the developmental trajectories of the children with reading disability in Study II, at least in reading accuracy. Finally, the cut-off scores used in Study III might have dramatized the picture by foregrounding the groups with different developmental trajectories from each other. Looking at the reading fluency means of the subgroups with varying reading status reveals that, on average, the reading ability of the late-emerging and resolving children was approximately 0.5 standard deviations below the mean of the typical readers in Grades 2 and 8, respectively. Thus, the individual changes observed in the groupings were less clear when studied with continuous measures.

The 35% of children with reading disability found in the family-risk group in Study II is in line with earlier findings in other languages, where the proportions have ranged from 34% to 66% (Pennington & Lefly, 2001; Scarborough, 1990; Snowling et al., 2003). However, these figures also depend on the criteria used, and should not therefore be directly compared as representative of the proportions of family-risk children with reading disability in different orthographies. On the other hand, the majority of the children with family risk – 65% in Study II and 58% in Study III – followed the path of their typically reading classmates. The finding that the family-risk children without dyslexia in Grade 2 differed in only one measure from their typically reading counterparts was somewhat unexpected as, according to the multiple deficit model of dyslexia, I would have expected to find a clearer difference between these two groups (Pennington, 2006; van Bergen et al., 2014), as has usually been found in English (Pennington & Lefly, 2001; Snowling et al., 2003, 2007) and Dutch (van Bergen et al., 2011, 2012). The invisibility of this group difference in Finnish might be due to the transparent orthography of Finnish, where acquiring basic decoding skill is relatively easy compared to languages with more opaque orthographies (Aro & Wimmer, 2003; Seymour et al., 2003). A finer-grained measure, such as auditory perception of phoneme length, has been shown to separate these two groups in Finnish as in other languages (Pennala et al., 2010).

A more fine-grained grouping of family-risk children, i.e., no dyslexia, persistent, late-emerging and resolving dyslexia, was found in Finnish similarly to the previous findings in English (Catts et al., 2012; Etmanskie et al., 2016; Leach et al., 2003; Lipka et al., 2006). However, our results differ from these in two respects: the proportions of children and their gender distribution in the four groups. The proportion of children in the Resolving group was two- to fourfold when compared to the groups in the previous studies (Leach et al., 2003 and Catts et al., 2012, respectively). Again, the easier-to-learn orthography of Finnish might have enabled a larger proportion of children to catch up compared to the situation in English. Differences between countries in teaching in schools serve as another speculative reason for the differences between orthographies in the proportion of resolving children. Another striking feature found in our subgrouping was the uneven gender distribution in the Resolving and Late-emerging groups: 80% of the children in the Resolving dyslexia group, but only 18% in the Late-emerging group were girls. The over-representation of boys in the group of late-emerging adolescents with dyslexia meant that in Grade 8 there were more males (65%) than females with dyslexia, despite the similarity between boys and girls in the prevalence of dyslexia in Grade 2. Previous studies concerning late-emerging and resolving dyslexia have either not found a significant gender difference in these groups (Leach et al., 2003), or have not reported it (Catts et al., 2012; Lipka et al., 2006). In a recent study by Etmanskie et al. (2016), more males were found in both the early- and late-emerging groups of poor comprehenders, whereas in word reading (closer to the criteria used in our study) the groups were too small to allow any reliable conclusion to be drawn. Our finding of a higher prevalence of males with reading disability in Grade 8 is in line with earlier findings in both research and clinical samples (Hawke et al., 2009; Quinn & Wagner, 2015; Rutter et al., 2004), although no clear reason for this gender differences has been found in genetic aetiology studies of reading difficulties (Hawke, Wadsworth, & DeFries, 2006; Hawke, Wadsworth, Olson, & DeFries, 2007).

In spite of the above-mentioned limitations in the comparability of the results of Studies II and III, three inevitable conclusions can be drawn. First, children with family risk for dyslexia are in high risk for reading difficulties when compared to their peers without family risk. Second, family-risk children do not constitute a single uniform group. Third, a follow-up extending beyond the first two grades is needed to reveal the true potential as well as shortcomings of each individual as a reader.

4.2 Early cognitive predictors of reading skills, risk and protective factors

The second aim of this research was to increase our understanding of the importance of different cognitive skills before school age in characterizing and predicting the development of and individual differences in reading skills after reading acquisition during the first grades. This was done by using two different methods: first, by examining the cognitive differences of groups with varying reading skills (Studies I and IV) or trajectories of reading (Study III), and second, by examining the predictive associations and power of cognitive skills for reading disability (Study I) and reading literacy (Study IV). Cognitive predictors were studied either categorically as profiles (Study I) or by means of continuous measures (Studies III and IV). All previously known significant cognitive predictors, i.e., phonological awareness, rapid naming, verbal short term memory, letter knowledge, and language skills, were included in the analyses (see the Introduction for a review). In addition, children's similarities with their parents (Study III), the amount of children's book reading (alone or shared with a parent) (Studies I and III), and children's persistence in task-focused behaviour (Study I) were examined to illuminate possible risk and protective factors for reading disability.

Using the same JLD sample, we have previously reported that children with reading disability at the end of Grade 2 had significantly poorer skills in language, phonological awareness, rapid naming, and letter knowledge throughout their childhood before school age (Torppa et al., 2010). Corresponding findings have also been reported with family-risk children with RD in other orthographies before and during school age (e.g., Boets et al., 2010; Pennington & Lefly, 2001; Snowling et al., 2003, 2007; van Bergen et al., 2011, 2012). In study IV, where the data for girls and boys were analysed separately, I found partial support for these earlier findings. First, in phonological awareness, rapid naming, and letter knowledge both girls and boys with family risk showed deficient performance when compared to girls without family risk. However, when compared to boys without family risk, the differences were not significant and effect sizes small or moderate. Second, the family-risk boys, but not family-risk girls, had poorer language skills than the control girls before school age. In addition, moderate effect sizes in language skills before school age were found in favour of the family risk girls when compared to family-risk boys. Finally, moderate effect sizes in language skills, phonological awareness and letter knowledge were also found in favour of girls among the children without family risk. These results seem to suggest that boys, especially those with family risk, are at a slightly higher risk for compromised development in later reading skills, particularly in reading comprehension, where language skills are of special importance. Small gender differences have, indeed, been found in, for example, PISA reading literacy, where girls outperformed boys in every OECD country in the 2009 and 2012 assessments (OECD, 2011, 2013, see also Chiu & McBride-Chang, 2006). However, not all studies have shown gender differences in reading (McGeown, Goodwin, Henderson, & Wright, 2012; White, 2007), or the difference has been found to be marginal (see Lietz, 2006, for a meta-analysis).

Among the cognitive predictors, rapid naming turned out to be a key marker of later reading disability. In Study I, it was found that the children in the Dysfluent subgroup, in which the most striking characteristic was slow rapid naming before school age, had the highest probability (.75) of ending up with RD. Moreover, among the children with a "low cognitive risk" profile (Unexpected and Typical), those who ended up with RD had poorer performance in the rapid naming and phonological awareness tasks than their counterparts with typical reading skills. Finally, in Study III rapid naming also labelled the two subgroups with reading disability in Grade 8: slow rapid naming skills characterised not only the children with persistent or late-emerging dyslexia but also their parents.

Previously it was shown that rapid naming, together with phonological awareness and letter knowledge in addition to family risk, is one of the key markers when predicting individual risk for reading disability (Puolakanaho et al., 2007). Moreover, rapid naming has proven to be one of the universal predictors of later reading skills in studies comparing these associations in different orthographies (Landerl et al., 2012; Ziegler et al., 2010). In Study III, in which the time window was extended past the early grades up to the last grades of secondary school, rapid naming appeared as a key characteristic in separating children with and without reading disability. This result supports earlier findings showing that the relative importance of rapid naming increases with development (Kirby et al., 2003; Vaessen, 2010). It is important to notice that in Study III the focus was on reading speed rather than accuracy. Rapid naming has shown stronger associations with reading speed than with accuracy (e.g., Torppa et al., 2012; Ziegler et al, 2010), which may partly explain the central role of rapid naming seen in Study III. Problems in reading fluency are commonly seen as the main bottleneck for individuals with reading disability in consistent orthographies (e.g., Frith et al., 1998; Peterson & Pennington, 2012; Wimmer, 1993), and rapid naming as one of its central predictors (e.g., Landerl & Wimmer, 2008; Papadopoulos et al., 2009; Torppa et al., 2012; van Bergen et al., 2011). The results are in line with these earlier findings. The mechanisms through which rapid naming affects reading fluency are not yet well known, and their investigation was beyond the scope of this research. However, Papadopoulos and his colleagues (2016) have recently shown, first, that the rapid naming – reading fluency relationship is partly mediated through phonological awareness and orthographic processing, and second, that processing speed, which is an integral part of both rapid naming and reading fluency, is of crucial importance in explaining their relationship. Finally, children's resemblance to their parents in rapid naming supports the idea of a genetic liability inherited from parents, and therefore meshes neatly with the multiple deficit models of reading disability (Pennington, 2006; van Bergen et al., 2014).

By emphasizing the importance of rapid naming I am not saying that other cognitive predictors are of little or no importance in reading development also after the early grades. In Study III, I found that children with persistent dyslexia showed poor performance in all the assessed cognitive skills except vocabulary. Moreover, the children with resolving dyslexia were characterized by deficiencies across several domains of cognitive skills (including vocabulary), but contrary to the persistent group these deficiencies were limited to the time before school entry. In fact, the cognitive profiles of the persistent and resolving groups did not differ from each other in any of the cognitive measures before school age. However, the children with resolving dyslexia were able not only to enhance their reading fluency, but also to improve their cognitive skills relative to others: their performance did not differ in any of the cognitive measures during school age from that of the children with no dyslexia, while they performed better than the children with persistent dyslexia in phonological awareness and rapid naming in Grades 3 and 8. No specific explanation was found for the fast school-age progress of the children with resolving dyslexia, but our measures of possible environmental effects were limited to parental education and the amount of book reading. Therefore, it remains unclear whether the children with resolving dyslexia suffered from developmental delay, whether they had a more advanced environment at school age (not tapped with our limited measures) or whether they were more capable of benefitting from school education.

The predictive power of early language skills turned out to be strong in Study IV, when the outcome was shifted to PISA reading literacy instead of reading fluency or reading disability status. This result was expected as, according to the lexical quality hypothesis, a large, high quality lexicon, in addition to word reading skill, has been seen as one of the two cornerstones of reading comprehension (Perfetti & Hart, 2001). Numerous studies have shown a strong link between vocabulary and reading comprehension (e.g., Muter et al., 2004; Nation & Snowling, 2004; Storch & Whitehurst, 2002; Torppa et al., 2007; Verhoeven & van Leeuwe, 2008). However, the time window between the assessments of language skills and the assessment of reading comprehension measured with the PISA reading task was exceptionally long in our study, i.e., approximately 13 years compared to the 2–6 years in the studies mentioned above. And yet, 22% and 44% (boys and girls, respectively) of the variance in PISA reading literacy was explained by language skills alone from the age of 2–2.5 years among the children with family risk.

In addition to language skills, the other assessed cognitive skills were systematically associated with PISA reading literacy among both girls and boys in the family-risk groups, whereas far fewer associations were found among the children without family risk. The stronger associations between the cognitive skills and PISA reading literacy together with poorer performance in the cognitive tasks support the idea suggested by the multiple deficit model that children with family risk have a higher genetic vulnerability. Moreover, among the family-risk boys the effects of language skills, phonological awareness and letter knowledge were additive, explaining close to all of the variance in PISA reading literacy in Grade 9, whereas among the family-risk girls no cognitive skill before school age added significantly to the predictive power of language skills at 3.5 years. The post hoc analyses conducted separately for the family risk boys and girls lent partial support to the idea of cumulative risk factors (Sameroff, Seifer, Baldwin, & Baldwin, 1993) among family-risk boys, where language skills were not associated with letter knowledge, whereas among family-risk girls language skills were moderately associated with both phonological awareness and letter knowledge.

The associations between the cognitive predictors and reading disability or the reading fluency profiles were not, however, straightforward. As Study I showed, a high cognitive risk profile did not inevitably lead to reading disability at the end of Grade 2; this was true in only one-half of cases. Task-focused behaviour showed as a possible moderating factor between early cognitive skills and reading disability: the children with high cognitive risk but no RD were more task-focused according to their teachers. Moreover, the opposite behaviour, i.e., task-avoidant behaviour, together with less time spent in reading, was a significant risk factor for RD for individuals with low cognitive risk. Previous research with another Finnish sample has shown a reciprocal relationship between task-avoidance and reading skills during the first school year. Children with poor cognitive performance before school age showed more task-avoidant behaviour at school, while task-focused behaviour was associated with steep progress in reading development, even when children's cognitive competence was taken into account (Onatsu-Arvilommi & Nurmi, 2000). The results of the current research support and extend these findings by showing that even if the variance in cognitive skills is narrowed by selecting either children with poor or good cognitive skills before school age, children with poor vs. good later reading skills differed in their relative amounts of task-avoidant or task-focused behaviour. Theoretically, task-focused behaviour is thought to originate from positive self-concept, successful previous learning experiences, and success expectations, which all lead to high effort in a new learning situation (Eccles, Midgley, Wigfield, Buchanan, & Reuman, 1993). Findings from the current research are in line with earlier studies showing that these kinds of motivational constructs have a unique effect on reading development above that of cognitive skills alone (e.g., Georgiou, Manolitsis, Nurmi, & Parrila, 2010; Onatsu-Arvilommi & Nurmi, 2000).

4.3 Reading skills at the end of secondary school

The final aim of this research was to determine the reading skills of children with family risk when they leave compulsory secondary school. According to the definition of dyslexia, children with reading disability can be expected to struggle in reading and spelling, but not necessarily in reading comprehension or reading literacy (Lyon, 2003). On the other hand, according to the multiple deficit model (Pennington, 2006), children with family risk for dyslexia inherit several aetiological risk factors from their parents, resulting in deficiencies in several cognitive domains, including language skills. Therefore, children with family risk could also be expected to show poor performance in tasks measuring reading literacy skills.

In Study IV, I found that reading fluency of family-risk girls and boys in Grade 8 was approximately 0.5 standard deviations below the means of children without family risk. Although the results of the group comparisons in reading fluency did not reach statistical significance, moderate to high effect sizes were found in favour of children without family risk. The large within-group variances resulting from the heterogeneity of their individual members probably explain the non-significant differences in means, as clear differences were found in the proportion of children with reading disability in Grade 8 in Study III: 33% vs. 9%, in children with and without family risk, respectively. Thus, the risk for having reading disability in Grade 8 was close to fourfold in children with family risk than those with no such risk, as also found earlier in Grade 2 with the same JLD sample (Puolakanaho et al., 2007). We need, however, to bear in mind that no population-based standardized scores were available when the classification criteria were set. Therefore, the proportion of children without family risk but with reading disability cannot be interpreted as an estimate of the prevalence of dyslexia in Finland. However, comparison of the proportions of children with dyslexia in the two groups is valid, as the same criteria were used for both groups. It may thus be concluded that compromised reading fluency skills were found among a substantial proportion of children with family risk for dyslexia, most of which were already evident in the early grades (Persistent group), with the remainder not emerging until the later grades (Late-emerging group).

However, the finding in Study II that the family-risk children who had no problems in reading acquisition did not differ in reading skills, even in Grade 8, from the children without family risk, would suggest that in the transparent orthography of Finnish the effects of family risk are less bruising than in other, more opaque, orthographies. For example, in English and Dutch the performance of family-risk children without reading disability has usually been found to fall between family-risk children with RD and typical readers without family risk (Boets et al., 2010; Snowling et al., 2003, 2007; van Bergen et al., 2011). Therefore, only weak support for the multiple deficit model was found in Study II, in this sense. Another possible interpretation is that it is a question of visibility, rather than variation in the degree of genetic predisposition: the transparency of the Finnish orthography makes the learning of basic decoding easy for most children, and this might have affected the visibility of the continuity of familial risk. This line of thinking is supported by our finding on auditory perception, in which the performance of the family-risk children without reading disability fell between the that of the family-risk children with RD and that of typical readers without family risk (Pennala et al., 2010), precisely as expected in light of the multiple deficit model.

In addition, in Study IV, it was found that boys with family risk scored lower in PISA reading literacy than girls with no such risk. The scores of girls with family risk and boys without family risk fell in between those of the two other groups, not differing from them, however. The poorer outcome of the family-risk boys was expected on the basis of the earlier findings related to their reading fluency development in Study III. The vast majority of the children with late-emerging dyslexia were boys, in contrast to the resolving group, in which boys formed a small minority. Moreover, the family-risk boys also had poor language skills, one of which, vocabulary, has been shown to be the other important factor in addition to word reading skill in explaining performance in the PISA reading tasks (Arnbak, 2012). Girls with family risk also seemed to be privileged in the sense that it was only in this group that school-age reading skills added to the explained variance of PISA reading literacy after pre-school-age cognitive skills were taken into account. As no measures of, for example, school engagement were available, the explanation for this result remains unclear. However, girls have been found to be more engaged in school and to perceive more support from teachers (Lam et al., 2012). In addition, reading engagement and reading for enjoyment have been shown to be higher for girls than boys in all the European countries (OECD, 2010; Sulkunen, 2013), providing self-generated opportunities to practise reading skills (Guthrie & Wigfield, 2000). The fact that 73% of the variance in PISA reading literacy was explained by cognitive skills at 3.5 years of age among the family-risk boys compared to 36% among the family-risk girls makes the comparison of the effects of school-age reading skills unfair, as very little unexplained variance remained among the family-risk boys. However, in a post-hoc re-analysis of the data, where, among the family-risk boys, language skills at the age of 3.5 years were entered as the only cognitive predictor before school-age, the result remained unchanged. No measure of reading fluency at school age added to the explained variance of PISA reading literacy among the family-risk boys, indicating that in this sense a true difference exists between family-risk boys and girls. All in all, boys with family risk seemed to struggle not only with reading fluency but also with reading literacy at the end of compulsory school.

Finally, in Study IV, relatively weak associations were found between reading fluency and PISA reading literacy. This is in line with earlier finding of a rather weak relationship between fluent word reading skills and reading comprehension in transparent orthographies, especially in the later grades (García & Cain, 2014). Moreover, several studies have shown that at least average text comprehension is possible also for struggling readers (Catts, Adlof, & Weismer, 2006; Nation, Clarke, Marshall, & Durand, 2004; Torppa et al., 2007). Interestingly, the family-risk boys showed a descending trend in the strength of this association with ascending grades, whereas the opposite was true for family-risk girls. This finding is in line with the results of Study III, where boys were overrepresented in the Late-emerging dyslexia group and girls in the Resolving dyslexia group. Among the children without family risk, reading fluency explained 9–16% of the variance in PISA reading literacy, a value comparable to the 13% found earlier by Artelt and colleagues (2001).

4.4 Concluding remarks and future directions

The findings of this research suggest, first, the need to take family risk for dyslexia seriously in efforts to identify children at potential risk for undesirable development in reading. Although half of the family-risk children did not encounter reading problems during primary and secondary school, the other half did not perform equally well. In the final stage of secondary school, approximately 35% of the family-risk children were classified as having reading disability. Moreover, the risk for classification as having RD was close to fourfold in this group compared to peers without family risk. In addition, family-risk children were overrepresented in all the subgroups with reading disability at different ages: both in the subgroup of children with high cognitive risk who ended up with reading disability in Grade 2 (Study I) and in the groups with persistent and late-emerging dyslexia in Grade 8 (Study III). Moreover, differences in reading and cognitive skills between children with and without family-risk were found even when gender was controlled. It is previously shown that taking family risk into account in predicting individual risk for reading disability in the early grades significantly increases the predictability of RD (Puolakanaho et al., 2007). The research reported here extends this finding by suggesting that family risk for dyslexia is a crucial factor affecting children's reading development beyond the early grades to the end of secondary school.

In addition to family risk, early cognitive skills appeared to be important predictors of future reading development, not only for reading accuracy and fluency, but also for PISA reading literacy. All three previously identified cognitive predictors (phonological awareness, rapid automatized naming, and letter knowledge) were associated with later reading skills, especially in children with family risk, but rapid automatized naming turned out to be of special importance. First, the highest proportion of the children with reading disability at the end of Grade 2 came from the subgroup Dysfluent, characterized by slow rapid naming in particular (Study I). Second, slow rapid naming also characterized the two groups with reading disability in Grade 8, i.e., the Late-emerging and Persistent dyslexia groups (Study III). Moreover, the parents of the adolescents in these two groups also showed slowness in rapid naming, suggesting a strong heritability of this skill. Taken together, these findings suggest that rapid automatized naming could serve as a key marker of later reading difficulties in Finnish, especially when reading fluency after primary school is considered as the reading outcome, and should therefore be used in the screening of children at risk for dyslexia. However, research using logistic regression analyses is needed to determine the sensitivity and specificity of these measures in correctly identifying children with dyslexia in adolescence, as well as to determine sensible cut-off scores in rapid naming at different ages. Likewise, the resemblance between children and parents in rapid naming skill opens a possibility for using parental rapid naming skill as an early marker of potential risk for their child. Knowledge on genetic transmission and the similarity between children and parents means that new understanding of the processes related to rapid naming might be achieved by a research focus on families with a common genetic and cognitive background.

Using the PISA reading task as the outcome measure at the end of the secondary school highlighted the importance of language skills as an early predictor and marker of future risk. While this is understandable because of the known centrality of the role of language skills in reading comprehension, this finding also widens the repertoire of possible tools for interventions. By practicing one's language skills, it is possible to enlarge one's general knowledge and one's ability to draw interferences and integrate information, which in turn will promote reading comprehension. Printed material could occupy a crucial role: awakening and maintaining interest in reading seems to be important, as the amount of reading engaged in is, based on the findings of Study I, a possible moderator of the reading outcomes of children with similar cognitive readiness. Moreover, if an intervention succeeds in keeping a child actively interested in working with such material, this could also affect the child's motivation, which in turn could promote persistence in future reading-related tasks and so further improve the child's reading skills. Whether an intervention including such elements would truly be successful in enhancing reading skill, is a question for future studies. Thus far, we are restricted to noting that language skills, interest in reading and persistence appear to be related to future reading skills.

Finally, the findings of this research highlight the importance of paying attention to boys, particularly to family-risk boys with deficiencies in their early language development, in both expressive and receptive language. Early support to improve their vocabulary and phonological awareness seems to be well justified. Parents, present in their everyday life as their natural caregivers, are the key persons in creating a positive home literacy environment and interesting their children in leisure time reading. This, in turn, may set in motion an ascending spiral of language and literacy skill development in which better skills in language will lead to more reading, thereby enlarging vocabulary and knowledge, as suggested in the recent meta-analysis by Mol and Bus (2011). If parents are able to awaken in their children an interest in printed material, this will probably have long-lasting effects. Educators in kindergartens, preschools and schools can also support children's literacy development by supplementing the input by parents. Keeping children engaged in educational and literacy-based activities seems to offer a potential path by which children's academic skills can be enhanced.

Almost all (86%) the family-risk children with difficulties in reading acquisition identified in this research were receiving extra support from their schools during Grades 1–3, suggesting that schools are doing well in identifying these children. It was also shown, however, that changes in children's reading status also occur after the early grades. In particular, the emergence of children with typical reading acquisition but with difficulties later on in becoming fluent readers highlights the need to monitor the development of pupils' reading skills up to the end of secondary school. If this is not done, the possibility to help these adolescents may be missed. This in turn will not only hinder them from realizing their full learning potential, but also predispose them to low academic self-concept. Both of these factors have been shown to be associated with future educational attainment (Guay, Larose, & Boivin, 2004), and can therefore be considered as potential risk-factors for dropping-out from the labour market and, ultimately, even society. Whether and to what extent such undesirable scenarios will be realised in the case of the children with family-risk for dyslexia is one of the interesting questions for future studies. Currently, JLD data are being gathered at ages 20 and 23 years. When analysed, these data may help to provide answers to specific questions of this kind.

YHTEENVETO (FINNISH SUMMARY)

Tässä tutkimuksessa tarkastelin lasten, joilla oli kohonnut perinnöllisen lukivaikeuden riski, lukutaidon kehitystä ala- ja yläkouluiässä. Tutkimuksen tavoitteena oli selvittää neljää asiaa: 1) miten näiden lasten lukutaito kehittyy kouluiässä verrattuna kontrollilapsiin, joilla ei ole suvussa kulkevaa lukivaikeusriskiä, 2) kuinka yhtenäinen ryhmä lapsia he ovat lukutaidon kehityksen suhteen, 3) mitkä, pääasiassa kognitiiviset, tekijät selittävät erilaisia lukutaidon kehityspolkuja ja onko löydettävissä tekijöitä, jotka suojaisivat yksilöitä näiltä kognitiivisten tekijöiden viitoittamilta poluilta, sekä 4) minkälaiset ovat näiden lasten lukutaidolliset valmiudet 15 vuoden iässä myöhempää kouluttautumista ja yhteiskunnassa pärjäämistä ajatellen.

Tutkimusjoukkona oli 200 keskisuomalaista lasta, joita on seurattu Lapsen kielen kehitys ja suvussa kulkeva lukivaikeusriski –hankkeessa syntymästä 20 vuoden ikään vuosina 1993–2016. Noin puolella lapsista oli kohonnut lukivaikeuden riski, koska ainakin toisella vanhemmista sekä jollain muulla lähisukulaisella on lukivaikeus. Lukivaikeus kulkee heillä suvussa. Tutkimuksen tavoitteisiin pyrin vastaamaan vertaamalla näiden lasten kehitystä sellaisten kontrollilasten kehitykseen, joilla ei vastaavaa sukuriskiä ollut. Hienovaraisempi erottelu riskiryhmän sisällä oli mahdollista vertaamalla lapsia, joilla kouluiässä luokiteltiin olevan lukivaikeus, lapsiin, jotka siltä välttyivät perinnöllisestä riskistä huolimatta. Lasten kognitiivisia taitoja eli kielitaitoa, fonologisia taitoja, nopeaa sarjallista nimeämistaitoa, kielellistä lyhytkestoista muistia ja kirjaintuntemusta arvioitiin useilla eri mittareilla sekä ennen kouluikää (2 vuoden iästä alkaen) että kouluiässä. Muina mahdollisina lukutaidon kehitystä muokkaavina tekijöinä tutkin lukuharrastuneisuuden ja tehtäväsuuntautuneisuuden merkityksiä, joista tiedot kerättiin vanhemmille, opettajille ja nuorille itselleen suunnatuilla kyselyillä sekä testaajien tutkimuskäyntien yhteydessä tekemistä arvioinneista. Lukemisen tarkkuutta ja sujuvuutta samoin kuin kirjoittamisen tarkkuutta arvioitiin 1., 2., 3., 7. ja 8. luokalla niin Jyväskylän yliopistossa toteutetuilla yksilöarvioinneilla kuin luokissa tehdyillä ryhmäarvioinneilla. Nuorten lukutaidollisia valmiuksia arvioitiin OECD:n tutkimusohjelmaan kuuluvan PISA–tehtäväkokonaisuuden lukemisen tehtävillä 9. luokalla 15 vuoden iässä.

Ensimmäisessä osatutkimuksessa tarkastelin varhaisten, ennen kouluikää arvioitujen kognitiivisten riskiprofiilien yhteyttä toisen luokan lopussa arvioituun lukivaikeuteen. Erityisesti olin kiinnostunut siitä, olisiko löydettävissä tekijöitä, jotka erottelisivat samanlaisen varhaisen kognitiivisen riskin (korkea tai matala) mutta erilaiseen lukutaidon lopputulemaan (lukivaikeus tai ei lukivaikeutta) päätyviä ryhmiä. Varhaisen kognitiivisen riskin määrittely perustui aiemmin tehtyyn mallinnukseen, jossa oli etsitty ensimmäisen luokan lopussa erilaiseen lukutaitoon päätyviä alaryhmiä näiden varhaisten kognitiivisten taitoprofiilien perusteella. Nämä riskiprofiilit jaettiin tässä ensimmäisessä osatutkimuksessa kahteen ryhmään. Korkean kognitiivisen riskin ryhmään luokiteltiin lapset, joilla oli pulmia erityisesti nopeassa sarjallisessa nimeämisessä, mutta myös taivutusmuotojen hallinnassa, fonologisessa tietoisuudessa sekä kirjainten nimien oppimisessa (*Ei sujuvat lukijat*). Lisäksi lapset, joiden kognitiivista kehitystä kuvasi laskeva profiili kaikissa muissa mitatuissa taidoissa paitsi lyhytkestoisessa kielellisessä muistissa (*Laskeva*) luokiteltiin korkean kognitiivisen riskin ryhmään. Tämän ryhmän lasten lukutaito ensimmäisen luokan lopussa oli keskimäärin noin yhden keskihajonnan verrokkiryhmän keskiarvoa heikompi. Matalan kognitiivisen riskin ryhmään luokiteltiin lapset, joilla oli hyvä kielitaito mutta yllättäen ongelmia kirjainten oppimisessa (*Odottamattomat*) sekä lapset, joilla ei ollut ongelmia varhaisessa kognitiivisessa kehityksessä (*Tyypilliset*). Havaittiin että valtaosalla lapsista, joilla todettiin lukivaikeus toisen luokan lopussa, oli suvussa kulkeva lukivaikeusriski, ja he kuuluivat korkean kognitiivisen riskin ryhmään. Lapset, jotka korkeasta kognitiivisesta riskistä huolimatta välttivät lukivaikeuden, jaksoivat opettajien arvioiden mukaan jatkaa ponnistelujaan myös kohdatessaan vaikeuksia koulutehtävissä. Lisäksi havaittiin, että matalan kognitiivisen riskin ryhmässä lapset, joilla voitiin todeta lukivaikeus toisen luokan lopussa, luovuttivat helposti vaikeiden tehtävien kohdalla ja viettivät vähemmän aikaa lukien. Ensimmäisen osatutkimuksen perusteella saatiin siis viitteitä siitä, että tukemalla lapsen kiinnostusta lukemiseen ja sinnikkyyttä ponnisteluun vaikeiden tehtävienkin edessä, kyettäisiin mahdollisesti puuttumaan kognitiivisten tekijöiden viitoittamaan kehityskulkuun. Vaikutusmekanismien todentaminen vaatisi luonnollisesti asetelmaa, jossa osan lapsista kehityskulkuun pyrittäisiin tietoisesti vaikuttamaan nyt havaituilla tekijöillä.

Toisessa osatutkimuksessa lapset, joilla oli suvussa kulkeva lukivaikeus, oli jaettu kahteen ryhmään: heihin, joilla todettiin lukivaikeus toisen luokan lopussa, ja heihin, joilla ei lukivaikeutta siinä vaiheessa ollut. Olin kiinnostunut siitä, miten näiden lasten lukemisen tarkkuus ja nopeus sekä toisaalta kirjoittamisen tarkkuus kehittyivät verrattuna kontrolliryhmän lapsiin. Taitojen kehittymistä arvioitiin toisen, kolmannen ja kahdeksannen luokan lopussa. Lisäksi pyrin selvittämään sitä, mitkä lukemiseen liittyvät prosessit mahdollisesti selittäisivät lukivaikeusryhmän lasten hitaampaa lukunopeutta. Osatutkimuksessa havaittiin, että lapset joilla oli suvussa kulkeva lukivaikeusriski mutta ei lukivaikeutta toisen luokan lopussa, kehittyivät lukutaidossaan keskimäärin verrokkiryhmän mukaisesti; ryhmät erosivat vain yhdessä kaikkiaan 21:stä luku- ja kirjoitustaidon arvioinnista. Sen sijaan lapset, joilla oli suvussa kulkeva lukivaikeusriski ja joilla todettiin lukivaikeus toisen luokan lopussa, olivat näitä kahta ryhmää heikompia niin lukemisen tarkkuudessa ja nopeudessa kuin kirjoittamisen tarkkuudessakin koko seurantajakson ajan. Heidän kehityksensä tosin oli hieman kahta muuta ryhmää nopeampaa erityisesti tarkkuudessa. Tämä selittynee ainakin osittain sillä, että kaksi muuta ryhmää olivat saavuttaneet hyvin korkean tarkkuustason jo tarkastelujakson alussa eli toisen luokan lopussa. Kahdeksannella luokalla näiden riskiryhmän lukivaikeuslasten taidot olivat tasolla, jonka kahden muun ryhmät lapset olivat saavuttaneet jo kolmannen luokan lopussa. Heidän taitonsa olivat siis keskimäärin noin viisi vuotta jäljessä tyypillisestä kehityksestä. Vertaamalla heidän lukunopeuttaan sanalistan, tekstin ja pseudosanatekstin lukemisessa, voitiin todeta, että nämä lapset lukivat listassa esitettyjä sanoja ja pseudosanatekstiä samalla nopeudella vielä kolmannellakin luokalla. Havainto saattaisi kertoa siitä, että nämä lapset käyttävät yksittäisiin kirjaimiin perustuvaa dekoodausta nopeamman, kirjaimia isompien yksiköiden havaitsemisen sijasta vielä kolmannen luokan lopussa. Vaihtoehtoinen tulkinta olisi, että heillä olisi dekoodauspulmien lisäksi ongelmia myös isompien yksiköiden havaitsemissa. Kahdeksannelle luokalle tultaessa nämäkin lapset lukivat listassa esitettyjä sanoja nopeammin kuin pseudosanoja eli olivat kyenneet omaksumaan taidon, jonka kaksi muuta ryhmää hallitsivat jossain määrin jo toisen luokan lopussa.

Kolmannessa osatutkimuksessa olin kiinnostunut lukivaikeusstatuksen pysyvyydestä. Olin siis kiinnostunut siitä, kuinka suuri osa lapsista, joilla toisen luokan lopussa voitiin luokitella lukivaikeus, voitaisiin tehdä näin myös kahdeksannen luokan lopussa. Lisäksi halusin selvittää, olisiko kirjoitusjärjestelmältään säännöllisessä suomen kielessä löydettävissä lapsia, joilla lukivaikeus ilmaantuisi vasta kolmannen luokan jälkeen ja lapsia, joiden lukutaito kehittyisi ikätovereiden tasolle alaluokkien lukemaan opettelemisen ongelmista huolimatta. Pyrin myös selvittämään, eroavatko erilaisen lukunopeuden kehityspolun omaavat ryhmät toisistaan kognitiivisten taitojen, lukemisharrastuneisuuden tai vanhempien kognitiivisten taitojen suhteen. Havaittiin, että 60 % lapsista, joilla voitiin todeta lukivaikeus joko toisella tai kahdeksannella luokalla, vaihtoi lukivaikeusstatustaan kuuden vuoden seurannan aikana. Tämä oli huomattavasti enemmän kuin olisi ollut ennustettavissa lukunopeutta arvioivien mittareiden epäluotettavuuden perusteella. Lisäksi ilmiö kyettiin todentamaan myös luokittelussa käyttämättömillä lukunopeuden ryhmäarvioinneilla. Nämä kaksi seikkaa varmentavat, että yksilöiden aseman muutoksissa on kyse todellisesta ilmiöstä, eikä yksilöiden sattumanvaraisesta sijoittumisesta katkaisurajojen eri puolille eri ikävaiheissa. Sekä sukupuoli että suvussa kulkeva lukivaikeusriski jakaantuivat epätasaisesti ryhmissä. Myöhään ilmaantuvan lukivaikeuden ryhmässä valtaosa oli poikia, kun taas lapset, jotka kehittyivät lukunopeudessa lähes ikätovereiden tasolle alkuvaiheen lukemaan oppimisen ongelmista huolimatta, olivat pääasiassa tyttöjä. Lapset, joilla oli suvussa kulkeva lukivaikeusriski, olivat yliedustettuina kaikissa lukivaikeuden ryhmissä. Lukivaikeusryhmät erosivat lukutaitoa ennakoivissa kognitiivisissa profiileissa mutta eivät lukuharrastuneisuudessa. Erityisen mielenkiintoinen oli havainto lasten ja heidän vanhempiensa ongelmien samankaltaisuudesta: pysyvän lukivaikeuden ja myöhään ilmaantuvan lukivaikeuden ryhmissä sekä lapsilla että heidän vanhemmillaan oli ongelmia nopeassa sarjallisessa nimeämisessä. Havainto sopii hyvin yhteen aiemman tiedon kanssa: säännöllisessä kirjoitusjärjestelmässämme lukemisen keskeisimmät ongelmat liittyvät lukunopeuteen, ja sen keskeisin ennustaja on sarjallisen nimeämisen taito. Lasten samankaltaisuutta vanhempiensa kanssa on mahdollista hyödyntää lukivaikeuden riskilasten tunnistamisessa sekä heidän keskeisten ongelma-alueidensa hahmottamisessa.

Viimeisessä osatutkimuksessa halusin selvittää, minkälaiset lukutaidolliset valmiudet ovat lapsilla, joilla on suvussa kulkeva lukivaikeuden riski, yläkoulun lopussa 15 vuoden iässä. Kansainvälisen PISA–tutkimuksen lukutaidon toistuvat, ns. linkkitehtävät, tarjosivat tähän oivallisen arviointikeinon, sillä PISA–tutkimuksen tavoitteena on mitata taitoja, joita nuori tarvitsee pärjätäkseen ammattiin kouluttautumisessa ja selviytyäkseen moninaisista tulevaisuuden yhteiskunnan haasteista. Suoriutuakseen hyvin PISA–tutkimuksen lukutaidon tehtävissä oppilaan on tehtävien laadintakomitean mukaan osattava paitsi lukea sujuvasti myös ymmärrettävä lukemansa sekä tulkita ja arvioida lukemaansa tekstiä. Tutkimuksessa pyrittiin selvittämään, mitkä ja kuinka hyvin varhaiset kognitiiviset tekijät ennustavat tällaista lukutaitoa, sekä kyetäänkö kouluiän lukunopeudella parantamaan kyseistä ennustettavuutta. Koska olin kiinnostunut sukuriskin lisäksi siitä, eroaako ennustettavuus tytöillä ja pojilla, tarkastelin yhteyksiä erikseen sukuriskin ja sukupuolen perusteella muodostetuissa ryhmissä. Tulokset osoittivat, että pojat, joilla on suvussa kulkeva lukivaikeusriski, suoriutuivat PISA–tutkimuksen lukutaidon arvioinneissa kontrolliryhmän tyttöjä heikommin. Heidän kognitiiviset taitonsa ennen kouluikää sekä lukunopeutensa kouluiässä olivat myös heikommat kuin kolmessa muussa ryhmässä. Näiden poikien joukossa varhainen kielitaito, fonologinen tietoisuus ja kirjaintuntemus 3,5 vuoden iässä selittivät 73 % PISA–tutkimuksen lukutaitoarvioinnista 12 vuotta myöhemmin. Vastaavasti tytöt, joilla oli suvussa kulkeva lukivaikeuden riski, erosivat kontrolliryhmän tytöistä selvimmin fonologisessa tietoisuudessa, kirjaintuntemuksessa sekä lukemisen nopeudessa. Heillä kognitiivisista tekijöistä vain kielitaito 3,5 vuoden iässä nousi merkitseväksi selittäjäksi selittäen 34 % PISA–tutkimuksen lukutaitoarvioinnista kahdeksannen luokan lukunopeuden selittäessä vielä 15 % varhaisen kielitaidon huomioimisen jälkeen. PISA–tutkimuksen lukutaitoarvioinneissa riskiryhmän tyttöjen suoritustaso oli riskiryhmän poikien ja kontrolliryhmän tyttöjen suoritustasojen välillä.

Kontrolliryhmän pojilla ja tytöillä varhaisten kognitiivisten tekijöiden yhteydet PISA–tutkimuksen lukutaitoarviointiin olivat vähäisiä. Kontrolliryhmän tytöillä kielitaito 3,5 vuoden iässä selitti 32 % PISA–tutkimuksen lukutaitoarvioinnista. Kontrolliryhmän pojilla yksikään kognitiivisista taidoista 3,5 vuoden iässä ei ollut merkitsevästi yhteydessä PISA–tutkimuksen lukutaitoarviointiin, mutta kielitaito 5–5,5 vuoden iässä korreloi merkitsevästi PISA–tutkimuksen lukutaitoarviointiin. Merkittävää oli myös havaita kontrolliryhmän poikien lievästi heikommat taidot kielessä, fonologisessa tietoisuudessa, kirjaintuntemuksessa sekä PISA–tutkimuksen lukutaitoarvioinneissa kontrolliryhmän tyttöihin verrattuna. Varhaisten lukutaidon kognitiivisten ennustajien rinnalle tämä tutkimus nosti kielitaidon merkityksen nuorten lukutaidon ennustajana. Ensivaikutelma poikien lukutaidon kehityksestä saattaa näyttää lohduttomalta, erityisesti jos suvussa on perinnöllistä lukivaikeutta. On kuitenkin huomattava, että tuloksia ei pidä tulkita siten, että kaikilla lukivaikeusriskipojilla olisi heikot lukutaitovalmiudet yläkoulun päättyessä. Sen sijaan tulokset antavat vahvan viestin siitä, että nämä pojat näyttäisivät olevan helposti tunnistettavia heikkojen varhaisten taitojensa perusteella, ja heidän kielellisiä ja fonologisia valmiuksiaan kannattaisi tukea jo varhain.

Kaiken kaikkiaan osatutkimukset osoittivat aiempia havaintoja tukien, että varhaiset kognitiiviset tekijät viitoittavat vahvasti yksilöiden kehityspolkuja. Erityisen selvästi tämä oli nähtävissä lapsilla, joilla oli suvussa kulkeva lukivaikeusriski. On kuitenkin huomattava, että kyseessä ei ole yhtenäinen joukko yksilöitä, joille kaikille olisi ennustettavissa ongelmia kehityksessä. Ensinnäkin, noin 55 %:lla näistä lapsista lukutaito kehittyi ikätovereiden tapaan ilman selviä pulmia sen paremmin ala- kuin yläkoulussakaan perinnöllisestä lukivaikeuden riskistä huolimatta. Toiseksi, huolimatta vajavaisista varhaisista kognitiivisista taidoista osalla lapsista riittävän hyvä lukutaito oli mahdollista saavuttaa. Kolmanneksi, vaikeudet lukemaan opettelemisessa alaluokilla eivät väistämättä johtaneet heikkoihin lukutaitovalmiuksiin yläkouluiässä. Tässä tutkimuksessa myönteiset kehityskulut näyttivät liittyvän useimmiten tyttöihin. Ei ole silti erityistä syytä ajatella, etteivätkö kyseiset kehityskulut olisi mahdollisia myös pojilla. Poikien, myös heidän, joilla ei ollut suvussa kulkevaa lukivaikeusriskiä, heikompi suoriutuminen tyttöihin verrattuna asettaa haasteita ympäristölle, esimerkiksi vanhemmille, kouluille ja opettajille: miten saada pojat innostumaan lukemisesta tai miten muokata opetustilanteet ja oppiminen poikia kiinnostavaksi? Lohdullista oli havaita, että vanhemmat näyttivät reagoivan lastensa vaikeuksiin lukemaan opettelemisessa lisäämällä yhteisiä lukuhetkiä. Pojat, joiden kehitys ei kaikilta osin todennäköisesti kulje ihanteellista polkua, näyttäisivät kuitenkin olevan kohtuullisen helposti tunnistettavissa varhaisten kognitiivisten taitojen arviointien perusteella. Varhainen tunnistaminen mahdollistaa varhaisen ongelmiin puuttumisen ja tuen tarjoamisen.

REFERENCES

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders: DSM-V, Fifth edition*. Washington, DC: American Psychiatric Association.

Araújo, S., Reis, A., Petersson, K. M., & Faísca, L. (2015). Rapid automatized naming and reading performance: A meta-analysis. *Journal of Educational Psychology, 107*, 868–883.

Arnbak, E. (2012). To what extent do basic skills predict students' PISA reading score? In N. Egelund (Ed.), *Northern lights on PISA 2009: Focus on reading* (pp. 75–90). Copenhagen: Nordic Council of Ministers.

Aro, M. (2004). *Learning to read. The effect of orthography*. Jyväskylä: Jyväskylä Studies in Education, Psychology and Social Research, 237.

Aro, M. & Wimmer, H. (2003). Learning to read: English in comparison to six more regular orthographies. *Applied Psycholinguistics, 24,* 621–635.

Artelt, C., Schiefele, U., & Schneider, W. (2001). Predictors of reading. *European Journal of Psychology of Education, 3*, 363–383.

Bast, J. & Reitsma, P. (1997). Mathew effects in reading: A comparison of latent growth curve models and simplex models with structured means. *Multivariate Behavioral Research, 32*, 135–167.

Bast, J. & Reitsma, P. (1998). Analyzing the development of individual differences in terms of Matthew effects in reading: Results from a Dutch longitudinal study. *Developmental Psychology, 34*, 1373–1399.

Bishop, D. V. M. (2009). Genes, cognition, and communication insights from neurodevelopmental disorders. *Annals of New York Academy of Sciences, 1156,* 1–18.

Boets, B., De Smedt, B., Cleuren, L., Vandewalle, E., Wouters, J., & Ghesquie`re, P. (2010). Towards a further characterization of phonological and literacy problems in Dutch-speaking children with dyslexia. *British Journal of Developmental Psychology, 28,* 5–31.

Bradley, L. & Bryant, P. (1983). Categorizing sounds and learning to read: A causal connection. *Nature, 301*, 419–421.

Burgess, S. R. & Lonigan, C. J. (1998). Bidirectional relations of phonological sensitivity and prereading abilities: Evidence from a preschool sample. *Journal of Experimental Child Psychology, 70*, 117–141.

Byrne, B. (1989). Phonemic awareness and letter knowledge in the child's acquisition of the alphabetic principle. *Journal of Educational Psychology, 81*, 313–321.

Caravolas, M., Lervåg, A., Defior, S., Seidlová Málková, G., & Hulme, C. (2013). Different patterns, but equivalent predictors, of growth in reading in consistent and inconsistent orthographies. *Psychological Science, 24,* 1398–1407.

Castles, A. & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition, 91*, 77–111.

Castles, A., Wilson, K., & Coltheart, M. (2011). Early orthographic influences on phonemic awareness tasks: Evidence from a preschool training study. *Journal of Experimental Child Psychology, 108*, 203–210.

Catts, H. W., Adlof, S. M., & Weismer, S. E. (2006). Language deficits in poor comprehenders: A case for the simple view of reading. *Journal of Speech, Language, and Hearing Research, 49*, 278–293.

Catts, H. W., Compton, D., Tomblin, J. B., & Bridges, M. S. (2012). Prevalence and nature of late-emerging poor readers. *Journal of Educational Psychology, 104*, 166–181.

Chiu, M. M. & McBride-Chang, C. (2006). Gender, context, and reading: A comparison of students in 43 countries. *Scientific Studies of Reading, 10*, 331–362.

Compton, D. L., Fuchs, D., Fuchs, L. S., Elleman, A. M., & Gilbert, J. K. (2008). Tracking children who fly below the radar: Latent transition modeling of students with late-emerging reading disability. *Learning and Individual Differences, 18*, 329–337.

Denckla, M. B. & Rudel, R. G. (1976). Rapid "automatized" naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia, 14*, 471–479.

Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., & Reuman, D. (1993). Development during adolescence. The impact of stage-environment fit on young adolescents' experiences in schools and in families. *The American Psychologist, 48*, 90–101.

Ehri, L. C. (1989). The development of spelling knowledge and its role in reading acquisition and reading disability. *Journal of Learning Disabilities, 22*, 356–365.

Ehri, L. C. (1998). Grapheme-phoneme knowledge is essential for learning to read words in English. In J. L. Metsala & L. C. Ehri (Eds.), *Word recognition in beginning literacy* (pp. 3–40). Mahwah, NJ: Erlbaum.

Etmanskie, J. M., Partanen, M., & Siegel, L. (2016). A longitudinal examination of the persistence of late emerging reading disabilities. *Journal of Learning Disabilities, 49*, 21–35.

Finnish National Board of Education (2016). *National core curriculum for basic education 2014*. Helsinki: Finnish National Board of Education, Publications, 2016:5.

Foulin, J. N. (2005). Why is letter-name knowledge such a good predictor of learning to read? *Reading and Writing, 18*, 129–155.

Francis, D. J, Shaywitz, S. E., Stuebing, K. K., Shaywitz, B. A., & Flecther, J. M. (1996). Developmental lag versus deficit models of reading disability: A longitudinal, individual growth curves analysis. *Journal of Educational Psychology, 88*, 3–17.

Frith, U., Wimmer, H., & Landerl, K. (1998). Differences in phonological recoding in German and English speaking children. *Scientific Studies of Reading, 2*, 31–54.

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

García, J. R. & Cain, K. (2014). Decoding and reading comprehension: A meta-analysis to identify which reader and assessment characteristics influence the strength of the relationship in English. *Review of Educational Research, 84*, 74–111.

Gayán, J. & Olson, R. K. (2003). Genetic and environmental influences on individual differences in printed word recognition. *Journal of Experimental Child Psychology*, *84*, 97–123.

Georgiou, G. K., Manolitsis, G., Nurmi, J.-E., & Parrila, R. (2010). Does task-focused versus task-avoidance behavior matter for literacy development in an orthographically consistent language? *Contemporary Educational Psychology, 35*, 1–10.

Georgiou, G. K., Parrila, R., & Kirby, J. (2006). Rapid naming speed components and early reading acquisition. *Scientific Studies of Reading, 10*, 199–220.

Georgiou, G. K., Parrila, R., & Kirby, J. (2009). RAN components and reading development from grade 3 to grade 5: What underlies their relationship? *Scientific Studies of Reading, 13,* 508–534.

Georgiou, G. K., Parrila, R., Kirby, J., & Stephenson, K. (2008). Rapid naming components and their relationship with phonological awareness, orthographic knowledge, speed of processing, and different reading outcomes. *Scientific Studies of Reading*, *12*, 325–350.

Georgiou, G. K., Parrila, R., & Papadopoulos, T. C. (2008). Predictors of word decoding and reading fluency across languages varying in orthographic consistency. *Journal of Educational Psychology, 100*, 566–580.

Goswami, U. & Bryant, P. (1990). *Phonological skills and learning to read*. London: Erlbaum

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

Guay, F., Larose, S., & Boivin, M. (2004). Academic self-concept and educational attainment level: A ten-year longitudinal study. *Self and Identity, 3*, 53–68.

Guthrie, J. T. & Wigfield, A. (2000). Engagement and motivation in reading. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research. Volume III* (pp. 403–422). New Jersey: Erlbaum.

Hammill, D. D. (2004). What we know about correlates of reading. *Exceptional Children, 70*, 453–468.

Hawke, J. L., Olson, R. K., Willcutt, E. G., Wadsworth, S. J., & DeFries, J. C. (2009). Gender ratios for reading difficulties. *Dyslexia, 15*, 239–242.

Hawke, J. L., Wadsworth, S. J., & DeFries, J. C. (2006). Genetic influences on reading difficulties in boys and girls: The Colorado Twin Study. *Dyslexia, 12*, 21–29.

Hawke, J. L., Wadsworth, S. J., Olson, R. K., & DeFries, J. C. (2007). Etiology of reading difficulties as a function of gender and severity. *Reading and Writing, 20,* 13–25.

Holopainen, L., Ahonen, T., & Lyytinen, H. (2001). Predicting delay in reading achievement in a highly transparent language. *Journal of Learning Disabilities, 34*, 401–413.

Hudson, R. F., Lane, H. B., & Pullen, P. C. (2005). Reading fluency assessment and instruction: What, why, and how? *The Reading Teacher*, *58*, 702–714.

Huemer, S. (2009). *Training reading skills. Towards fluency.* Jyväskylä: Jyväskylä Studies in Education, Psychology and Social Research, 360.

Hämäläinen, J. A., Salminen, H. K., & Leppänen, P. H. T. (2013). Basic auditory processing deficits in dyslexia: Systematic review of the behavioral and event-related potential/field evidence. *Journal of Learning Disabilities, 46,* 413–427.

Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology, 80,* 437–447.

Katusic, S., Colligan, R., Barbaresi, W., Schaid, D., & Jacobsen, S. (2001). Incidence of reading disability in a population-based birth cohort, 1976–1982, Rochester, Minn. *Mayo Clinic Proceedings, 76*, 1081–1092.

Kere, J. (2014). The molecular genetics and neurobiology of developmental dyslexia as model of a complex phenotype. *Biochemical and Biophysical Research Communications, 452*, 236–243.

Kirby, J., Parrila, R., & Pfeiffer, S. (2003). Naming speed and phonological awareness as predictors of reading development. *Journal of Educational Psychology, 95*, 453–464.

Kovacs, Y. & Plomin, R. (2007). Learning abilities and disabilities: Generalist genes, specialist environments. *Current Directions in Psychological Science, 16*, 284–288.

Kuhn, M. R., Schwanenflugel, P. J., & Meisinger, E. B. (2010). Aligning theory and assessment of reading fluency: Automaticity, prosody, and definitions of fluency. *Reading Research Quarterly, 45*, 230–251.

Laakso, M.-L., Poikkeus, A.-M., & Lyytinen, P. (1999). Shared reading interaction in families with and without genetic risk for dyslexia: Implications for toddlers' language development. *Infant and Child Development, 8,* 179–195.

LaBerge, D. & Samuels, J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology, 6*, 293–323.

Lam, S., Jimerson, S., Kikas, E., Cefai, C., Veiga, F. H., Nelson, B., … Zollneritsch, J. (2012). Do girls and boys perceive themselves as equally engaged in school? The results of an international study from 12 countries. *Journal of School Psychology, 50*, 77–94.

Landerl, K. & Moll, K. (2010). Comorbidity of learning disorders: Prevalence and familial transmission. *Journal of Child Psychology and Psychiatry 51*, 287–294.

Landerl, K., Ramus, F., Moll, K., Lyytinen, H., Leppänen, P. H. T., Lohvansuu, K., … Schulte-Körne, G. (2012). Predictors of developmental dyslexia in

European orthographies with varying complexity. *Journal of Child Psychology and Psychiatry, 54*, 686–694.

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

Leach, J. M., Scarborough, H. S., & Rescorla, L. (2003). Late-emerging reading disabilities. *Journal of Educational Psychology, 95*, 211–224.

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

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

Lepola, J., Salonen, P., & Vauras, M. (2000). The development of motivational orientations as a function of divergent reading careers from pre-school to the second grade. *Learning and Instruction, 10,* 153–177.

Leppänen, P. H. T., Hämäläinen, J. A., Salminen, H. K., Eklund, K. M., Guttorm, T. K., Lohvansuu, K., … Lyytinen, H. (2010). Newborn brain event-related potentials revealing atypical processing of sound frequency and the subsequent association with later literacy skills in children with familial dyslexia. *Cortex*, *46,* 1362–1376.

Lietz, P. (2006). A meta-analysis of gender differences in reading achievement at the secondary school level. *Studies in Educational Evaluation, 32,* 317–344.

Lipka, O., Lesaux, N., & Siegel, L. (2006). Retrospective analyses of the reading development of Grade 4 students with reading disabilities: Risk status and profiles over 5 years. *Journal of Learning Disabilities, 39*, 364–378.

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). A definition of dyslexia. *Annals of Dyslexia, 53,* 1–14.

Lyytinen, H., Erskine, J., Ahonen, T., Aro, M., Eklund, K., Guttorm, T., … Viholainen, H. (2008). Early identification and prevention of dyslexia: Results from a prospective follow-up study of children at familial risk for dyslexia. In G. Reid, F. Manis, & L. Siegel (Eds.), *The Sage handbook of dyslexia* (pp. 121–146). Thousand Oaks, CA: Sage.

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

Martini, F. & Sénéchal, M. (2012). Learning literacy skills at home: Parent teaching, expectations, and child interest. *Canadian Journal of Behavioural Science, 44,* 210–221.

McBride-Chang, C. (1995). The ABCs of the ABCs: The development of letter-name and letter-sound knowledge. *Merrill-Palmer Quaterly, 45*, 285–308.

McGeown, S., Goodwin, H., Henderson, N., & Wright, P. (2012) Gender differences in reading motivation: Does sex or gender identity provide a better account? *Journal of Research in Reading, 35*, 328–336.

Mol, S. E. & Bus, A. G. (2011). To read or not to read: A meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin, 137*, 267–296.

Muter, V., Hulme, C., Snowling, M., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology, 40*, 665–681.

Nation, K., Clarke, P., Marshall, C. M., & Durand, M. (2004). Hidden language impairments in children: Parallels between poor reading comprehension and specific language impairment? *Journal of Speech, Language, and Hearing Research, 47*, 199–211.

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

Neuhaus, G., Foorman, B. R., Francis, D. J., & Carlson, C. D. (2001). Measures of information processing in rapid automatized naming (RAN) and their relation to reading. *Journal of Experimental Child Psychology, 78*, 359–373.

Norton, E. S. & Wolf, M. (2012). Rapid automatized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. *Annual Review of Psychology, 63*, 427–452.

OECD (2002). *Reading for change: Performance and engagement across countries: Results from PISA 2000. Executive summary.* Paris: OECD.

OECD (2009*). PISA 2009 assessment framework*. *Key competencies in reading, mathematics and science.* Paris: OECD.

OECD (2010). *PISA 2009 results: Learning to learn: student engagement, strategies and practices (Volume III)*. Paris: OECD.

OECD (2011). *PISA 2009 at a glance*. Paris: OECD.

OECD (2013). *PISA 2012 results: What students know and can do – Student performance in mathematics, reading and science (Volume I, Revised edition*). Paris: OECD.

Olson, R. K. (2006). Genes, environment, and dyslexia. The 2005 Norman Geschwind memorial lecture. *Annals of Dyslexia, 56*, 205–238.

Olson, R. K., Keenan, J. M., Byrne, B., & Samuelsson, S. (2014). Why do children differ in their development of reading and related skills? *Scientific Studies of Reading, 18*, 38–54.

Onatsu-Arvilommi, T. P. & Nurmi, J.-E. (2000). The role of task-focused and task-avoidant behaviors in the development of reading and mathematical skills during the first school year: A cross-lagged longitudinal study. *Journal of Educational Psychology, 92*, 478–491.

Papadopoulos, T. C., Georgiou, G., & Kendeou, P. (2009). Investigating the double-deficit hypothesis in Greek: Findings from a longitudinal study. *Journal of Learning Disabilities, 42*, 528–547.

Papadopoulos, T. C., Spanoudis, G. C., & Georgiou, G., (2016). How is RAN related to reading fluency? A comprehensive examination of the prominent theoretical accounts. *Frontiers in Psychology, 7*, 1–15.

Parrila, R., Aunola, K., Leskinen, E., Nurmi, J.-E., & Kirby, J. R. (2005). Development of individual differences in reading: Results from longitudinal studies in English and Finnish. *Journal of Educational Psychology, 97*, 299–319.

Pennala, R., Eklund, K., Hämäläinen, J., Richardson, U., Martin, M., Leiwo, M., … Lyytinen, H. (2010). Perception of phonemic length and its relation to reading and spelling skills in children with familial risk for dyslexia at the three first grades in school. *Journal of Speech, Language, and Hearing Research, 53,* 710–724.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101,* 385–413.

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

Perfetti, C. A. (1985). *Reading ability*. New York: Oxford University Press.

Perfetti, C. A., Beck, I., Bell, L., & Hughes, C. (1987). Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first-grade children. *Merrill-Palmer Quarterly, 33*, 283–319.

Perfetti, C. & Hart, L. (2001). The lexical quality hypothesis. In L. Verhoeven, C. Erlbro, & P. Reitsma (Eds.), *Precursors of functional literacy* (pp. 189–214). Amsterdam: John Benjamins.

Peterson, R. L. & Pennington, B. F. (2012). Developmental dyslexia. *Lancet, 279,* 1997–2007.

Phillips, L. M., Norris, S. P., Osmond, W. C., & Maynard, A. M. (2002). Relative reading achievement: A longitudinal study of 187 children from first through sixth grades. *Journal of Educational Psychology, 94,* 3–13.

Piasta, S. B. & Wagner, R. K. (2010). Developing early literacy skills: A meta-analysis of alphabet learning and instruction. *Reading Research Quarterly, 45*, 8–38.

Plomin, R., DeFries, J. C., & Loehlin, J. C. (1977). Genotype–environment interaction and correlation in the analysis of human behavior. *Psychological Bulletin*, *84,* 309–322.

Plomin, R. & Kovacs, Y. (2005). Generalist genes and learning disabilities. *Psychological Bulletin*, *131*, 592–617.

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

Quinn, J. M. & Wagner, R. K. (2015). Gender differences in reading impairment and in the identification of impaired readers: Results from a large-scale study of at-risk readers. *Journal of Learning Disabilities, 48*, 433–445.

Rutter M., Caspi A., Fergusson D., Horwood, L. J., Goodman, R., Maughan, B., … Carrol, J. (2004). Sex differences in developmental reading disability: New findings from 4 epidemiological studies. *JAMA, 291*, 2007–2012.

Salonen, P., Lepola, J., & Niemi, P. (1998). The development of first graders' reading skill as a function of pre-school motivational orientation and phonemic awareness. *European Journal of Educational Psychology, 2,* 155–173.

Sameroff, A. J., Seifer, R., Baldwin, A., & Baldwin, C. (1993). Stability of intelligence from preschool to adolescence: The influence of social and family risk factors. *Child Development, 64*, 80–97.

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

Scarborough, H. S., Dobrich, W., & Hager, M. (1991). Preschool literacy experience and later reading achievement. *Journal of Learning Disabilities*, *24*, 508–511.

Sénéchal, M. (2006). Testing the home literacy model: Parent involvement in kindergarten is differentially related to Grade 4 reading comprehension, fluency, spelling, and reading for pleasure. *Scientific Studies of Reading, 10*, 59–87.

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

Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94,* 143–174.

Share, D. L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition, 55*, 151–218.

Share, D. L. (2004). Knowing letter names and learning letter sounds: A causal connection. *Journal of Experimental Child Psychology, 88*, 213–233.

Share, D. L. (2008). On the anglocentricities of current reading research and practice: The perils of overreliance on an "outlier" orthography. *Psychological Bulletin, 134*, 584–615.

Shaywitz, B. A., Holford, T. R., Holahan, J. M., Fletcher, J. M., Stuebing, K. K., Francis, D. J., & Shaywitz, S. E. (1995). A Matthew effect for IQ but not for reading: Results from a longitudinal study. *Reading Research Quarterly, 30*, 894–906.

Shaywitz, S. E., Escobar, M. D., Shaywitz, B. A., Fletcher, J. M., & Makuch, R. (1992). Evidence that dyslexia may represent the lower tail of a normal distribution of reading ability. *The New England Journal of Medicine, 326*, 145–150.

Shaywitz, S. E., Fletcher, J. M., Holahan, J. M., Schneider, A. E., Marchione, K. E., Stuebing, K. K., … Shaywitz, B. A. (1999). Persistence of dyslexia: The Connecticut Longitudinal Study of dyslexia at adolescence. *Pediatrics, 104*, 1351–1359.

Shaywitz, S. E., Shaywitz, B. A., Fletcher, J. M., & Escobar, M. D. (1990). Prevalence of reading disability in boys and girls: Results of the Connecticut Longitudinal Study. *JAMA, 264*, 998–1002.

Snowling, M. J. (2008). Specific disorders and broader phenotypes: The case of dyslexia. *The Quarterly Journal of Experimental Psychology, 61*, 142–156.

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

Snowling, M. J. & Melby-Lervåg, M. (2016). Oral language deficits in familial dyslexia: A meta-analysis and review. *Psychological Bulletin, 142*, 498–545.

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

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21,* 360–407.

Stanovich, K. E. (1988). Explaining the differences between the dyslexic and garden variety poor readers: The phonological-core variable-difference model. *Journal of Learning Disabilities, 21*, 590–604.

Stanovich, K. E. (1998). Refining the phonological core deficit model. *Child and Adolescent Mental Health, 3*, 17–21.

Stephenson, K. A., Parrila, R. K., Georgiou, G. K., & Kirby, J. R. (2008). Effects of home literacy, parents' beliefs, and children's task-focused behavior on emergent literacy and word reading skills. *Scientific Studies of Reading, 12*, 24–50.

Storch, S. A. & Whitehurst, G. J. (2002). Oral language and code-related precursors to reading: Evidence from a longitudinal structural model. *Developmental Psychology, 38*, 934–947.

Sulkunen, S. (2013). Adolescent literacy in European urgent call for action. *European Journal of Education, 48*, 528–542.

Taylor, J., Roehrig, A. D., Hensler, B. S., Connor, C. M., & Schatschneider, C. (2010). Teacher quality moderates the genetic effects on early reading. *Science, 328*, 512–514.

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

Torppa, M., Georgiou, G. K., Salmi, P., Eklund, K., & Lyytinen, H. (2012). Examining the double-deficit hypothesis in an orthographically consistent language. *Scientific Studies of Reading, 16*, 287–315.

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities, 43*, 1–14.

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

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

Treiman, R., Tincoff, R., Rodriguez, K., Mouzaki, A., & Francis, D. J. (1998). The foundations of literacy: Learning the sounds of letters. *Child Development, 69*, 1524–1540.

Vaessen, A., Bertrand, D., Tóth, D., Csépe, V., Fáısca, L., Reis, A., & Blomert, L. (2010). Cognitive development of fluent word reading does not qualitatively differ between transparent and opaque orthographies. *Journal of Educational Psychology, 102*, 827–842.

van Bergen, E., de Jong, P. F., Plakas, A., Maassen, B., & van der Leij, A. (2012). Child and parental literacy levels within families with a history of dyslexia. *Journal of Child Psychology and Psychiatry, 53*, 28–36.

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

van Bergen, E., van der Leij, A., & de Jong, P. F. (2014). The intergenerational multiple deficit model and the case of dyslexia. *Frontiers in Human Neuroscience, 8*, 1–13.

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

Verhoeven, L. & van Leeuwe, J. (2008). Prediction of the development of reading comprehension: A longitudinal study. *Applied Cognitive Psychology,* 407–423.

White, B. (2007). Are girls better readers than boys? Which boys? Which girls? *Canadian Journal of Education, 30*, 554–581.

Wimmer, H. (1993). Characteristics of developmental dyslexia in a regular writing system. *Applied Psycholinguistics, 14*, 1–33.

Wolf, M. & Bowers, P. G. (1999). The double-deficit hypothesis for the developmental dyslexias. *Journal of Educational Psychology, 91*, 415–438.

Ziegler, J. C., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Faísca, L., … Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: A cross-language investigation. *Psychological Science, 21,* 551–559.

ORIGINAL PAPERS

I

PREDICTING READING DISABILITY: EARLY COGNITIVE RISK AND PROTECTIVE FACTORS

by

Kenneth Eklund, Minna Torppa, & Heikki Lyytinen, 2013

Dyslexia, 19, 1–10

Abstract

This longitudinal study examined early cognitive risk and protective factors for Grade 2 reading disability (RD). We first examined the reading outcome of 198 children in four developmental cognitive subgroups that were identified in our previous analysis (Lyytinen et al., 2006): dysfluent trajectory, declining trajectory, unexpected trajectory, and typical trajectory. We found that RD was unevenly distributed among the subgroups, although children with RD were found in all subgroups. A majority of the children with RD had familial risk for dyslexia. Second, we examined in what respect children with similar early cognitive development but different RD outcome differ from each other in cognitive skills, task focused behaviour, and print exposure. The comparison of the groups with high cognitive risk but different RD outcome showed significant differences in phonological skills, in the amount of shared reading and in task focused behaviour. Children who ended up with RD despite low early cognitive risk had poorer cognitive skills, more task avoidance, and they were reading less than children without RD and low cognitive risk. In summary, lack of task avoidance seemed to act as a protective factor, which underlines the importance of keeping children interested in school-work and reading.

Keywords: Reading disability, Dyslexia, Familial risk, Cognitive risks, Protective factors, Longitudinal

Developmental dyslexia runs in families (e.g., Cardon, et al., 1994; Hallgren, 1950; Taipale et al., 2003) and one useful way to understand its early development is through prospective family risk studies following children born into families with parental dyslexia. The risk for dyslexia increases from a few percent among the general population to about 40% for an individual whose parents and relatives have been affected (e.g. Puolakanaho, et al., 2007). In the present study, we report associations of cognitive risk and protective factors with reading skill outcomes of 198 Finnish children with different profiles of early cognitive development, followed from birth to school age in the Jyväskylä Longitudinal study of Dyslexia (JLD).

On the basis of family risk studies as well as other evidence, a wide consensus has been reached on the strongest early cognitive predictors of reading difficulties, namely, phonological awareness and letter knowledge (e.g. Byrne, 1998; Puolakanaho et al., 2008; Scarborough, 2001; Vellutino, Fletcher, Snowling, & Scanlon, 2004). In highly consistent orthographies such as Finnish or German, strong predictive links also exist between reading and serial naming speed, RAN (e.g., Holopainen, Ahonen, & Lyytinen, 2001; Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010; Wimmer & Mayringer, 2002). In addition, variation in children’s print exposure, particularly in the amount of shared reading between the parent and child (e.g., Scarborough & Dobrich, 1994; Sénéchal & LeFevre, 2002; Torppa, Poikkeus, Laakso, Eklund, & Lyytinen , 2006), task focused behavior (including task-involved goal orientation and engagement in high-effort tasks) (e.g. Hirvonen, Georgiou, Lerkkanen, Aunola, & Nurmi, 2010; Onatsu-Arvilommi & Nurmi, 2000; Stephenson, Parrila, Georgiou, & Kirby, 2008), and variability in school environment (e.g., Rowan, Correnti, & Miller, 2002; Torppa et al., 2007) are known to predict to reading outcomes.

In a previous analysis of our JLD-data (Lyytinen et al., 2006) we have identified subgroups in children's cognitive development and examined their early development of reading skills. Development of children's expressive and receptive spoken language was assessed with the Finnish adaptation of theMacArthur Communicative Development Inventory (Lyytinen, 1999) at the age of 1-2.5 years, the Reynell Developmental Language Scales (Reynell & Huntley, 1987) (2.5 y), Peabody Picture Vocabulary (Dunn & Dunn, 1981) and the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) at 3.5 and 5 years. Skills in phonological awareness were measured with Segment identification, Synthesis and Initial phoneme identification and production at 3.5, 4.5, 5.5 and 6.5 years (see Puolakanaho et al. 2003). Additional measures included: rapid serial naming RAN (Denckla & Rudel, 1974) of objects (3.5 y), objects and colours (5.5 y) and objects, colours, digits and letters (6.5 y), letter knowledge (Letter identification at 3.5 and 4.5 y, Letter naming at 3.5, 4.5, 5, 5.5 and 6.6 y, Visual matching of letter string pairs at 3.5, 4.5, and 5 y, and Word identification at 3.5, 4.5, 5, and 5.5 y), morphological awareness (Comprehension of adjectival, noun and verb inflections at 2.5y and inflectional morphology at 3.5 and 5 y) (P. Lyytinen and Lyytinen, 2004), and verbal short term memory (Forward digit span (Gathercole & Adams, 1994) at 3.5, 5, and 6.5 y, Syllable span at 5 y and Sentence and Nonword repetition (Korkman, Kirk, & Kemp, 1998) at 3.5 and 5.5 y).

Using the mixture modeling feature of MPLUS (L.K. Muthen & Muthen, 2004), subgroups were identified in a two-step procedure. First, a common latent factor which extracts the common variance shared by the individuals in the seven skill domains introduced above (receptive language, expressive language, phonological awareness, rapid serial naming, letter knowledge, morphological awareness and verbal short term memory) was identified. This was used to ascertain the specific effect of each skill domain in the second phase, i.e. when clustering children with similar patterns of development into the subgroups using a latent class factor. Four subgroups were identified (see Figure 1): a group with a ‘dysfluent trajectory’ (n = 12; 11 at risk vs. 1 control); a group with a ‘declining trajectory’ (n = 35; 24 at risk vs. 11 controls); a group with an ‘unexpected trajectory’ (n = 67; 33 at risk vs. 34 controls); and a group with a ‘typical trajectory’ (n = 85, 38 at risk vs. 47 controls).

This differential development of early cognitive skills was linked to early reading and spelling skills assessed in the autumn and spring of Grade 1 (at about 7 and 7 years 9 months of age, respectively), and in the autumn of Grade 2 (at about 8 years of age). There were three groups with difficulties in reading acquisition. The Dysfluent subgroup was characterized by highly significant difficulties with naming speed (especially at 5.5 and 6.5 years, when naming speed can be more reliably measured), in addition to difficulties in morphology, phonological awareness and letter knowledge. Children in this subgroup acquired relatively good levels of reading accuracy but were the slowest of all children on measures of reading speed. All except one of the children in this group had familial risk for dyslexia. The Declining subgroup was characterized by a decreasing developmental trajectory within all skill domains other than memory skills. Children in this subgroup showed difficulties both in reading accuracy and fluency at the early stages of reading acquisition. This subgroup also showed the largest within-group variation in reading and writing skills, with children experiencing familial risk scoring significantly lower than control children. Children in the Unexpected subgroup were characterized by the strongest skills of all four subgroups in receptive and expressive language as well as in morphological skills and memory. Interestingly, however, children in this subgroup showed a declining trajectory in letter knowledge and had a somewhat lower reading skill at the onset of formal schooling. The Typical subgroup had no difficulties in early cognitive development or in reading acquisition. Compared to the other groups, they showed a continuous elevation of their relative skill level across development, which made them the most skilled subgroup prior to school entry. In the present analyses we examined these four subgroups further and extended our focus to include protective factors. At the time of the analyses reported in Lyytinen et al. (2006) children were too young for a diagnosis of reading disability (RD) .

In this study we asked the following questions:

1. What proportion of the children in the subgroups had RD at the end of Grade 2?
2. Why did some of the children classified to have a high cognitive risk profiles for RD (the Dysfluent and Declining groups) have RD while others did not? And, in addition, why some of the children ended up with RD despite their low cognitive risk?
3. To what extent did print exposure and task focused behavior act as protective factors against RD?

Method

Participants

Data were drawn from the prospective Jyväskylä Longitudinal Study of Dyslexia (JLD, see e.g. Lyytinen et al., 2008). A total of 214 Finnish families joined the study prior to the birth of their children. Half of the participating families (the at-risk group due to the presence of familial risk for dyslexia) had a parent who scored at least -1.0 standard deviation below the mean of the normative sample in reading or spelling and who also reported similar problems among his or her immediate relatives. Familial risk for RD was confirmed by self-reported literacy difficulties in questionnaire data and through structured interview (see, Leinonen et al., 2001). Here we present the data from 198 children (106 at-risk for familial dyslexia, 92 controls) for whom complete data were available and extends from age of 5 years to the end of Grade 2 (age 8 years 10 months).

Measures

Table 1 summarizes the skill domains assessed, the ages and grades of children during the assessments. For all measures z-scores calculated using the mean and standard deviation values of the control group (n = 92) were used. For the details of early cognitive measures see Lyytinen et al. (2006).

Measures of protective factors

Task focused behavior. Task focused behavior was assessed with five questions: 1. *When facing difficulties, does the child have a tendency to find something else to do instead of focusing on the task at hand? 2. Does the child actively try to solve even the most difficult tasks? 3. Does it seem that the child easily gives up the task at hand? 4. Does the child show persistence when working with the tasks? 5. When problems occur with a task, does the child turn his or her attention to other things?* The respondent (tester, teacher or parent) used a 5-point Likert scale to rate how well the claim fit the child's behaviour (1 = *not at all* … 5 = *to great extent*). Each respondent answered the same questions, but the context in which they had to evaluate child's behavior varied: for testers the context was the child's behavior during an assessment, for teachers it was during school lessons, and for parents whilst doing homework in the home. Testers evaluated the child's behavior at the age of 6.5 and 8.9 years, and for teachers and parents at Grades 1 and 2. The factor score of the five items with Maximum likelihood extraction (done separately for each respondent type and evaluation time) was used as the dependent measure. A one factor solution explained 55.90 % and 50.81 % of the variance of testers' responses at the age of 6.5 and 8.9 years, respectively, 66.18 % and 65.86 % of the variance of teachers' responses and 55.69 % and 60.48 % of the variance of parents' responses at Grade 1 and 2, respectively.

Shared reading. A mean composite score was derived for the four items pertaining to shared reading at the ages of 6 and 8 years. This included: frequency of (1) mother and (2) father reading to the child, (3) the typical duration of a reading episode, and (4) the total time per day that the child spent reading a book with an adult. Parents responded to the first two items using a five-point scale (1 = *not at all/seldom* ... 5 = *several times a day*) and to the third and fourth items using a three-point scale (1 = *less than 15 min/day* ... 3 = *longer than 45 min/day*).

Reading alone. The time spent by the child engaged in solitary reading activities was calculated from three questions at the age of 8 years: (1) how often the child read alone, (2) the typical duration of a reading episode, and (3) the total time per day that the child spent reading a book alone. Parents responded to the first item using a five-point scale (1 = *not at all/seldom* ... 5 = *several times a day*) and to the second and third items using a three-point scale (1 = *less than 15 min/day* ... 3 = *longer than 45 min/day*).

Classification of children for RD

The classification of children for RD at the end of Grade 2 was based on performance in five tasks: 1. Oral word and pseudoword reading, 2. Oral text reading, 3. Oral pseudoword text reading, 4. Oral word list reading, and 5. Spelling words and pseudowords. Four measures of reading speed and four measures of reading / spelling accuracy were calculated. The procedure leading to classification of RD was the following: first, using a cutoff score based on the JLD control group, a child was considered to have deficient skills in each respective task if his or her score fell to the 10th percentile or below; second, the child's skills had to be at or below the 10th percentile either 1) in at least three out of the four accuracy measures or 2) at least three out of the four fluency measures, or 3) in two accuracy measures and in two fluency measures to be classified as RD. (see Puolakanaho et al., 2007).

Results and Discussion

Our analyses revealed that the RD children in Grade 2 were unevenly distributed in the subgroups of early cognitive development (χ^2 (3) = 28.80, $p < .001$) (see Table 2). Although RD was identified in all groups, the highest proportion was found in the Dysfluent (75 %) and in the Declining subgroups (38 %) whereas there was a lower proportion of RD in the Unexpected (21 %) and Typical subgroups (12 %). The large majority of children with RD in each subgroup had a familial risk for dyslexia: Dysfluent 88.9 %, Declining 84.6 %, Unexpected 78.6 %, and Typical 70.0 %.

For subsequent analyses of the risk and protective factors, we combined the subgroups with cognitive profiles that indicated high risk for RD (Dysfluent and Declining) and the subgroups with cognitive profiles that indicated low risk for RD (Unexpected and Typical) in order to increase the group sizes. Four new groups were formed: 1. High early cognitive risk and Grade 2 RD (HR_RD, n = 22), 2. High early cognitive risk and no Grade 2 RD (HR_noRD, n = 24), 3. Low early cognitive risk and Grade 2 RD (LR_RD, n = 24), and 4. Low early cognitive risk and no Grade 2 RD (LR_noRD, n = 128).

The comparisons between the children with high early cognitive risk profiles but different RD outcomes (HR_noRD vs. HR_RD) showed that their skills in receptive language and morphology at the age of 5 years, expressive language at 5.5 years, letter knowledge and phonological awareness at 6.5 years, rapid serial naming and verbal short term memory at 6.5 and 8.9 years, and IQ at 5 and 8.5 years were not significantly different, but that after one year of schooling children's skills in these two groups differed in phonological awareness (see Table 3). Task focused behavior (teacher report) appeared to act as a protective factor: HR-noRD children were more task focused than HR_RD children. No differences were found in the amount of time spent reading alone or in shared reading with a parent, but the amount of shared reading grew significantly more between the ages of 6 and 8 years in the HR_RD compared to the HR_noRD group ($F(1, 147) = 3.88$, $p \leq .01$). This may indicate that the parents of the HR_RD group were responding to the needs of their children by spending more time reading with them after becoming aware of their reading problems.

The comparisons of the children with low early cognitive risk but different RD outcomes (LR_noRD vs. LR_RD) suggested that poorer cognitive skills, task avoidance, and less time spent reading were significant risk factors for RD. The LR_RD children had weaker skills in phonological awareness (at 6.5 years and in Grade 1), RAN (6.5 years), memory (Grade 2), and IQ (Grade 2) than did the LR_noRD children. According to parental reports, they were also more task avoidant (at Grades 1 and 2), and were spending less time reading alone (at 8 years). These findings suggest the presence of difficulties in phonological awareness and rapid naming in the LR_RD group immediately prior to school entry and is consistent with our previous reports of substantial inter-individual variation in reading component skills both between but also within the subgroups (Lyytinen et al. 2006).

Conclusions

Although compromised early cognitive development - especially difficulties in fluent automatized naming- is a risk for later RD, approximately half of the children with a early profile of high cognitive risk did not end up developing RD. In contrast, in 16 % of the children in the group designated at low cognitive risk group had RD. Even the presence of an optimal development of early language skills did not necessarily act as a protective factor for RD in all cases, when the key cognitive skills needed for reading, namely, phonological awareness, letter knowledge, and naming speed were hampered, especially among children with familial risk. We have previously shown that including familial risk in addition to the cognitive predictors significantly improves the prediction of RD (Puolakanaho et al., 2007). Also in this study, the familial risk per se seemed to increase the risk for RD.

A protective factor for children with high cognitive risk prior to school age appeared to include a lack of task avoidance. High levels of task-focused behavior tended to be associated with the absence of RD at the end of Grade 2 irrespective of the presence of early cognitive risk factors. In contrast, task avoidance and less time spent engaged in reading compared to peers, appeared to increase risk for children with low cognitive risk profiles.

These findings underline the importance of maintaining children's engagement in educational and literacy-based activities, and particularly for the children already at risk. These findings also support our previous findings that children with good reading skills have more shared reading with their parents prior to school entry than children with slow decoding and poor reading comprehension (Torppa et al., 2007).

Fortunately, it appeared in this study that parents of children with RD seemed to react to children's RD by increasing shared reading with their children after school entry. Whether this will help some of these children to overcome their RD in the subsequent grade levels remains as an interesting question for future studies.

Acknowledgements

The Jyväskylä Longitudinal study of Dyslexia (JLD) was part of the Finnish Center of Excellence Program (2000-20011) and has been supported by the Academy of Finland, Niilo Mäki Institute and University of Jyväskylä. We would like to thank the families for participating in the study.

References

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

Cardon, L. R., Smith, S. D., Fulker, D. W., Kimberling, W. J., Pennington, B. F., & DeFries, J. C. (1994). Quantitative trait locus for reading disability on chromosome 6. *Science, 266,* 276-279.

Denckla, M. B., & Rudel, R. G. (1974). Rapid ”automatized” naming of pictured objects, colors, letters and numbers by normal children. *Cortex, 10,* 471-479.

Dunn, L. M., & Dunn, L. M. (1981). *Peabody Picture Vocabulary Test-Revised*. Circle Pines. MN: American Guidance Service.

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

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

Hirvonen, R., Georgiou, G. K., Lerkkanen, M.-K., Aunola, K., & Nurmi, J.-E. (2010). Task-focused behaviour and literacy development: A reciprocal relationship. *Journal of Research in Reading, 33,* 302-319.

Holopainen, L., Ahonen, T., & Lyytinen, H. (2001). Predicting delay in reading achievement in a highly transparent language. *Journal of Learning Disabilities, 34,* 401-413.

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

Korkman, M., Kirk, U., & Kemp, S. (1998). *NEPSY: A developmental neuropsychological assessment.* San Antonio: Psychological Corporation.

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

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

Lyytinen, H., Erskine, J. , Ahonen, T., Aro, M., Eklund, K:, Guttorm, T., Hintikka, S., Hämäläinen, J., Ketonen, R., Laakso, M-L., Leppänen, P.H.T., Lyytinen, P., Poikkeus, A.-M., Puolakanaho, A., Richardson, U., Salmi, P., Tolvanen, A., Torppa, M. & Viholainen, H. (2008). Early Identification and Prevention of Dyslexia: Results From a Prospective Follow-up Study of Children at Familial Risk for Dyslexia. In G. Reid, A.J. Fawcett, F. Manis. & L. S. Siegel (Eds.), *Handbook of Dyslexia*, (pp. 121-146). London: Sage publications.

Lyytinen, P. (1999). *Varhaisen kommunikaation ja kielen kehityksen arviointimenetelmä* (Finnish manual for the MacArthur Communicative Development Inventory, CDI). University of Jyväskylä, Child Research Center and Niilo Mäki Institute. Jyväskylä: Yliopistopaino.

Lyytinen, P., & Lyytinen, H. (2004). Growth and predictive relations of vocabulary and inflectional morphology in children with and without familial risk for dyslexia. *Applied Psycholinguistics, 25*, 397 – 411.

Muthén, L. K., & Muthén, B. O. (2004). *Mplus User's Guide.* Los Angeles.

Onatsu-Arvilommi, T. & Nurmi, J.-E. (2000). The Role of Task-Avoidant and Task-Focused Behaviors in the Development of Reading and Mathematical Skills During the First School Year: A Cross-Lagged Longitudinal Study. *Journal of Educational Psychology, 92(3)*, 478–491.

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

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P.H.T., Poikkeus, A.-M., Tolvanen, A., Torppa, A., & Lyytinen, H. (2008). Developmental Links of Very Early Phonological and Language Skills to the 2nd Grade Reading Outcomes: Strong to Accuracy but Only Minor to Fluency. *Journal of Learning Disabilities, 41(4),* 353-370.

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

Reynell, J., K., & Huntley, M. (1987). *Reynell Developmental Language Scales Manual* (2nd ed.). Windsor, UK: NFER-Nelson.

Rowan, B., Correnti, R., & Miller, R. J. (2002). What large-scale, survey research tells us about teacher effects on student achievement: Insights from the *prospects* study of elementary schools. *Teachers College Record, 104(8),* 1525-1567.

Scarborough, H. S. (2001). Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In S. Neuman & D. Dickinson (Eds.), *Handbook for research in early literacy* (pp. 97-110). New York: Guilford Press.

Scarborough, H.S., & Dobrich, W. (1994). On the efficacy of reading to preschoolers. *Developmental Review*, *14*, 245-302.

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

Stephenson, K., Parrila, R., Georgiou, G., & Kirby, J. (2008). Effects of home literacy, parents' beliefs, and children's task-focused behavior on emergent literacy and word reading skills. *Scientific Studies of Reading*, *12*, 24-50.

Taipale, M., Kaminen, N., Nopola-Hemmi, J., Haltia, T., Myllyluoma, B., Lyytinen, H., Müller, K., Kaaranen, M., Lindsberg, P. J., Hannula-Jouppi, K., & Kere, J. (2003). A candidate gene for developmental dyslexia encodes a nuclear tetratricopeptide repeat domain protein dynamically regulated in brain. *Proceedings of the National Academy of Sciences*, *100*, 11553-11558.

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

Torppa, M., Tolvanen, A., Poikkeus, A-M. Eklund, K., Lerkkanen, M-K., Leskinen, E., & Lyytinen, H. (2007). Reading Development Subtypes and Their Early Characteristics. *Annals of Dyslexia, 57*, 3-52.

Torppa, M., Lyytinen,P., Erskine, J., Eklund, K., & Lyytinen H. (2010) Language development, literacy skills and predictive connections to reading in Finnish in children with and without familial risk for dyslexia. *Journal of Learning Difficulties, 43(4),* 308-321, doi: 10.1177/0022219410369096.

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

Wechsler, D. (1989). *Wechsler Preschool and Primary Scale of Intelligence-Revised*. San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1991). *Wechsler Intelligence Scales for Children* (3rd ed.). Sidcup, United Kingdom: The Psychological Corporation.

Wimmer, H., & Mayringer, H. (2002). Dysfluent reading in the absence of spelling difficulties: a specific disability in regular orthographies. *Journal of Educational Psychology, 94*, 272-77.

TABLE 1. Skill domains, ages/grades of assessment, and applied tasks.

Skill domain	Age / Grade of assessment	Tasks
1. Receptive language	5.0 yr	Peabody Picture Vocabulary (PPVT-R; Dunn & Dunn, 1981)
2. Expressive language	5.5 yr	Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983)
3. Morphology	5.0 yr	Mastery of inflectional morphology (see Lyytinen & Lyytinen, 2004)
4. Letter knowledge	6.5 yr	Letter naming
5. Phonological awareness	6.5 yr	Segment identification, Synthesis, Initial phoneme identification, Initial phoneme production (see Puolakanaho et al., 2003)
	7.8 yr / Gr 1	Initial phoneme production, Syllable deletion
6. Rapid serial naming	6.5 yr	Rapid serial naming of objects (RSN objects), RSN colors, RSN numbers, and RSN letters using Rapid Automatized Naming Test (see Denckla & Rudel,1974)
	8.9 yr / Gr 2	RSN objects
7. Memory	6.5 yr	Forward digit span (see Gathercole & Adams, 1994)
	8.5 yr / Gr 2	Series of numbers scale,WISC-III (Wechsler, 1991)
8. IQ	5.0 yr	Wechsler Preschool and Primary Scales of Intelligence (WPPSI-R; Wechsler, 1989)
	8.5 yr / Gr 2	Wechsler Intelligence Scale for Children – Third Edition

		(WISC-III; Wechsler, 1991)
9. Task focused behavior	6.5 yr 8.9 yr / Gr 2	Tester report. Child's behavior during assessment.
	7.8 yr / Gr 1 8.5 yr / Gr 2	Teacher report. Child's behavior during lessons at school.
	7.5 yr / Gr 1 8.9 yr / Gr 2	Parent report. Child's behavior when doing homework.
10. Shared reading	6.0 yr 8.0 yr / Gr 2	Frequency and amount of time of the children's home reading activities together with parent
11. Reading alone	8.0 yr / Gr 2	Frequency and amount of time of children's solitary reading activities
12. Reading speed	8.9 yr / Gr 2	Reading time in Oral reading of individually presented words/pseudowords, Oral word list reading, Oral text reading, Oral pseudoword text reading
13. Reading accuracy	8.9 yr / Gr 2	Reading accuracy in Oral reading of individually presented words/pseudowords, Oral text reading, Oral pseudoword text reading
14. Spelling accuracy	8.9 yr / Gr 2	Spelling accuracy of individually presented words and pseudowords

TABLE 2. Number of children with or without reading disability at the end of Grade 2 according to the subgroups of early cognitive risk.

Reading status	Declining[a] N = 34	Dysfluent[a] N = 12	Unexpected[a] N = 67	Typical[a] N = 85
Reading disability	13 (38.2 %)	9 (75.0 %)	14 (20.9 %)	10 (11.8 %)
No reading disability	21 (61.8 %)	3 (25.0 %)	53 (79.1 %)	75 (88.2 %)

[a] The classification of children into four groups was based on mixture modeling of cognitive development before school-age (for details see Lyytinen et al., 2006).

TABLE 3. Means, standard deviations, and group differences in cognitive skills, task focused behavior, and home environment measures.

	HR_RD		HR_noRD		LR_RD		LR_noRD		
	n = 18 - 22		n = 20 - 24		n = 22 - 24		n = 107 - 128		
	M	SD	M	SD	M	SD	M	SD	F
Receptive language									
5.0 yr	-1.02[a]	.91	-.56[a,b]	1.11	-.15[b]	.99	-.01[b]	1.11	6.49***
Expressive language									
5.5 yr	-1.22[a]	1.25	-.62[a,b]	1.38	-.20[b]	.95	-.01[b]	1.04	8.44***
Morphology									
5.0 yr	-1.29[a]	1.20	-.74[a,b]	1.00	-.29[b,c]	.94	.01[c]	.96	12.95***
Letter knowledge									
6.5 yr	-1.08[a]	.68	-.51[a,b]	1.19	-1.05[a,b]	.83	.08[b]	.92	17.71***
Phonological awareness									
6.5 yr	-1.00[a]	.76	-.83[a]	.88	-.62[a]	.79	.12[b]	.83	19.98***
7.8 yr / Gr 1	-1.53[a]	1.66	-.26[b,c]	1.20	-1.27[a,b]	1.42	.08[c]	.72	23.72***
Rapid serial naming									
6.5 yr	-2.00[a]	2.27	-.51[a,b]	1.55	-1.24[a]	.97	-.05[b]	1.00	18.22***
8.9 yr / Gr 2	-1.05[a]	1.66	.00[a,b]	.73	-.28[a,b]	1.06	.13[b]	.87	9.13***
Memory									
6.5 yr	-.67[a]	1.25	-.00[a,b]	.84	-.27[a,b]	1.00	.11[b]	1.04	3.92**
8.5 yr / Gr 2	-.81[a]	1.06	-.56[a,b]	1.00	-.68[a]	1.00	-.01[b]	.95	7.23***
IQ									
5.0 yr	-.88[a]	1.38	-.51[a,b]	1.29	-.48[a,b]	1.00	.04[b]	1.11	5.44**

8.5 yr / Gr 2	-.47[a,b]	1.07	-.15[a,b]	1.05	-.61[a]	.77	.04[b]	.95	4.15**
Task focused behavior, tester report									
6.5 yr	-.92[a]	1.21	-.29[a,b]	1.04	-.47[a,b]	1.32	.07[b]	.94	6.53***
8.9 yr / Gr 2	-1.07[a]	1.67	-.16[a,b]	.85	-.64[a,b]	1.31	.09[b]	.71	10.71***
Task focused behavior, teacher report									
7.8 yr / Gr1	-1.27[a]	1.10	.06[b]	.85	-.38[a,b]	1.25	.08[b]	.91	6.34***
8.9 yr / Gr 2	-.68[a]	.92	-.08[a,b]	1.00	.01[a,b]	.93	.14[b]	.90	4.89**
Task focused behavior, parent report									
7.5 yr / Gr 1	-.49[a]	1.11	-.12[a,b]	1.03	-.61[a]	.94	.11[b]	.87	5.77***
8.9 yr / Gr 2	-.22[a]	1.23	-.12[a]	.92	-.62[b]	1.14	.13[a]	1.07	3.28*
Shared reading, parent report									
6.0 yr	-.20	.86	-.37	1.09	-.02	1.05	.08	1.06	1.40
8.0 yr	.47	.98	-.33	.92	.31	.88	-.03	.98	2.42
Reading alone, parent report									
8.0 yr	-.06[a]	1.30	-.22[a]	.99	-.49[b]	1.04	.17[a]	.98	2.97*

Note. Groups with different superscript letter ([a, b] or [c]) were significantly different in the post hoc pair wise comparisons of ANOVA F tests ($p \leq .05$). Bonferroni or Dunnett's T3 corrections were used depending on equality or inequality of the variances. Degrees of freedom varied between 3,188 – 3,194 in cognitive measures and 3,152 – 3,189 in teacher and parent reports due to missing data in single measures.

II

LITERACY SKILL DEVELOPMENT OF CHILDREN WITH FAMILIAL RISK FOR DYSLEXIA THROUGH GRADES 2, 3, AND 8

by

Kenneth Eklund, Minna Torppa, Mikko Aro, Paavo Leppänen, & Heikki Lyytinen,
2015

Journal of Educational Psychology, 107, 126–140

Permanent link to this item: http://urn.fi/URN:NBN:fi:jyu-201503091444

Abstract

This study followed the development of reading speed, reading accuracy, and spelling in transparent Finnish orthography through Grades 2, 3, and 8. We compared two groups of children with familial risk for dyslexia, with or without dyslexia in Grade 2 (Dys_FR, n = 35 and NoDys_FR, n = 66) to a group of children without familial risk and dyslexia (Controls, n = 72). The Dys_FR group showed persisting deficiency especially in reading speed, and, to a minor extent, in reading and spelling accuracy. The Dys_FR children, contrary to the other two groups, relied heavily on letter-by-letter decoding in Grades 2 and 3. In children not fulfilling the criteria for dyslexia in Grade 2, the familial risk did not substantially affect the subsequent development of literacy skills.

Keywords: Reading speed, Reading accuracy, Spelling, Familial risk, Dyslexia, Reading disability, Development, Longitudinal

Introduction

Literacy skills are a key to educational and occupational success in most societies. For a considerable proportion of the population, difficulties in reading and spelling development make them vulnerable to underachievement throughout their school years and even beyond (Snowling, Adams, Bishop, & Stothard, 2001). Children with a family history of dyslexia comprise a substantial part of this population: 34 % – 66 % of children born to families with dyslexia have been reported to have severe difficulties in reading and spelling acquisition during the first grades at school (Pennington & Lefly, 2001; Puolakanaho et al., 2007; Scarborough, 1990; Snowling, Callagher, & Frith, 2003). The majority of studies of reading development have focused on reading accuracy, and less is known about the development of reading speed (Landerl & Wimmer, 2008; Share, 2008) and spelling (Lervåg & Hulme, 2010). In reading speed there are a few longitudinal follow-ups spanning beyond Grade 3 (de Jong & van der Leij, 2003; Landerl & Wimmer, 2008; Parrila, Aunola, Leskinen, Nurmi, & Kirby, 2005), but follow-ups at school age with samples including children with familial risk for dyslexia are scarce (see, however, Snowling, Muter, & Carroll, 2007; van Bergen et al., 2010). This longitudinal study examines reading and spelling development across Grades 2, 3, and 8 in three groups: children with familial risk for dyslexia and dyslexia in Grade 2, children with familial risk but no dyslexia in Grade 2, and children without a familial risk and without dyslexia. We have three aims: to study the stability of reading and spelling skills beyond the literacy acquisition phase, to examine the effect of familial risk on reading and spelling development, and to examine the effect of reading task and material (word list, text, and pseudoword text) on reading speed in different groups at different ages.

Stability in Reading Speed, Reading Accuracy, and Spelling

Only a few studies have described reading and spelling development from childhood to adolescence in a longitudinal design, and most of them involve English-speaking children and have focused on the development of reading accuracy (Francis, Shaywitz, S.E., Stuebing, Shaywitch, & Flecther, 1996; Parrila et al., 2005; Shaywitch et al., 1995). During recent years reading speed and fluency (speed adjusted for accuracy), have begun to attain more attention in developmental reading research. In one of the few studies focusing on the development of reading speed, Landerl and Wimmer (2008) reported high stability and steady growth in a sample of German-speaking (Austrian) children in Grades 1, 4, and 8. Correlations between reading speed measures at different grade levels varied from .59 to .81, indicating high stability, which was confirmed at the individual level: 8 out of 11 slow readers in Grade 1 were still at least one standard deviation below the sample average in Grade 8. Similarly, high correlations were reported in reading speed between words (.69) and nonwords (.66) in a shorter Dutch follow-up ranging from Grades 1 to 3 (de Jong & van der Leij, 2002) as well as in English between grades 1 and 2 in word list (.79) and oral text reading (.82) fluency (Kim, Wagner, & Lopez, 2012). In Finnish, correlations between Grade 1 (fall) and Grade 2 (spring) have varied from .59 in text reading fluency (Parrila et al., 2005) to .67 in word recognition fluency (Torppa et al., 2007).

The stability of reading accuracy has also been reported to be high. In an English-speaking Canadian sample the across-grade correlations varied between .47 and .94 in the yearly assessments from Grades 1 to 5 (Parrila et al., 2005). In transparent orthographies, the development of reading accuracy is very different from English, because the acquisition of reading accuracy in transparent orthographies is fast. In a cross-language comparison of seven languages, Aro and Wimmer (2003) reported that the percentage of accurately read pseudowords approached 90 % at the end of Grade 1 in all six orthographies (German, Dutch, Swedish, French, Spanish, and Finnish) other than English. Even children with dyslexia have been reported to read at least words with high accuracy after Grade 1: the average accuracy percentage was 91 % in a Dutch sample of children with dyslexia (de Jong & van der Leij, 2003). Therefore, reading accuracy is seldom followed up and reported on in transparent orthographies after Grade 1. Leppänen, Niemi, Aunola, and Nurmi (2006) have, however, reported moderate to high correlations, ranging from .52 to .91, in reading accuracy of words and sentences in a Finnish sample between four assessments during Grades 1 and 2.

As noted in various definitions of dyslexia, including the one from the International Dyslexia Association, problems in spelling are one key marker of dyslexia: "Dyslexia is a specific learning disability… characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities" (p. 2) (Lyon, Shaywitz, & Shaywitz, 2003). Spelling development, however, has attracted less attention (Caravolas, Hulme, & Snowling, 2001; Lervåg & Hulme, 2010). There are studies that have examined the early prerequisites and predictors of spelling skill during the early grades of school in different orthographies (e.g., Furness & Samuelsson, 2010; Kim & Petscher, 2011; Leppänen et al., 2006; Torppa et al., 2013; Wimmer & Mayringer, 2002). But there are only a few longitudinal follow-ups that have examined the stability of spelling skill beyond the first grades at school in children without dyslexia (Abbot, Berninger, & Fayol, 2010; Landerl & Wimmer, 2008; Lervåg & Hulme, 2010), and with dyslexia (Shaywitz et al., 1999; Snowling et al., 2007). Several studies have shown that children with reading difficulties are often poor in both reading and spelling (van Bergen, de Jong, Plakas, Massen, & van der Leij, 2012; de Jong & van der Leij, 2003; Pennala et al., 2010; Pennington & Lefly, 2001; Puolakanaho et al., 2008). In addition, the finding that spelling training in children with dyslexia enhances reading skills supports the idea of a close relationship between reading and spelling (Ise & Schulte-Körne, 2010). However, dissociation between spelling and reading has also been reported (Fayol, Zorman, & Lété, 2009; Moll & Landerl, 2009; Wimmer & Mayringer, 2002). Reported correlations between two assessments of spelling have indicated moderate to high stability in English (.62–.92, in Grades 1–7) (Abbott et al., 2010), in Norwegian (.47–.78, Grades 1–3)

(Lervåg & Hulme, 2010), and in German (.44–.77) (Landerl & Wimmer, 2008). A tendency for stronger correlations between words as compared with pseudowords (.67–.78 vs. .47–.59, respectively) (Lervåg & Hulme, 2010) as well as later vs. earlier grades (.44–.47 in Grades 1–4 vs. .77 for Grades 4 and 8; Landerl & Wimmer, 2008) has also been reported. Correlational stability was not reported in the studies with a sample of children with dyslexia, but stable group differences between children with and without dyslexia were found between Grades 6–9 (ages 9 to 14 years) (Shaywitz et al., 1999) and between 8 and 12 years of age (Snowling et al., 2007). Our study is, to our knowledge, the first to examine the stability in reading speed and accuracy, as well as in spelling, in a sample of children with and without familial risk for dyslexia across a long time period from Grade 2 to Grade 8 (ages 8 to 14 years).

Familial Risk as a Continuum

Several candidate susceptibility genes have been found to be linked to developmental dyslexia (Galaburda, LoTurco, Ramus, Fitch, & Rosen, 2006; Giraud & Ramus, 2012; Scerri & Schulte-Körne, 2010), and the idea of multiple risk factors, some of which are transmitted also to offspring without dyslexia, is widely accepted (Bishop, 2009; Pennington, 2006; Pennington & Lefly, 2001; Pennington et al., 2012; Snowling, 2008; Snowling et al., 2003). Pennington (2006) has suggested that multiple risk factors both in the genome and environments lead to a continuum of vulnerability instead of a dichotomous distribution of risk. At the behavioral level, this suggestion has been tested by comparing the performance of children with familial risk, either with or without dyslexia, and controls. If the familial risk is continuous, also the group of children with familial risk but no dyslexia should show lower performance in the underlying cognitive skills (endophenotypes) as compared to controls. The studies comparing these three groups have mainly shown that children with familial risk who do not fulfill the criteria of dyslexia perform significantly below the level of the controls in certain language and literacy skills both prior to and after school entry (Boets et al., 2010;

Gallagher, Frith, & Snowling, 2000; Pennington & Lefly, 2001; Snowling, 2008; Snowling et al., 2003; van Bergen et al., 2012, 2010).

In English-speaking children, Pennigton and Lefly (2001) found that the scores of children with familial risk but without dyslexia in Grade 2 were significantly lower—on average 0.5 standard deviations—than the scores of children with no familial risk and no dyslexia in all except one reading task. In line with this result, Snowling et al. (2003) found that the at-risk children without dyslexia showed poor performance in nonword reading and phonetic spelling at the age of 6 years and poor skills in spelling, nonword reading accuracy, and reading comprehension at the age of 8 years. In addition, in a follow-up study in adolescence Snowling et al. (2007) reported that the at-risk unimpaired performed weaker than controls in exception word reading, text reading accuracy, and in all timed reading tasks. However, the at-risk unimpaired children did not show deficient performance in word reading accuracy at 8 years (Snowling et al., 2003), neither in untimed nonword reading accuracy nor in reading comprehension in adolescence (Snowling et al., 2007). The classification of children with dyslexia in these studies was based on a composite score including word reading and spelling accuracy as well as reading comprehension (Snowling et al., 2003, 2007).

Van Bergen and colleagues (2012, 2010) have also found evidence for the continuity of genetic liability of dyslexia in Dutch samples of children. At the end of Grade 2, children with familial risk but no dyslexia scored higher than children with familial risk and dyslexia, but were impaired, as compared to controls, in all literacy measures (i.e., reading accuracy and fluency), and spelling (van Bergen et al., 2012). It is noteworthy that the differences between the groups were similar irrespective of whether the items were words or nonwords. In another Dutch sample (van Bergen et al., 2010), where dyslexia was diagnosed in Grade 5, the at-risk non-dyslexic children performed worse in nonword reading fluency in Grades 1, 2, and 5 than typically reading control children. However, in word reading fluency the groups did not differ anymore in Grade 5. The classification of children with dyslexia was based solely on reading fluency (van Bergen et al., 2012, 2010).

On the other hand, the Dutch-speaking sample in Boets et al. (2010) showed support for the continuous nature of the effects of familial risk in pre-reading skills before school age only, but not any more in literacy skills at school age. Boets et al. (2010) found that the non-dyslexic at-risk children were poorer than control children in nonword repetition at kindergarten but not in Grades 1 and 3. They also found that this group was as good as the control group in word reading accuracy and speed as well as in nonword reading speed in Grades 1 and 3. The only significant differences found between these two groups at school age were in nonword reading accuracy and spelling, both of which emphasize accurate decoding ability (Boets et al., 2010). In a Finnish sample, no significant differences were found between children with familial risk without dyslexia and typical readers from control families in reading related pre-reading skills, including language skills and phonological sensitivity at 1.5–5.5 years, and rapid serial naming and letter knowledge at the age of 3.5–5.5 years (Torppa et al., 2010). In Grade 2, the same groups did not differ from each other in reading accuracy or speed, nor in spelling irrespective of whether the material was individually presented words or nonwords, or presented in the form of a list or text (Torppa et al., 2010). However, differences between the same three groups were found in brain responses to non-speech pitch change in sounds at birth (Leppänen et al., 2010) as well as in the ability to discriminate speech-stimuli with a barely perceivable difference in Grade 2 and in Grade 3 (Pennala et al., 2010). In the sample, the classification of dyslexia was based on reading speed and accuracy as well as on spelling accuracy (Pennala et al., 2010; Torppa et al., 2010).

Because several factors vary between these studies (e.g., language and orthography, age and way of classifying dyslexia, used stimuli and tasks) it is difficult to draw firm conclusions of the reasons for differing findings. It seems, however, that differences between the groups without reading difficulty and with or without familial risk are more clearly present early in the development of skills (Boets et al., 2010; Snowling et al., 2007; van Bergen et al., 2010). In addition, typical readers with or without familial risk have performed at the same level in tasks such as word reading and reading comprehension, where it is possible to make use of skills other than phonological decoding related skills (i.e., semantic and syntactic skills and contextual cues) to facilitate reading (Boets et al., 2010; Snowling, 2008; Snowling et al., 2007; van Bergen et al., 2010) or when there is less pressure, such as no time limit (Snowling et al., 2007). Based on the previous findings from Grade 2 in the Finnish sample (Torppa et al., 2010), and the fact that group differences tend to diminish along with age (Boets et al., 2010; Snowling et al., 2007; Torppa et al., 2010; van Bergen et al., 2010), we expect that children with familial risk but no reading difficulty in Grade 2 will not differ from the control children in any of the reading and spelling measures in Grades 3 and 8.

The Effect of Task on Reading Speed

Differences in reading speed across tasks have been interpreted to reflect different processes involved in different reading tasks. Reading pseudowords has generally been considered as a good measure of decoding ability because it requires grapheme-to-phoneme decoding (e.g., Coltheart, Rastle, Perry, Langdom, & Ziegler, 2001). Children with reading difficulty have been shown to have serious deficiency with this type of decoding, at least in opaque orthographies (Bergmann & Wimmer, 2008; Ziegler, Perry, Ma-Wyatt, Ladner, & Shulte-Körne, 2003). In word reading, whether presented in a list or text format, the use of lexicon (i.e., activation of lexical representations) can substantially quicken reading speed by enabling fast whole word recognition (Coltheart al., 2001; Frith, Wimmer, & Landerl, 1998).

Reading time of dyslexic readers has been shown to be more dependent on word length both in pseudoword and word reading than in control children (Ziegler, 2003; Zoccolotti et al., 2005). These findings have been interpreted to support the view that dyslexic readers rely more on phonological letter-by-letter decoding than typical readers. On the other hand, Bergmann and Wimmer (2008) have shown that even dyslexic readers (German speaking, aged 15–18 years) rely on the direct access to lexical information when reading from print to phonology for familiar letter strings, even though they are slower than nonimpaired readers. The so-called lexicality effect (i.e., the faster reading of word stimuli compared to nonwords), has been demonstrated to increase with grade level from Grade 1 to Grade 5 (Zoccolotti, De Luca, Di Filippo, Judica, & Martelli, 2009). This finding has been interpreted to be a result of more efficient use of the lexical information as children get older (Zoccolotti et al., 2009). This gradual shift from mainly using sequential letter-to-sound decoding to the predominant use of fast whole word recognition during the development of reading acquisition gets support from Vaessen and Blomert (2010). Their study shows increasing speed differences over years (Grades 1–6) between word and pseudoword reading. In the present study we examine whether in Finnish, similarly as in Italian (Zoccolotti et al., 2009), children with dyslexia show a later developmental shift of emphasis from phonological decoding strategy to lexical processing than typically reading children. We assess this shift by comparing speed in pseudoword text reading to word list and text reading in Grades 2, 3, and 8.

Skilled fluent reading is based on accurate and automatic word recognition in different contexts that facilitates the activation of semantic processes. Together with the appropriate use of prosody, reading fluency supports quick comprehension of reading material (Kuhn, Schwanenfugel, & Meisinger, 2010). Words in context are usually read faster and more accurately than the same words without context (Jenkins, Fuchs, van den Broek, Espin, &

Deno, 2003). According to Posner and Snyder (1975), there are two processes used for speeding up word identification in a textual context: automatic semantic activation of lexical memory and slow-acting attention-demanding conscious use of context and world knowledge. Jenkins et al. (2003) have shown that the mean reading rate of fourth graders with dyslexia was uniformly discrepant from skilled readers both in context and list. However, children with dyslexia seemed to benefit less than skilled readers from the context: their reading rate in text was 1.19 times of the rate of list reading whereas in skilled readers the figure was 1.67 (Jenkins et al., 2003).

According to the verbal efficiency theory (Perfetti, 1985), deficiencies in children's word reading proficiency affect their fluency skills. A certain level of word reading proficiency seems to be needed before cognitive resources may be released for the language processing needed in fluent text reading (Kim et al., 2012). Skillful readers can identify the meaning of familiar words rapidly just by sight without effort (Ehri, 2005). Other factors besides activation of lexical representations may also speed up word recognition in text reading. Stanovich (1980) found that context allows readers to anticipate possible upcoming words, while eye movement studies have shown that it is possible to get information of the next word parafoveally already before fixating on it (Hyönä, 2011). Barker, Torgesen, and Wagner (1992) demonstrated that orthographic skills have a much stronger influence on reading speed of text, as compared to the speed of single word identification: 20 % vs. 5 %, respectively. Deficiency in fluent access to word representations (i.e., poor orthographic skills) would therefore affect more reading speed of text in context, and thus reduce the difference in reading speed between text and single words. Longitudinal design, such as the one used in our study, can reveal whether and at what age children with familial risk and dyslexia acquire sufficient word decoding skills for the release of cognitive recourses in language processing in order to speed up reading text in context compared with word list reading.

The Present Study

In summary, our study addresses three questions. First, what is the stability of reading and spelling skills after the early reading acquisition phase? Second, what is the effect of familial risk on reading and spelling development? We compare the development of reading speed, reading accuracy, and spelling across Grades 2, 3, and 8 in three groups of children: (1) Dyslexia and familial risk, (2) No dyslexia with familial risk, and (3) Control children with no dyslexia and without familial risk. Third, are reading speed differences in varying reading tasks and materials (word list, text and pseudoword text) similar across the three groups of participants and across Grades 2, 3, and 8?

Method

Participants

All children (N = 173) in this study were participants of the Jyväskylä Longitudinal Study of Dyslexia (JLD) (e.g., Lyytinen et al., 2008). They were originally selected for one of two groups: with familial risk for dyslexia or without familial risk for dyslexia[1]. For this study children were further allocated to three groups according to their reading and spelling skills at the end of Grade 2 and familial risk status: (1) Children with dyslexia and familial risk (Dys_FR, n = 35), (2) Children with no dyslexia and with familial risk (NoDys_FR, n = 66),

1) From the 200 children originally screened, 18 children refused to take part in the Grade 8 assessments, of whom 3 were from the group of children with reading disability and familial risk (Dys_FR), 4 from the group of children with no reading disability and with familial risk (NoDys_FR), and 11 were from the Control group (children with no reading disability and without familial risk).

2) Nine children without familial risk fulfilled the criteria for reading disability at the end of Grade 2 and were excluded from this study similarly as in other studies examining the continuity of the genetic risk.

and (3) a Control group of children with no dyslexia and without familial risk, (C, n = 72)[2]. (See below for the descriptions of the familial risk and dyslexia). Characteristics of the groups are presented in Table 1. There were no differences between the groups in the parents' age or education, the children's performance IQ, age or gender distribution. However, the verbal IQ in the Dys_FR group was lower than in the NoDys_FR and C groups ($F(2,169) = 6.63$, $p < .01$).

All the children spoke Finnish as their native language and had no mental, physical, or sensory impairments. An exclusion criterion was both verbal (VIQ) and performance IQ (PIQ) being below 80, assessed in Grade 2 using the Wechsler Intelligence Scale for Children—Third Edition (WISC—III; Wechsler, 1991). Four performance scale subtests (Picture Completion, Block Design, Object Assembly, and Coding) and five verbal scale subtests (Similarities, Vocabulary, Comprehension, Series of Numbers, and Arithmetic) were used to estimate the PIQ and VIQ, respectively. None of the participants were excluded according to the exclusion criterion. All participants attended regular classroom education.

Familial Risk: Screening of the Families

The children were originally selected from among 9368 newborns born in the province of Central Finland between April 1993 and July 1996. The selection was made using a three-stage procedure: (1) A short parental questionnaire including three questions concerning difficulties in learning to read and spell among parents and their close relatives (8417 respondents); (2) A detailed parental questionnaire concerning the reading history, the persistence of reading and spelling difficulties, and the reading habits of parents and their close relatives (3130 respondents); (3) Testing of the reading and spelling skills (410 parents).

For the child to be originally included in the familial risk group (n = 108) either of the parents had to show deficient performance in oral text reading, or spelling, and in single word reading tasks tapping phonological and orthographic processing. In addition, a reported onset of literacy problems during early school years and a first-degree relative with corresponding difficulties were required for inclusion in the familial risk group. In the group without familial risk, both parents (n = 92) had no reported family history for dyslexia and had a z-score above -1.0 in all reading and spelling tasks described above. The IQ of all parents, assessed with the Raven B, C, and D matrices (Raven, Court, & Raven, 1992), had to be equal to or above 80 (for full details of recruitment, see Leinonen et al., 2001).

Identification of Children with Dyslexia in Grade 2

The identification of dyslexia was based on performance in five tasks (see below for the descriptions of the tasks): 1. Oral word and pseudoword reading, 2. Oral text reading, 3. Oral pseudoword text reading, 4. Oral word list reading, and 5. Spelling words and pseudowords. Four measures of reading speed were calculated: 1. Mean response time (reaction time + response duration) of correctly read words and pseudowords presented one by one, 2. The number of read words per minute in Oral text reading task, 3. The number of pseudowords read per minute in Oral pseudoword text reading, and 4. The number of correctly read words in two minutes in Oral word list reading. Respectively, four measures of reading and spelling accuracy were calculated: the number of 1. correctly read words and pseudowords presented one at a time, 2. correctly read words in Oral text reading, 3. correctly read pseudowords in Oral pseudoword text reading, and 4. correctly written words and pseudowords, presented one by one in a dictation task.

For the identification of dyslexia, a two-step procedure was used. First, a cut-off criterion for deficient performance was defined for each of the eight measures using the 10^{th} percentile of the Control group's performance. Second, a child was considered to have dyslexia if she/he scored below the criteria in at least three out of four measures of reading speed and/or in at least three out of four measures in reading and spelling accuracy. In addition, a child who scored below the criteria both in two speed and two accuracy measures was considered to have dyslexia.

Measures

Trained testers assessed reading and spelling skills individually in a laboratory setting with four different tasks in Grade 2 (June), Grade 3 (April), and Grade 8 (November) as a part of the JLD assessment procedure: 1. Oral text reading, 2. Oral Pseudoword text reading, 3. Oral word list reading, and 4. Spelling pseudowords. In all reading tasks children were instructed to read “as quickly and accurately as they could”. Two different measures were calculated from each task: reading speed (the number of letters read in 1 second) and reading accuracy (the percentage of correctly read items). Arithmetical means, calculated from the three oral reading tasks described above, were used as composite measures of reading speed and reading accuracy separately for Grades 2, 3, and 8. The Cronbach alpha reliability for the reading speed composite was .93, .89, and .88 and for the reading accuracy composite .82, .83, and .75, in Grade 2, 3, and 8, respectively.

Oral text reading (Grades 2, 3, and 8). At each grade level, participants read aloud an age-appropriate text for oral text reading. In Grade 2, the text (title “Exciting journeys”) consisted of 19 sentences in 5 paragraphs with a total of 124 words / 877 letters (mean word length = 7.07 letters and mean sentence length = 6.53 words). For Grade 3, the text (title “Useless belongings”) consisted of 18 sentences in 4 paragraphs and a total of 189 words / 1154 letters (mean word length = 6.11 letters and mean sentence length = 10.50 words). Finally, the Grade 8 text (title “Fjelds of Lapland”) consisted of 16 sentences in 3 paragraphs and a total of 207 words / 1591 letters (mean word length = 7.68 letters/word and mean sentence length = 12.94 words). Reading performance was recorded on a Walkman tape recorder (Grades 2 and 3) or a laptop computer (Grade 8). The total time to read the text was measured with a stop watch. The tapes and sound files were subsequently used to check the scoring of the children's accuracy and speed. To assess the reliability of accuracy scoring, the accuracy was scored independently by two trained coders in a randomly selected 10 % of the sample, and the inter-rater agreement was .98.

Oral pseudoword text reading (Grades 2, 3, and 8). Participants read a short text aloud made up of 19 pseudowords / 137 letters (Grade 2) or 38 pseudowords / 277 letters (Grades 3 and 8). The words and structure of the sentences resembled real Finnish in form but had no meaning. The mean word length was 7.21 letters / word in Grade 2 and 7.29 letters / word in Grades 3 and 8. Similarly to the oral text reading, the child's reading performance was recorded and correctness of reading and time spent on reading were checked. In 10 % of the sample, each pseudoword was judged by two coders as correctly or incorrectly read, and the inter-rater agreement was .95.

Oral word list reading, (Grades 2, 3, and 8). In the standardized reading test of Lukilasse (Häyrinen, Serenius-Sirve, & Korkman, 1999) the participant had 2 minutes to read aloud as many words as possible from a 90-item (Grade 2) or 105 item (Grade 3) list, assembled vertically in columns. The same list which was used in Grade 3 was administered also in Grade 8 but the time limit was reduced to 1 minute. The length of the words increased gradually, ranging from 3 to 18 letters/word in Grade 2, and from 3 to 22 letters/word in Grades 3 and 8. The mean length of the words was 9.08 letters in Grade 2 and 9.57 letters in Grades 3 and 8. A trained tester marked the incorrectly read words as the child was reading aloud. The correctness of tester markings was checked by another listener in 10 % of the sample using the recordings, and the inter-rater reliability was .99.

Oral word and pseudoword reading (used only for the identification procedure of dyslexia in Grade 2). Children read aloud three- and four-syllable words and pseudowords (10 of each type, altogether 40 items) presented one by one with the program Cognitive Workshop (developed by the Universities of Dundee and Jyväskylä) on a computer screen.

Spelling pseudowords (Grades 2, 3, and 8). We measured spelling accuracy with a list of pseudowords consisting of 12 four-syllable items in Grades 2 and 3, and 20 three- to five-syllable items in Grade 8. Participants listened through headphones as a computer presented the items twice with a 2-second interval. Each pseudoword was scored as correct if all the phonemes were correctly written without missing or extra letters. The percentage of correctly written pseudowords was used as the spelling accuracy measure separately for each grade. Cronbach's alpha reliability coefficients were .80, .71, and .70 for Grades 2, 3, and 8, respectively.

Spelling words and pseudowords (used only for the identification procedure of dyslexia in Grade 2). Participants used a pencil to write 6 four-syllable words and 12 four-syllable pseudowords presented similarly as described above. Each stimulus (word or pseudoword) was scored as correct if the participants wrote all the phonemes correctly without missing or extra letters. The percentage of correctly written words / pseudowords was used as the spelling accuracy measure. Cronbach's alpha reliability coefficient was .87.

Results

Distributions and Stability of Literacy Skills

All distributions of reading speed measures were normal or close to normal. The distributions of reading and spelling accuracy, instead, showed a ceiling effect in all tasks in all grades. The ceiling effect was particularly clear in Oral word list reading accuracy with 82.5 %, 89.0 %, and 98.3 % of the participants exceeding 90 % accuracy in Grades 2, 3, and 8, respectively. The ceiling effect also appeared in Oral text reading accuracy where the portion of children above the 90% accuracy level was 79.2 %, 86.2 %, and 89.5 % in Grades 2, 3, and 8, respectively. We applied logarithmic transformation to correct the distribution in the Oral text reading task, whereas the distributions of the tasks for Oral word list reading and Spelling pseudowords could not be normalized. Because of the non-normal distributions, we conducted both parametric and nonparametric analyses when applicable. As all conclusions derived from the parametric and nonparametric analysis results were identical, we report only the parametric results. In reading and spelling accuracy measures, one to four extreme outliers were moved to the tail of the distribution before analyses to avoid overemphasising their effects on results. No participants were dropped from the sample.

Table 2 presents correlations between overall (averaged composite measure of) reading speed and accuracy as well as spelling accuracy. For the reading speed measures, the correlations between performance across different grades were high (.72 – .88). For reading accuracy measures, the correlations varied from moderate to high (.51 – .69), and for spelling measure they were moderate (.41 – .59).

Continuity of the Familial Risk: Group Differences in the Development of Literacy Skills

We examined the development of reading speed and accuracy as well as spelling in the groups with Mixed-Design ANOVAs including Grade (2, 3, and 8) as the within-subjects factor and Group (Dys_FR, NoDys_FR, and Controls) as the between-subjects factor. For both reading speed and accuracy, a composite score was used as the measure at each grade level (arithmetic mean from the three tasks: List, Text and Pseudoword text reading). Figure 1 presents the development of each skill in the three groups. To evaluate the gain children made between two grades (Grade 2 and Grade 3; Grade 3 and Grade 8), a difference score was calculated by subtracting the corresponding means from each other. We used One-Way ANOVAs to study group differences in these gains as well as in separate tasks of reading speed and accuracy, and spelling in each grade. In the post hoc pairwise comparisons either Bonferroni (when equal variances) or Dunnett's T3 (when unequal variances) correction was used when evaluating the significances of group differences (see Table 3).

In the Mixed-Design ANOVA for the reading speed composite both main effects, Grade and Group, were significant (F(1.62, 271.69) = 724.69, p < .001, η_p^2 = .81 and F(2, 168) = 49.79, p < .001, η_p^2 = .37, respectively), as was the Grade x Group interaction (F(3.23, 271.69) = 2.93, p < .05, η_p^2 = .03). For further evaluating the dissimilarity between the groups in the development of reading speed between Grade 2 and Grade 3 as well as between Grade 3 and Grade 8, the tests of within-subject contrast for the Grade x Group interaction were used. The effect was significant for the development between Grade 2 and Grade 3 (F(2,168) = 7.31, p < .001, η_p^2 = .08), but not for the development between Grade 3 and Grade 8, which suggests that the reading speed development differed between groups in Grade 2 and Grade 3, but not in Grade 3 and Grade 8. The ANOVA post hoc pairwise comparisons (with Bonferroni corrections for significance) of the reading speed improvement between Grade 2 and Grade 3 showed that children in the Dys_FR group improved their overall reading speed more than the children in the Control group (p < .001) and the NoDys_FR (p < .01) group between Grade 2 and Grade 3. However, the children in the Dys_FR group still did not reach the level of the other two groups as shown by the post hoc ANOVA comparisons at Grade 3 (see Table 3). The overall reading speed of children in the Dys_FR group was about 50 %, 65 %, and 75 % in Grades 2, 3, and 8, respectively, from the reading speed of children in the two other groups (NoDys_FR and Controls). In Grade 8, the overall reading speed of Dys_FR children was approximately at the level of third graders as compared to the two other groups, indicating a lag of 5 years in development. Effect sizes were estimated (Cohen's d computed using pooled standard deviation) and they were large not only for Grades 2 and 3, but also for Grade 8: Dys_FR vs. NoDys_FR (d = 1.21) and Dys_FR vs. Control group (d = 1.73). No significant differences between the NoDys_FR and Control group were found in ANOVA post hoc pairwise comparisons (with Bonferroni corrections for significance) of the gain children made in overall reading speed between Grade 2 and Grade 3 or between Grade 3 and Grade 8.

For each task in each grade level, we separately conducted One-Way ANOVAs. These showed that children in the Dys_FR group read slower in all tasks throughout Grades 2, 3, and 8 than the two other groups (see Table 3). The two groups without dyslexia, (NoDys_FR and Controls), did not differ from each other in any of the reading speed measures, although the effect sizes varied from small to moderate (.15 – .42).

In the analysis of the reading accuracy composite both main effects, Grade and Group, were significant (F(1.75, 293.92) = 104.28, p < .001, η_p^2 = .38 and F(2,168) = 83.12, p < .001, η_p^2 = .50, respectively) as well as, the Grade x Group interaction (F(3.50, 293.92) = 11.72, p < .001, η_p^2 = .12). The test of within-subject contrasts for the Grade x Group interaction was not significant between Grade 2 and Grade 3, but it was significant between Grade 3 and Grade 8 (F(2,168) = 18.78, p < .001, η_p^2 = .18), a result which suggests that there was a difference in the developmental pace of reading accuracy between the groups in Grade 3 and Grade 8. The ANOVA post hoc pairwise comparisons (with Dunnett's T3 corrections for significance) showed that between Grade 3 and Grade 8 the children in the Dys_FR group developed faster in reading accuracy than did the children in the other two groups (both p < .001). However, as with reading speed above, the children in the Dys_FR group did not quite reach the level of the other two groups (see Figure 1 and Table 3). In the Dys_FR group the overall reading accuracy level reached 90 % in Grade 8, whereas the two groups without dyslexia, (NoDys_FR and Controls), had reached the 90 % level in overall reading accuracy already at the end of Grade 2. Effect sizes were large not only in Grades 2 and 3 but also for the Grade 8 group comparisons in reading accuracy: Dys_FR vs. NoDys_FR (d = 1.11) and Dys_FR vs. Control group (d = 1.72). No significant differences between the NoDys_FR and Control group were found in ANOVA post hoc pairwise comparisons (with Bonferroni corrections for significance) of the gain children made in overall reading accuracy between Grade 2 and Grade 3 or between Grade 3 and Grade 8.

One-Way ANOVAs, done separately for each task in each grade, showed that children in the Dys_FR group made more errors in all reading tasks throughout Grades 2, 3, and 8 than the two other groups (see Table 3). The two groups without dyslexia did not differ from each other in any of the reading accuracy measures, except in text reading accuracy in Grade 3. Effect sizes were small or medium (.03 – .66) between these two groups in reading accuracy measures throughout Grades 2, 3, and 8.

In the analysis of pseudoword spelling both main effects, Grade and Group, were significant (F(1.87, 314.79) = 181.98, $p < .001$, η_p^2 = .52 and F(2,168) = 49.57, $p < .001$, η_p^2 = .37, respectively). Also the Grade x Group interaction was significant (F(3.75 , 314.79) = 11.86, $p < .001$, η_p^2 = .12). The test of within-subject contrasts for the Grade x Group interaction was significant between Grade 2 and Grade 3, as well as between Grade 3 and Grade 8 (F(2,168) = 8.64, $p < .001$, η_p^2 = .09 and F(2,168) = 5.84, $p < .01$, η_p^2 = .06, respectively). The ANOVA post hoc pairwise comparisons (with Dunnett's T3 corrections for significance) showed that between Grade 2 and Grade 3, children in the Dys_FR group improved their spelling accuracy more than children in the Control group ($p < .05$) and the NoDys_FR group ($p < .01$), and more than the Control group ($p < .01$) between Grade 3 and Grade 8. Note, however, that the starting point of spelling accuracy in the two groups without dyslexia was approximately twice as high as in the Dys_FR group (with accuracy percentages of 73 % vs. 39 %). Although children in the Dys_FR group made better progress in spelling accuracy than the NoDys_FR and Control groups, they reached accuracy level of 82.39 % in Grade 8, which is comparable to the level of third graders in the other two groups (see Table 3). The group differences in Grade 8 were confirmed by effect sizes, which were large: 1.13 (Dys_FR vs. NoDys_FR) and 1.45 (Dys_FR vs. Control group). The two groups without dyslexia, NoDys_FR and Controls, reached close to 95 % accuracy level in pseudoword spelling in Grade 8, and did not differ from each other in any of the spelling measures. Effect sizes were small or moderate (.01 – .36).

Differences in Reading Speed according to Task in Different Groups

To see whether the differences in reading speed between the three tasks were similar in the three groups, we performed three separate Mixed-Design ANOVAs. Task (text vs. pseudoword text, text vs. word list, or pseudoword text vs. word list) was used as the within-subjects factor and Group (Dys_FR, NoDys_FR, and Control group) as the between-subjects factor. We did all ANOVAs separately for each grade level (2, 3, and 8) to see whether the differences between tasks were similar in each grade. Because nine Mixed-Design ANOVAs were conducted, stricter than usual significance cut-offs were used to avoid familywise errors. This was done by dividing the commonly used significance levels by the number of ANOVAs done. As a follow-up analysis, we compared performance in the different tasks within each group using paired sample t tests. Figure 2 presents group differences in the three reading speed tasks in Grades 2, 3, and 8. Table 4 presents F values and estimates of the effect sizes of the Mixed-Design ANOVAs.

Word list vs. pseudoword text. We compared reading speed in word list and pseudoword text reading first to see the effect of lexicality. Both main effects, Task and Group, were significant. The interaction Task x Group was significant in Grades 2 and 3. In paired sample t tests, the difference between tasks was not significant in the Dys_FR group, a result which suggests that children in this group read word lists and pseudoword texts at equal speeds. In the NoDys_FR group and in the Control group, children read the word lists about 1 to 2 letters/second faster than pseudoword texts ($t(64) = 6.47$, $p < .001$ and $t(65) = 12.14$, $p < .001$ in Grade 2 and Grade 3, respectively for the NoDys_FR group, and $t(70) = 8.87$, $p < .001$ and $t(71) = 15.13$, $p < .001$ for the Control group, in Grade 2 and Grade 3, respectively). In

Grade 8, all groups read word lists about 2.5 letters/second faster than pseudoword texts ($t(32) = 11.36$, $t(64) = 11.40$, and $t(70) = 9.60$, all $p < .001$, for the Dys_FR, NoDys_FR, and Control group, respectively; see Table 3).

Word list vs. text. We compared reading speed in word lists and text reading to see the effect of context on reading speed. Both main effects, Task and Group, were significant in all grades (2, 3, and 8). The interaction Task x Group was significant only in Grade 2. In paired sample t tests the difference between tasks was significant in all groups ($t(34) = 9.01$, $t(64) = 17.03$, and $t(70) = 19.61$, all $p < .001$, for the Dys_FR, NoDys_FR, and Control group, respectively) indicating that all groups read words in context faster than isolated words. However, the ANOVA post hoc pairwise group comparisons (with Bonferroni corrections for the significance) indicated that the difference in reading speed between word lists and texts was smaller in the Dys_FR group than in the NoDys_FR group and in the Control group (both $p < .001$). In Grade 3 and in Grade 8, all groups read text faster than they read word lists ($t(34) = 6.92$ and $t(34) = 7.48$, $t(64) = 10.51$ and $t(64) = 8.26$, and $t(71) = 14.62$ and $t(71) = 8.30$, all $p < .001$, for the Dys_FR, NoDys_FR, and Control group in Grade 3 and in Grade 8, respectively).

Text vs. Pseudoword text. Finally, we compared reading speed between text and pseudoword text reading tasks to see the effect of the lexicality and meaning of the text. Both main effects, Task and Group, as well as the interaction Task x Group in Grades 2, 3, and 8 were significant. In the ANOVA post hoc pairwise group comparisons (with Bonferroni corrections for the significance) the difference in reading speed between texts and pseudoword texts was smaller in the Dys_FR group than in the NoDys_FR and Control groups (all $p < .001$ in Grades 2 and 3, and both $p < .01$ in Grade 8) (2 vs. 4 letters/second, respectively in Grades 2 and 3, and 4 vs. 5 letters/second in Grade 8, see Table 3).

Discussion

In this study, we examined three aspects of literacy development: the stability of literacy skills after the initial reading acquisition phase across Grades 2, 3, and 8; the effect of familial risk on literacy skill development during this period; and the effects of different types of reading material (word list, text and pseudoword text) on reading speed. We compared the development of three groups: children with familial risk and dyslexia (the Dys_FR group), children with familial risk but without dyslexia (the NoDys_FR group), and Control group of children with no dyslexia and without familial risk.

We found high stability for reading speed development, whereas in reading and spelling accuracy the development was moderately stable from the second to the eighth grade. Children with familial risk and dyslexia (the Dys_FR group) did not catch up to the other two groups in reading speed, reading accuracy or spelling, although they progressed more than the other two groups in reading speed between Grade 2 and Grade 3, in reading accuracy between Grade 3 and Grade 8, and in spelling accuracy throughout the follow-up. The Dys_FR group's literacy skills in Grade 8 were overall comparable to the level of the third graders in the two other groups. The children with familial risk but no dyslexia (NoDys_FR) did not differ significantly from the Control group children in any of the assessed reading and spelling measures, except in text reading accuracy in Grade 3, although the effect sizes were often of moderate size between the two groups. The reading speed in children with familial risk and dyslexia varied less according to the type of reading material than in the two other groups in Grades 2 and 3, but this effect diminished in Grade 8.

In reading speed, the correlations across groups between the grades were high (.72 – .88). This indicates high stability of development and is in line with earlier findings in consistent orthographies (Landerl & Wimmer, 2008; Parrila et al., 2005; Torppa et al., 2007).

The size of the correlation between the assessments in Grades 2 and 8, was .72, which showed that even after 6 years of school attendance, the relative positions of individuals remained very similar. The nearly parallel developmental paths of the three groups confirm the idea of stability in reading speed. The only exception, the faster progress made by children in the Dys_FR group in reading speed between Grades 2 and 3, could be interpreted to be a delayed developmental spurt that was made by normally developing children before the end of Grade 2. In previous Finnish studies of reading accuracy (Aunola, Leskinen, Onatsu-Arvilommi, & Nurmi, 2002;Leppänen, Niemi, Aunola, & Nurmi, 2004) as well as in a Finnish study of oral reading fluency (Parrila et al., 2005), initial reading level has been found to be negatively associated with the development of reading skill during the first two grades at school. Our finding that children in the NoDys_FR and Control groups made only a little progress in reading speed between Grades 2 and 3 suggests that this kind of negative association between the initial level and further growth in reading speed continues to be true until the end of Grade 3. Between Grades 3 and 8 the development in the three groups was highly parallel, and we found no evidence suggesting either catching up or falling behind in any group. This supports the idea that differences between the groups are long-lasting, as has been found to be the case in Dutch (Boets et al., 2010; de Jong & van der Leij, 2003; van Bergen et al., 2010) and in English readers with and without dyslexia (Francis et al., 1996; Snowling et al., 2007).

The consistent lag of the Dys_FR group in reading speed, present already at the beginning of the follow-up, could be expected because in transparent orthographies the main characteristic of dyslexia has been shown to be slow reading (e.g., de Jong & van der Leij, 2003; Landerl & Wimmer, 2008; Landerl, Wimmer, & Frith, 1997; Wimmer, 1996; Zoccolotti et al., 1999). The magnitude of the lag in Grade 8, approximately 5 years, was, however, larger than expected. De Jong and van der Leij (2003) have previously reported that Dutch children diagnosed with dyslexia in Grade 3 on the basis of reading fluency showed a delay of 3.5 years by the end of Grade 6 when compared to normal readers in reading speed. In addition, in earlier studies that have used a reading level matched group as controls, the age difference has usually been 3 to 4 years on average (Constantinidou & Stainthorp, 2009; Ziegler et al., 2003).

The stability in reading accuracy development was moderate to relatively high according to correlations (.51 – .69) between Grades 2, 3, and 8, but lower than in reading speed. Correlations were somewhat lower than reported in previous studies of Finnish orthography (Leppänen et al., 2006; Parrila et al., 2005). The size of the correlations could be inflated by ceiling effects, but only for word list and text reading. In these tasks, where the items were real words, the percentage of correctly read words exceeded 90 % before our first assessment point in this study (i.e., the end of Grade 2) in the NoDys_FR and Control groups and in Grade 3 in the Dys_FR group. The accuracy percentages in the NoDys_FR and Control groups are comparable to those reported earlier in transparent orthographies (Aro & Wimmer, 2003; de Jong & van der Leij, 2003). The ceiling effect also explains the finding that children in the Dys_FR group made better progress in reading accuracy between Grades 3 and 8 than children in the two other groups. After Grade 3, the children in the NoDys_FR and Control groups simply had less room for development, having accuracy percentages at or above 96 % in word list and text reading. In Grade 8, the mean percentage of correctly read words in the word list reading task was above 97 % in all groups. Our finding that most children in the Dys_FR group also acquired accurate reading of words is in line with the notion of de Jong and van der Leij (2003) that dyslexic children learning to read in a regular orthography will eventually acquire sufficiently good skills in phonemic awareness to enable accurate decoding ability. However, reading accuracy concerning pseudoword items remained rather low in the Dys_FR group even in Grade 8 (round 82 %) and was equivalent to the accuracy of second graders in the NoDys_FR and C groups. This indicates persistent problems in phonological decoding among reading disabled children when the demands of the task increases, in line with the findings of de Jong and van der Leij (2003). Previously, also the parents of children with familial risk for dyslexia have shown difficulties in phonological decoding in in the Jyväskylä Longitudinal Study of Dyslexia (Leinonen et al., 2001).

Problems in phonological decoding were seen especially clearly in pseudoword spelling, in which children in the Dys_FR group started the follow-up in Grade 2 with a very low accuracy percentage, 39 %. Although they progressed faster than the other groups throughout the whole follow-up period, they remained behind children in the two other groups and ended up with a similar accuracy level as in pseudoword text reading (i.e., 82 %) in Grade 8. This percentage is, however, much higher than the level of German-speaking Austrian children with reading and spelling difficulties: the mean of correctly spelled words for them was around 40 % – 45 % in Grade 4 (Wimmer & Mayringer, 2002). This is probably due to the fact that in Germany a simple phoneme-grapheme translation is not sufficient for accurate spelling (Wimmer & Mayringer, 2002). In contrast to German, Finnish orthography has symmetrically transparent correspondences between phonemes and graphemes, that is, both from the point of view of reading and spelling. The stability in spelling was moderate (.41 – .59), but somewhat lower than found earlier in Finnish (Leppänen et al., 2006). This discrepancy is probably due to this study's use of pseudoword items, whereas in Leppänen et al. (2006) a word spelling task was used. In pseudoword spelling tasks, correlations have been found to be lower than between tasks including words (Lervåg & Hulme, 2010).

The greater gains in literacy skills by children in the Dys_FR group between Grades 2 and 3 could also be due to the extra support and intervention they have received. At Finnish schools, over 20 % of all school children in Grades 1 to 9 receive part-time special education at some point of the school year. This type of extra support is most frequent at the lowest grade levels, and the most common indication for part-time special education is problems in reading development. Altogether, 85.7 % of children in the Dys_FR group received various amount and various kind of extra support at school during Grades 1 to 3. This proportion is much bigger than the amounts of extra support in the NoDys_FR and Control groups (34.8 % and 11.1 %, respectively). In addition, 48.6 % of children in the Dys_FR group (4.5 % in the NoDys_FR and none in the Control group) took part in an intensive intervention study (55 hours within 14 weeks) organized by the JLD project including speech and auditory training as well as practicing of reading and writing. However, despite this support they have received, the literacy skills lagged substantially behind the skills of their peers.

Our findings give weak support to the continuity of familial risk. The means of the NoDys_FR group fell between those of the Dys_FR group and of the Control group, but the NoDys-FR and Control groups differed significantly in only one of the reading and spelling measures: text reading accuracy in Grade 3. Note also that the NoDys-FR group performed constantly better than the Dys_FR group. However, although the difference between the NoDys_FR group and the Control group was overall not significant, the moderate effects sizes suggest that with a larger sample size we might have found significant difference. On the other hand, significant differences between groups with or without familial risk and no dyslexia have been found with much smaller sample sizes in English (Snowling et al., 2003, 2007) and in Dutch (Boets et al., 2010; van Bergen et al., 2010).

The majority of the findings of group differences in literacy skills before and at school age in English and Dutch have supported the idea of continuity of familial risk (Boets et al., 2010; Pennington & Lefly, 2001; Snowling, 2008; Snowling et al., 2003, 2007; van Bergen et al., 2012, 2010), although signs of diminishing group differences along with age have been reported (Boets et al., 2010; Snowling et al., 2007; Torppa et al., 2010; van Bergen et al., 2010). Because in our study the NoDys_FR group and the Control group differed from each other only in one task, no firm conclusions of diminishing vs. expanding group differences could be made.

Most prominent support for the continuous nature of familial risk comes from studies employing tasks relying heavily on accurate grapheme-to-phoneme decoding, that is, pseudoword or nonword word reading accuracy (Boets et al., 2010; Pennington & Lefly, 2001; Snowling et al., 2003, 2007; van Bergen et al., 2010). No differences between the two groups with or without familial risk and no dyslexia, on the other hand, have been reported in tasks where other than phonological processing could be used instead or as support of phonological decoding, i.e. in word reading (Boets et al., 2010; van Bergen et al., 2010; Snowling 2003) and reading comprehension in adolescence (Snowling et al., 2007). No differences have been reported either in reading task, where there has been no time pressure, i.e. un-timed nonword reading accuracy (Snowling et al., 2007) or where the orthography of the language used has been extremely transparent, like in Finnish (Torppa et al., 2010). Therefore, it seems reasonable to think that the requirements of the task or the transparency of orthography, or both, might affect the visibility of the continuity of familial risk. Finnish is in the shallowest end of the orthographic depth continuum, with close one-to-one correspondence between graphemes and phonemes. This high correspondence makes the learning of decoding and foundation level reading easy (Seymour, Aro, & Erskine, 2003), and most of the children, even those with familial risk can learn accurate decoding by the end of Grade 2. In English, on the other hand, where nonword reading has been found to be poorer than in more transparent German (Frith et al., 1998), the complexity and inconsistencies of orthography could bring out differences between groups.

The discrepant results concerning the continuous nature of familial risk can also be a consequence of differences in classifying children with or without dyslexia. Whereas in our study we based the classification on reading speed, reading accuracy, and spelling, Snowling et al. (2003, 2007) based their classification on a composite score that included reading comprehension in addition to word reading and spelling accuracy. It is thus possible that slow readers with good comprehension skills, a group shown to be present at least in the Finnish sample (Torppa et al., 2007), might have ended up in the non-dyslexia group. Likewise, van Bergen et al. (2010) based their classification of children solely on fluency. That is, they did not take reading or spelling inaccuracy as criteria. So, it is also possible that the group of at-risk nondyslexic children in the Dutch sample included children with difficulties in accuracy but not in fluency. This possibility is supported by the finding that in that study children with typical reading skills but with the familial risk differed from control children only in pseudoword reading in Grade 5 (van Bergen et al., 2010), a task which relies heavily on accurate grapheme-phoneme decoding ability. Interestingly, in another Dutch speaking sample the family-risk non-dyslexia and control children were more similar to each other when the classification was based on word reading fluency, word reading accuracy, and spelling accuracy (Boets et al., 2010). To further explore this question, the existing datasets should be re-analysed with applying uniform criteria in classification of children into subgroups.

To better understand the slow reading speed in our Dys_FR group, we compared reading speed in different tasks across groups. In Grades 2 and 3, children in the Dys_FR group read pseudoword texts and word lists at equal speeds, whereas the two other groups read word lists about 1 – 2 letters / second faster than pseudoword texts. This raises at least two potential suggestions for conclusions. First, it might suggest that children in the Dys_FR group used the same processes in word and pseudoword reading, relying mainly on letter-by-letter decoding. This conclusion is in line with the findings of Ziegler et al. (2003) regarding English and German speaking children with dyslexia. In orthographically transparent Italian, Zoccolotti et al. (2005) have found that Italian children with dyslexia showed a clear word length effect in word reading, which suggests that the children were using a sub-lexical reading procedures still in Grade 3. However, it has been reported in an Italian sample that by Grade 6 lexical reading appears to be available even for children with dyslexia (Barca, Burani, Di Filippo, & Zoccolotti, 2006). In the sample of our study, a similar addition of lexical reading process seems to have taken place by Grade 8: children in the Dys_FR group read word lists about 2.5 letters/second faster than pseudoword texts, similarly to the children in the two other groups, albeit with the overall lower speed. Second, the slower reading speed of the Dys_FR group in the word list reading as compared with the other two groups can be a consequence of not only poor decoding skills but also of difficulties in the use of orthographic lexicon, as suggested by Bergmann and Wimmer (2008). These difficulties could result from their lower exposure to printed text and as a consequence lower familiarity with the presented words; word frequency has been shown to have a strong effect on word recognition speed already in school-aged children (Zoccolotti et al., 2009). Children in the NoDys_FR and Control groups seemed able to take advantage of their orthographic lexicon and recognize at least the most frequent and therefore familiar words by sight already in Grade 2. This is in line with the findings in another orthographically transparent language, Italian, where lexicality effect was present in high frequency words already at the end of Grade 1 and low frequency words in Grade 3 (Zoccolotti et al., 2009).

In Grade 2, a similar kind of developmental lag seemed to be present also in the ability of children in the Dys_FR group to use contextual cues, such as syntactic and semantic information: the difference in reading speed between word lists and texts was smaller in the Dys_FR group than in the NoDys_FR and Control groups. At the end of Grade 2, decoding is still toilsome in the Dys_FR group, and thereby fewer cognitive resources are left for language processing (Perfetti, 1985; Kim et al., 2012) in children with dyslexia. In Grades 3 and 8, all groups read texts approximately 2 letters/second faster than word list, a result that is in line with the earlier findings in which the same words in context were read faster than without context by fourth graders (Jenkins et al., 2003). Children with dyslexia were beginning to utilize contextual cues from Grade 3, at least one year later than normally developing children. And finally, the smaller difference throughout the follow-up period in reading speed between text and pseudoword text reading in the Dys_FR group suggests longstanding deficiencies in automatization of decoding in familiar words, as suggested by Share (2008), and/or deficient use of word and sub-word level representations and contextual cues (Snowling, 2008; Stanovich, 1980), or both. Methodological limitations, such as more than one varying factor in comparisons between the tasks, prevent us from making firm conclusions about the processes used in different tasks and to what extent they are specifically compromised in the Dys_FR group.

In conclusion, the findings of the current longitudinal study confirm that the literacy difficulties of children with familial risk for dyslexia and dyslexia in Grade 2 are often persistent. On the other hand, in spite of the familial risk, children who have acquired the basic reading skills follow, for the most part, the developmental track of children without reading difficulties or familial risk also later on. In other words, it appears, at least on the group level, that if there are no signs of reading difficulties in Grade 2, one can anticipate typical literacy development also in later grades. But is this is true also at the individual level? Do the age-appropriate literacy skills shown here guarantee that these children with familial risk of dyslexia will also have age-appropriate reading comprehension skills later, as shown by Snowling et al. (2007) with English-speaking children? These remain important questions for future studies.

References

Abbott, R. D., Berninger, V. W., & Fayol, M. (2010). Longitudinal relationships of levels of language in writing and between writing and reading in Grades 1 to 7. *Journal of Educational Psychology, 102*(2), 281–298. doi: 10.1037/a0019318

Aro, M., & Wimmer, H. (2003). Learning to read: English in comparison to six more regular orthographies. *Applied Psycholinguistics, 24,* 621–635. doi: 10.1017.S0142716403000316

Aunola, K., Leskinen, E., Onatsu-Arvilommi, T., & Nurmi, J.-E. (2002). Three methods for studying developmental change: A case of reading skills and self-concept. *British Journal of Educational Psychology, 72,* 343–364.

Barca, L., Burani, C., Di Filippo, G., & Zoccolotti, P. (2006). Italian developmental dyslexic and proficient readers: Where are the differences? *Brain and Language, 98*, 347–351. doi:10.1016/j.bandl.2006.05.001

Barker, T. A., Torgesen, J. K., & Wagner, R. K. (1992). The role of orthographic processing skills on five different reading tasks. *Reading Research Quarterly, 27*(4), 334–345.

Bergman, J., & Wimmer, H. (2008). A dual-route perspective on poor reading in a regular orthography: Evidence from phonological and orthographic lexical decisions. *Cognitive Neuropsychology, 25*(5), 653–676. doi: 10.1080/02643290802221404

Bishop, D. V. M. (2009). Genes, cognition, and communication insights from neurodevelopmental disorders. *Annals of New York Academy of Sciences, 1156,* 1–18. doi: 10.1111/j.1749-6632.2009.04419.x

Boets, B., De Smedt, B., Cleuren, L., Vandewalle, E., Wouters, J., & Ghesquie`re, P. (2010). Towards a further characterization of phonological and literacy problems in Dutch-speaking children with dyslexia. *British Journal of Developmental Psychology, 28,* 5–31. doi: 10.1348/026151010X485223

Caravolas, M. (2004). Spelling development in alphabetic writing systems: A cross-linguistic perspective. *European Psychologist*, *9*(1), 3–14. doi: 10.1027/1016-9040.9.1.3

Caravolas, M., Hulme, C., & Snowling, M. J. (2001). The foundations of spelling ability: Evidence from a 3-year longitudinal study. *Journal of Memory and Language, 45,* 751–774. doi:10.1006/jmla.2000.2785

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108*(1), 204–256.

Constantinidou, M., & Stainthorp, R. (2009). Phonological awareness and reading speed deficits in reading disabled Greek-speaking children. *Educational Psychology, 29*(2), 171–186. doi: 10.1080/01443410802613483

de Jong, P. F., & van der Leij, A. (2002). Effects of phonological abilities and linguistic comprehension on the development of reading. *Scientific Studies of Reading, 6*(1), 51–77.

de Jong, P. F., & van der Leij, A. (2003). Developmental changes in the manifestation of a phonological deficit in dyslexic children learning to read a regular orthography. *Journal of Educational Psychology*, *95*(1), 22–40. doi: 10.1037/0022-0663.95.1.22

Ehri, L. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading*, *9*(2), 167–188.

Fayol, M., Zorman, M., & Lété, B. (2009). Associations and dissociations in reading and spelling French: Unexpectedly poor and good spellers. *British Journal of Educational Psychology Monograph Series II, 6*, 63–75. doi:10.1348/000709909X421973

Francis, D. J, Shaywitz, S. E., Stuebing, K. K., Shaywitch, B. A., & Flecther, J. M. (1996). Developmental lag versus deficit models of reading disability: A longitudinal, individual growth curves analysis. *Journal of Educational Psychology, 88*(1), 3–17.

Frith, U., Wimmer, H., & Landerl, K. (1998). Differences in phonological recoding in German- and English-speaking children. *Scientific Studies of Reading, 2*(1), *31-54.*

Furness, B., & Samuelsson, S. (2010). Predicting reading and spelling difficulties in transparent and opaque orthographies: A comparison between Scandinavian and US/Australian children. *Dyslexia 16*, 119–142. doi: 10.1002/dys.401

Galaburda, A. M., LoTurco, J., Ramus, F., Fitch, R. H., & Rosen, G. D. (2006). From genes to behavior in developmental dyslexia. *Nature Neuroscience, 9*(10), 1213–1217. doi: 10.1038/nn1772

Gallagher, A., Frith, U., & Snowling, M. J. (2000). Precursors of literacy delay among children at genetic risk of dyslexia. *Journal of Child Psychology and Psychiatry, 41*(2), 203–213.

Giraud A-L., & Ramus F. (2012). Neurogenetics and auditory processing in developmental dyslexia, *Current Opinion in Neurobiology,* http://dx.doi.org/10.1016/j.conb.2012.09.003

Hyönä, J. (2011). Foveal and parafoveal processing during reading. In S. Liversedge, I. Gilchrist & S. Everling (Eds.), *Oxford handbook of eye movements*. Oxford: Oxford University Press.

Häyrinen, T., Serenius-Sirve, S., & Korkman, M. (1999). *Lukilasse. Lukemisen, kirjoittamisen ja laskemisen seulontatesti ala-asteen luokille 1–6* [Screening test for reading, spelling and counting for the grades 1–6]. Helsinki: Psykologien Kustannus Oy.

Ise, E. & Schulte-Körne, G. (2010). Spelling deficits in dyslexia: evaluation of an orthographic spelling training. *Annals of Dyslexia, 60,* 18–39. doi: 10.1007/s11881-010-0035-8.

Jenkins, J. R., Fuchs, L. S., van den Broek, P., Espin, C., & Deno, S. L. (2003). Accuracy and fluency in list and context reading of skilled and RD groups: Absolute and relative performance levels. *Learning Disabilities Research & Practice, 18*(4), 237–245.

Kim, Y.-S. (2010). Componential skills in early spelling development in Korean. *Scientific Studies of Reading, 14*(2), 137–158. doi: 10.1080/10888430903034812

Kim, Y.-S., & Petscher, Y. (2011). Relations of emergent literacy skill development with conventional literacy skill development in Korean. *Reading and Writing, 24*, 635–656. doi 10.1007/s11145-010-9240-4

Kim, Y.-S., Wagner, R. K., & Lopez, D. (2012). Developmental relations between reading fluency and reading comprehension: A longitudinal study from Grade 1 to Grade 2. *Journal of Experimental Child Psychology 113,* 93–111. doi: 10.1016/j.jecp.2012.03.002

Kuhn, M. R., Schwanenflugel, P. J., & Meisinger, E. B. (2010). Aligning theory and assessment of reading fluency: Automaticity, prosody, and definitions of fluency. *Reading Research Quarterly, 45*(2), 230–251. doi:10.1598/RRQ.45.2.4

Landerl, K., & Wimmer, H. (2008). Development of word reading fluency and spelling in a consistent orthography: An 8-year follow-up. *Journal of Educational Psychology, 100*(1), 150–161. doi: 10.1037/0022-0663.100.1.150

Landerl, K., Wimmer, H., & Frith, U. (1997). The impact of orthographic consistency on dyslexia: a German-English comparison. *Cognition, 63,* 315–334.

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

Leppänen, P. H. T., Hämäläinen, J. A., Salminen, H. K., Eklund, K. M., Guttorm, T. K., Lohvansuu, K., Puolakanaho, A., & Lyytinen, H. (2010). Newborn brain event-related potentials revealing atypical processing of sound frequency and the subsequent association with later literacy skills in children with familial dyslexia, *Cortex*, 1362–1376. doi:10.1016/j.cortex.2010.06.003

Leppänen, U., Niemi, P., Aunola, K., & Nurmi, J.-E. (2004). Development of reading skills among preschool and primary school pupils. *Reading Research Quarterly, 39*(1), 72–93.

Leppänen, U., Niemi, P., Aunola, K., & Nurmi, J.-E. (2006). Development of reading and spelling Finnish from preschool to Grade 1 and Grade 2. *Scientific Studies of Reading, 10*(1), 3–30.

Lervåg, A., & Hulme, C. (2010). Predicting the growth of early spelling skills: Are there heterogeneous developmental trajectories? *Scientific Studies of Reading, 14*(6), 485–513*. doi: 10.1080/10888431003623488*

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). A definition of dyslexia. *Annals of Dyslexia, 53,* 1–14.

Lyytinen, H., Erskine, J., Ahonen, T., Aro, M., Eklund, K., Guttorm, T., … Viholainen, H. (2008). Early Identification and Prevention of Dyslexia: Results From a Prospective Follow-up Study of Children at Familial Risk for Dyslexia. In G. Reid, F. Manis, & L.

Siegel (Eds.), *The Sage handbook of dyslexia* (pp. 121–146). Thousand Oaks, CA: Sage.

Moll, K. & Landerl, K. (2009). Double dissociation between reading and spelling deficits. *Scientific Studies of Reading, 13*(5), 359–382. doi: 10.1080/10888430903162878

Parrila, R., Aunola, K., Leskinen, E., Nurmi, J.-E., & Kirby, J. R. (2005). Development of individual differences in reading: Results from longitudinal studies in English and Finnish. *Journal of Educational Psychology, 97*(3), 299–319. doi: 10.1037/0022-0663.97.3.299

Pennala, R., Eklund, K., Hämäläinen, J., Richardson, U., Martin, M., Leiwo, M., … Lyytinen, H. (2010). Perception of phonemic length and its relation to reading and spelling skills in children with familial risk for dyslexia at the three first grades in school. *Journal of Speech, Language, and Hearing Research, 53*, 710–724.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101*, 385–413. doi:10.1016/j.cognition.2006.04.008

Pennington, B. F., & Lefly, D. L. (2001). Early reading development in children at family risk for dyslexia. *Child Development, 72*(3), 816–833.

Pennington, B. F., Santerre-Lemmon, L., Rosenberg, J., MacDonald, B., Boada, R., Friend, A., … Olson, R. K. (2012). Individual prediction of dyslexia by single versus multiple deficit models. *Journal of Abnormal Psychology, 121*(1), 212–224. doi: 10.1037/a0025823

Perfetti, C. A. (1985). Reading ability. New York: Oxford University Press.

Posner, M. I., & Snyder, C. R. R. (1975). Attention and cognitive control. In R. Solso (Ed.), *Information processing and cognition: The Loyola Symposium* (pp. 55–85). Hillsdale, NJ: Erlbaum.

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P. H. T., Poikkeus, A-M., … Lyytinen, H. (2007). Very early phonological and language skills: estimating individual risk of reading disability. *Journal of Child Psychology and Psychiatry, 48*(9), 923–931. doi:10.1111/j.1469-7610.2007.01763.x

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P. H. T., Poikkeus, A-M., … Lyytinen, H. (2008). Developmental links of very early phonological and language skills to the 2nd Grade reading outcomes: Strong to accuracy but only minor to fluency. *Journal of Learning Disabilities, 41*(4), 353–370.

Raven, J. C., Court, J. H., & Raven, J. (1992). *Standard progressive matrices*. Oxford, United Kingdom: Oxford Psychologists Press.

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

Scerri, T. S., & Schulte-Körne, G. (2010). Genetics of developmental dyslexia. *European Child and Adolescent Psychiatry, 19*(3), 179–197. doi: 10.1007/s00787-009-0081-0

Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94,* 143–174.

Share, D. L. (2008). On the anglocentricities of current reading research and practice: The perils of overreliance on an "outlier" orthography. *Psychological Bulletin, 134*(4), 584–615. doi: 10.1037/0033-2909.134.4.584

Shaywitz, B. A., Holford, T. R., Holahan, J. M., Stuebing, K. K., Francis, D. J., & Shaywitz, S. E. (1995). A Matthew effect for IQ but not for reading: Results from a longitudinal study. *Reading Research Quarterly, 30*(4), 894–906.

Snowling, M. (1998). Dyslexia as a phonological deficit: Evidence and implications. *Child Psychology & Psychiatry Review, 3*(1), 4–11.

Snowling, M. J. (2008). Specific disorders and broader phenotypes: The case of dyslexia. *The Quarterly Journal of Experimental Psychology, 61*(1), 142–156.

Snowling, M. J., Adams, J. W., Bishop, D. V. M., & Stothard, S. E. (2001). Educational attainments of school leavers with a preschool history of speech-language impairments. *International Journal of Language and Communication Disorders, 36*(2), 173–183. doi: 10.1080/1368282001001989 2

Snowling, M. J., Callagher, A., & Frith, U. (2003). Family risk of dyslexia is continuous: Individual differences in the precursors of reading skill. *Child Development, 74*(2), 358–373.

Snowling, M. J., Muter, V., & Carroll, J. (2007). Children at family risk of dyslexia: A follow-up in early adolescence. *Journal of Child Psychology and Psychiatry, 48*(6), 609-618. doi: 10.1111/j.1469-7610.2006.01725.x

Stanovich, K. E. (1980). Toward an interactive-compensatory model of individual differences in the development of reading fluency. *Reading Research Quarterly, 16*(1), 32–71.

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities, 43*(4), 1–14. doi: 10.1177/0022219410369096

Torppa, M., Parrila, R., Niemi, P., Lerkkanen, M.-K., Poikkeus, A.M., & Nurmi, J.-E. (2013). The double deficit hypothesis in the transparent Finnish orthography: a longitudinal study from kindergarten to Grade 2. *Reading and Writing, 26*(8), 1353–1380. doi: 10.1007/s11145-012-9423-2

Torppa, M., Tolvanen, A., Poikkeus, A-M., Eklund, K., Lerkkanen, M-K., Leskinen, E., & Lyytinen, H. (2007). Reading development subtypes and their early characteristics. *Annals of Dyslexia, 57*(1), 3–32.

van Bergen, E., de Jong, P. F., Plakas, A., Maassen, B., & van der Leij, A. (2012). Child and parental literacy levels within families with a history of dyslexia. *Journal of Child Psychology and Psychiatry, 53*(1), 28–36. doi: 10.1111/j.1469-7610.2011.02418.x

van Bergen, E., de Jong, P. F., Regtvoort, A., Oort, F., van Otterloo, S., & van der Leij, A. (2010). Dutch children at family risk of dyslexia: Precursors, reading development, and parental effects. *Dyslexia, 17,* 2–18. doi: 10.1002/dys.423

Vaessen, A., & Blomert, L. (2010). Long-term cognitive dynamics of fluent reading development. *Journal of Experimental Child Psychology, 105,* 213–231. doi:10.1016/j.jecp.2009.11.005

Wechsler, D. (1991). *Wechsler Intelligence Scales for Children* (3rd ed.). Sidcup, United Kingdom: The Psychological Corporation.

Wimmer, H. (1996). The nonword reading deficit in developmental dyslexia: Evidence from children learning to read German. *Journal of Experimental Child Psychology, 61,* 80–90.

Wimmer, H., & Mayringer, H. (2002). Dysfluent reading in the absence of spelling difficulties: A specific disability in regular orthographies. *Journal of Educational Psychology, 94*(2), 272–277.

Ziegler J. C., Perry, C., Ma-Wyatt, A., Ladner, D., & Schulte-Körne, G. (2003). Developmental dyslexia in different languages: Language-specific or universal? *Journal of Experimental Child Psychology, 86,* 169–193.

Zoccolotti, P., De Luca, M., Di Filippo, G., Judica, A., & Martelli, M. (2009). Reading development in an orthographically regular language: Effects of length, frequency, lexicality and global processing ability. *Reading and Writing, 22,* 1053–1079. doi: 10.1007/s11145-008-9144-8

Zoccolotti, P., De Luca, M., Di Pace, E., Gasperini, F., Judica, A., & Spinelli, D. (2005). Word length effect in early reading and in developmental dyslexia. *Brain and Language, 93,* 369–373.

Zoccolotti, P., De Luca, M., Di Pace, E., Judica, A., Orlandi, M., & Spinelli, D. (1999) Markers of developmental surface dyslexia in a language (Italian) with high grapheme-phoneme correspondence. *Applied Psycholinguistics, 20,* 191–216.

Table 1. Characteristics of Parents and Their Children in the Three Groups: Children with Dyslexia and Familial risk, Children with No Dyslexia and with Familial Risk, and Control Children with No Dyslexia and without Familial Risk.

	Dys_FR[a]		NoDys_FR[a]		C[a]		Paired group comparisons
	M	SD	M	SD	M	SD	
Parents							
Mother's Age	29.62	4.26	29.32	4.22	29.67	4.10	
Mother's Education[b]	4.09	1.42	4.40	1.44	4.60	1.34	Dys_FR=NoDys_FR=C
Father's Age	31.53	5.36	31.64	5.04	32.75	5.34	
Father's Education[b]	3.61	0.99	3.71	1.41	3.75	1.48	
Children					D		
WISC-III[c]							
Verbal IQ	94.17	9.75	100.85	11.77	102.3	11.1	Dys_FR<NoDys_FR* Dys_FR< C**
Performance IQ	97.26	14.25	100.77	11.79	103.2	14.1	
Age, at grade 2	8.98	0.34	8.99	0.32	8.98	0.29	
Age, at grade 3	9.99	0.45	9.85	0.32	9.83	0.29	Dys_FR=NoDys_FR=C
Age, at grade 8	14.48	0.44	14.30	0.54	14.35	0.28	
	Girls	Boys	Girls	Boys	Girls	Boys	
Gender	19	16	32	34	34	38	

Note.

a) Dys_FR = Dyslexia with familial risk, n = 35, NoDys_FR = No dyslexia with familial risk, n = 66, and C = Control children with no dyslexia and without familial risk, n = 72.

b) Parental education was classified using a 7-point scale: 1 = only comprehensive school (CS); 2 = CS and short-term vocational courses; 3 = CS and a vocational school degree; 4 = CS and a vocational college degree; 5 = CS and a lower university degree / a polytechnic degree; 6 = upper secondary general school and a lower university degree / a polytechnic degree; 7 = CS or upper secondary general school and a higher university degree (Master's or a Doctorate-level degree).

c) WISC-III = *Wechsler Intelligence Scale for Children.*

* $p \le .05$, ** $p \le .01$

Table 2. Spearman Correlations of Reading Speed, Reading Accuracy, and Spelling accuracy in Grades 2, 3, and 8.

	Reading speed			Reading accuracy			Spelling accuracy	
	1.	2.	3.	4.	5.	6.	7.	8.
Reading speed[a]								
1. 2nd Grade	-							
2. 3rd Grade	.88***	-						
3. 8th grade	.72***	.78***	-					
Reading accuracy[a]								
4. 2nd Grade	.53***	.55***	.50***	-				
5. 3rd Grade	.63***	.55***	.54***	.69***	-			
6. 8th grade	.47***	.47***	.38***	.51***	.62***	-		
Spelling accuracy[b]								
7. 2nd Grade	.49***	.46***	.41***	.52***	.49***	.40***	-	
8. 3rd Grade	.40***	.40***	.32***	.52***	.49***	.40***	.59***	-
9. 8th grade	.36***	.35***	.30***	.37***	.39***	.31***	.41***	.44***

Note

[a] Reading speed and accuracy are the arithmetic means of three oral reading tasks at each grade: Word list, Text, and Pseudoword text.

[b] Spelling accuracy is the percentage of correctly spelled items in Pseudoword spelling -task.

N = 173 in all correlations between the 3rd and 8th grade measures, and N = 171 in correlations where a 2nd grade measure is included.

*** $p < .001$

Table 3. Descriptive Statistics and Group Comparisons of Dys_FR, NoDys_FR and Control Groups with One-Way ANOVAs in Reading Speed and Accuracy, and Spelling Accuracy at Grades 2, 3, and 8.

	Dys_FR[a]		NoDys_FR[a]		C[a]			Effect size[b]		
	M	SD	M	SD	M	SD	F[c]	Dys_FR vs. NoDys_FR	Dys_FR vs. C	NoDys_FR vs. C
Reading speed										
Overall[d]										
Grade 2	2.77[x]	.83	5.53[y]	1.55	6.22[y]	1.88	56.81***	2.07	2.12	.40
Grade 3	4.00[x]	1.07	6.21[y]	1.63	6.71[y]	1.72	36.05***	1.53	1.76	.30
Grade 8	6.78[x]	1.74	8.96[y]	1.87	9.49[y]	1.51	30.79***	1.21	1.73	.32
Word list										
Grade 2	2.20[x]	.72	4.87[y]	1.77	5.54[y]	2.09	43.27***	1.80	1.88	.34
Grade 3	3.61[x]	1.13	6.34[y]	2.01	6.88[y]	1.97	38.41***	1.57	1.87	.27
Grade 8	6.96[x]	2.02	9.29[y]	2.61	9.66[y]	2.30	16.23***	0.97	1.23	.15
Text										
Grade 2	4.01[x]	1.51	7.92[y]	2.37	8.89[y]	2.55	54.01***	1.87	2.15	.39
Grade 3	4.92[x]	1.61	8.11[y]	2.17	8.81[y]	2.24	41.99***	1.61	1.89	.32
Grade 8	8.59[x]	1.91	11.17[y]	2.06	11.81[y]	1.58	37.13***	1.30	1.93	.35
Pseudoword text										
Grade 2	2.09[x]	.75	3.80[y]	1.06	4.22[y]	1.43	39.52***	1.79	1.70	.33
Grade 3	3.47[x]	1.19	4.17[y]	1.25	4.43[y]	1.41	6.34***	0.57	0.72	.19
Grade 8	4.54[x]	1.42	6.37[y]	1.55	6.94[y]	1.69	26.08***	1.23	1.50	.35
Reading accuracy										
Overall[e]										
Grade 2	77.38[x]	11.49	90.62[y]	6.76	92.30[y]	4.63	53.22***	1.54	2.04	.30
Grade 3	82.21[x]	7.31	93.15[y]	5.71	95.05[y]	3.88	69.73***	1.75	2.51	.40

Grade 8	90.14^{x}	6.09	95.70^{y}	4.46	96.76^{y}	2.39	31.12***	1.11	1.72	.31
Word list										
Grade 2	87.58^{x}	8.97	94.72^{y}	4.38	96.28^{y}	3.27	32.91***	1.46	1.92	.41
Grade 3	90.84^{x}	6.71	96.04^{y}	3.77	97.35^{y}	2.87	28.67***	1.05	1.50	.40
Grade 8	97.34^{x}	3.66	99.54^{y}	1.11	99.41^{y}	1.85	13.84***	0.96	0.83	.08
Text										
Grade 2	85.25^{x}	10.05	94.52^{y}	4.02	94.64^{y}	4.69	33.24***	1.39	1.40	.03
Grade 3	90.00^{x}	5.52	95.32^{y}	3.93	97.27^{z}	1.89	44.95***	1.18	2.15	.66
Grade 8	90.35^{x}	5.83	95.57^{y}	4.16	96.78^{y}	2.12	31.84***	1.10	1.78	.38
Pseudoword text										
Grade 2	59.10^{x}	21.82	82.63^{y}	15.72	85.94^{y}	10.52	38.10***	1.32	1.83	.25
Grade 3	65.52^{x}	15.05	87.86^{y}	12.15	90.34^{y}	8.38	58.58***	1.71	2.32	.24
Grade 8	82.14^{x}	12.94	92.03^{y}	9.63	94.03^{y}	5.21	20.84***	0.92	1.44	.27
Spelling accuracy[f]										
Grade 2	39.05^{x}	28.99	74.36^{y}	17.32	74.53^{y}	19.10	39.96***	1.62	1.59	.01
Grade 3	64.05^{x}	21.18	82.45^{y}	16.67	87.96^{y}	14.19	24.44***	1.01	1.45	.36
Grade 8	82.29^{x}	15.36	94.32^{y}	7.23	95.49^{y}	4.45	29.90***	1.13	1.45	.20

Note. Groups with different superscript letter ($^{x, y}$ or ^{z}) were significantly different in the post hoc pair wise comparisons of ANOVA F tests ($p \leq .05$). Bonferroni or Dunnett's T3 corrections were used depending on equality or inequality of the variances.

a) Dys_FR = Dyslexia with familial risk, n = 35, NoDys_FR = No dyslexia with familial risk, n = 66, and C = Control children with no dyslexia and without familial risk, n = 72.

b) Effect sizes were estimated with Cohen's *d* (computed with pooled standard deviations).

c) Degrees of freedom varied between 2,165 – 2,170 due to missing data in single measures.

d) Overall reading speed = Arithmetic mean of the number of read letters/second in Word list, Text and Pseudoword text reading.

e) Overall reading accuracy = Arithmetic mean of the percentage of correctly read words/pseudowords in Word list, Text and Pseudoword text reading.

f) Spelling accuracy = percentage of correctly written pseudowords.

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 4. F-values and Estimates of Effect Sizes from Mixed-Desing ANOVAs with Reading Speed as the Dependant Measure, Task as the Within-subjects Factor and Group as the Between-subjects Factor.

Compared tasks	Main effect of Task	Effect size[a]	Main effect of Group[b]	Effect size[a]	Interaction effect of Task*Group	Effect size[a]
Word list vs. Pseudoword text						
2nd grade	F(1,168) = 176.47***	.31	F(2,168) = 47.54***	.36	F(2,168) = 12.55***	.13
3rd grade	F(1,170) = 215.07***	.56	F(2,170) = 25.74***	.23	F(2,170) = 36.76***	.30
8th grade	F(1,166) = 244.49***	.60	F(2,166) = 26.77***	.24	F(2,166) = 11.12	.01
Word list vs.Text						
2nd grade	F(1,168) = 597.92***	.78	F(2,168) = 54.67***	.39	F(2,168) = 14.55***	.15
3rd grade	F(1,170) = 292.26***	.63	F(2,170) = 44.36***	.34	F(2,170) = 13.14	.04
8th grade	F(1,169) = 152.17***	.47	F(2,169) = 29.98***	.26	F(2,169) = 11.06	.01
Text vs.Pseudoword text						
2nd grade	F(1,168) = 1591.75***	.78	F(2,168) = 58.93***	.41	F(2,168) = 27.09***	.24
3rd grade	F(1,170) = 1549.10***	.76	F(2,170) = 30.92***	.27	F(2,170) = 35.36***	.29
8th grade	F(1,167) = 2249.39***	.93	F(2,167) = 34.66***	.29	F(2,167) = 16.12*	.07

Note.

[a] Effect size = Partial Eta Squared.

[b] Groups: Dys_FR = Dyslexia with familial risk, n = 35, NoDys_FR = No dyslexia with familial risk, n = 66, and C = Control children with no dyslexia and without familial risk, n = 72.

Because multiple Mixed-Design ANOVAs were conducted a stricter than usual cut-offs for significance were used: * $p \leq .005$, ** $p \leq .001$, *** $p \leq .0001$.

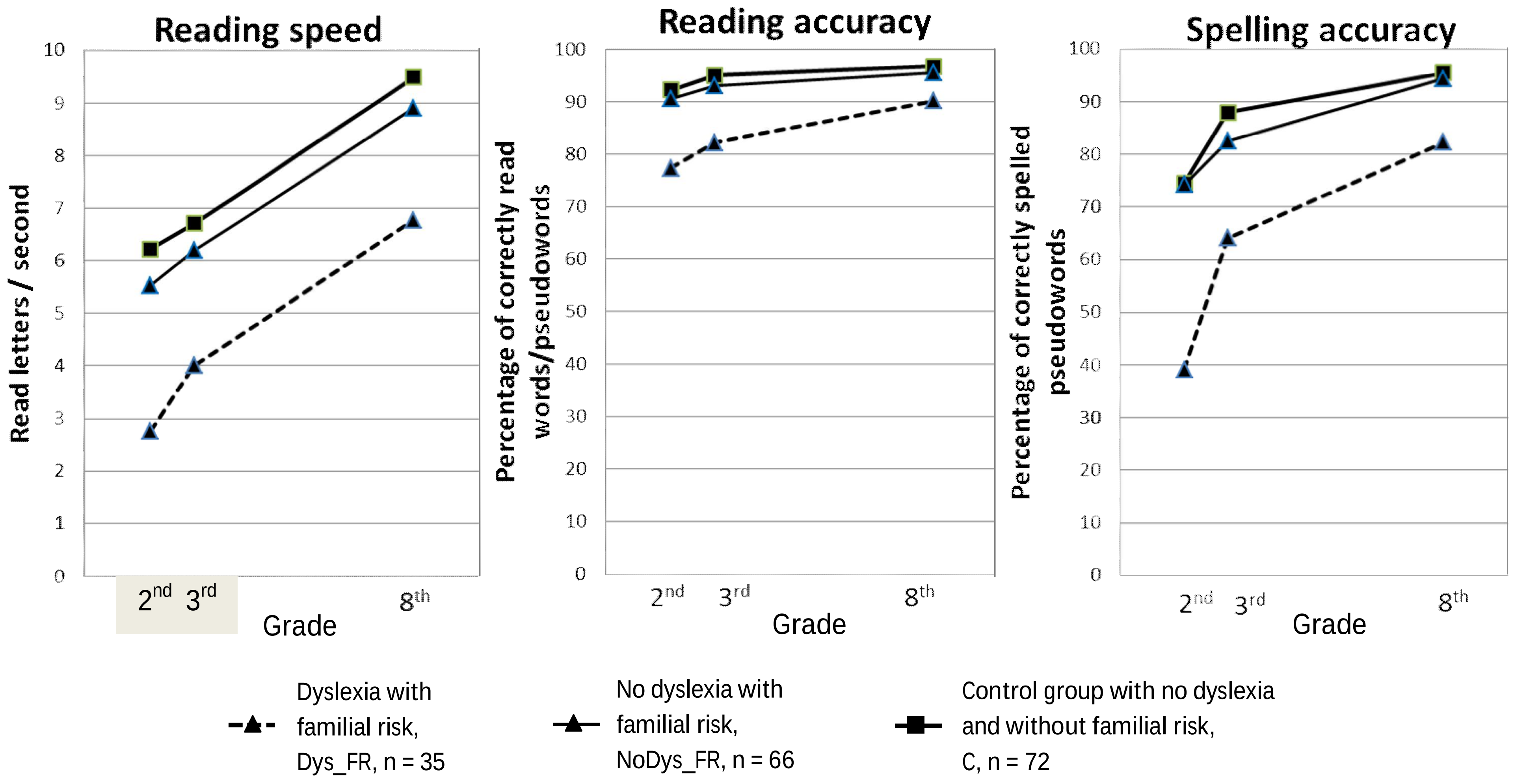


Figure 1. Reading Speed and Accuracy (Composite Means), and Pseudoword Spelling Accuracy in the Three Groups: Children with Dyslexia and Familial Risk, No dyslexia with Familial Risk, and Control children at the 2nd, 3rd, and 8th Grade.

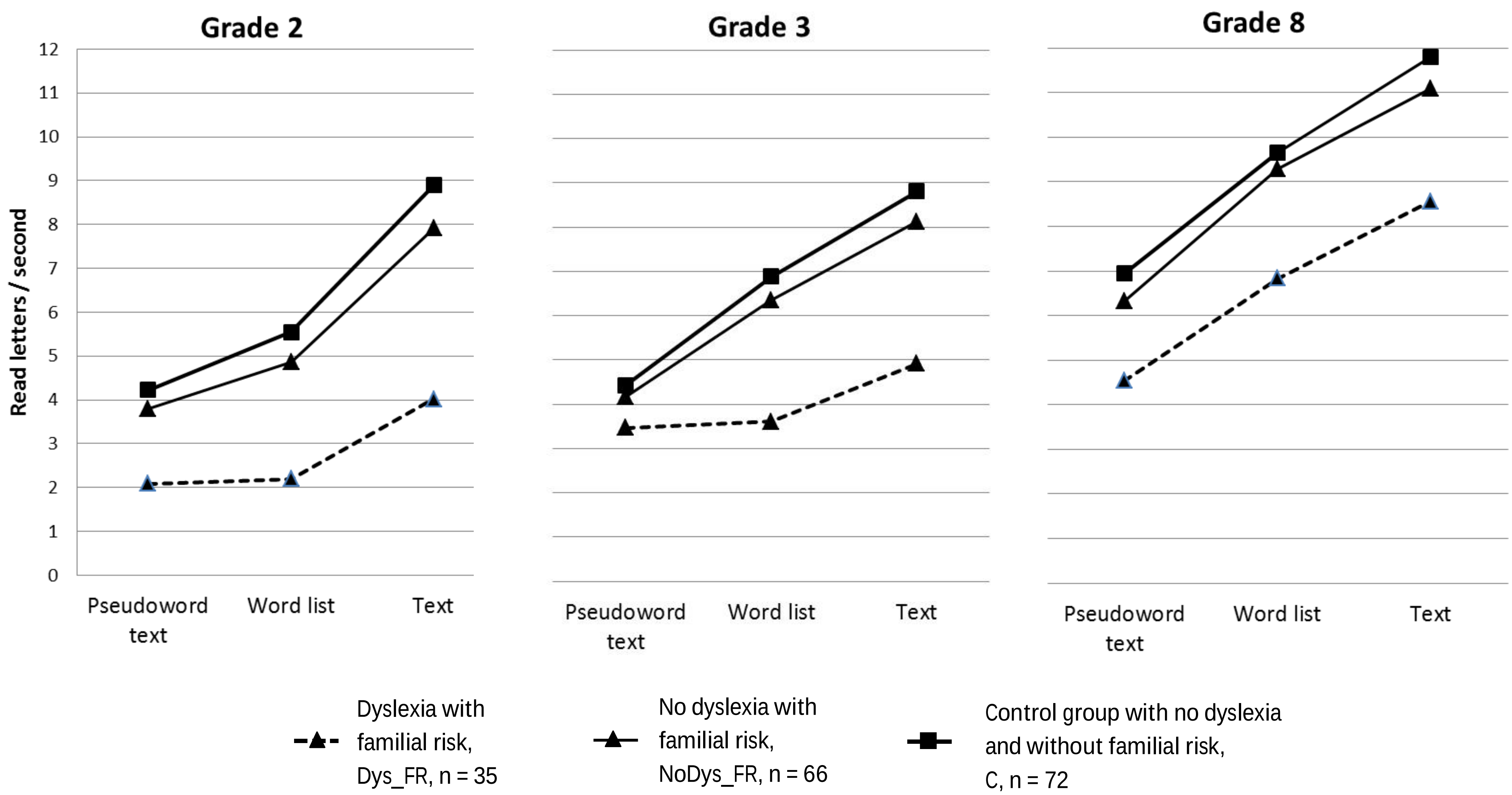


Figure 2. Reading Speed Means in Pseudoword Text, Word List, and Text Reading Tasks in the Three Groups: Children with Dyslexia and Familial Risk, No dyslexia with Familial Risk, and Control children at the 2nd, 3rd, and 8th Grade.

III

LATE-EMERGING AND RESOLVING DYSLEXIA: A FOLLOW-UP STUDY FROM AGE 3 TO 14

by

Minna Torppa, Kenneth Eklund, Elsje van Bergen, & Heikki Lyytinen, 2015

Journal of Abnormal Child Psychology, 43, 1389–1401

Permanent link to this item: http://urn.fi/URN:NBN:fi:jyu-201601051013

ABSTRACT

This study focuses on the stability of dyslexia status from Grade 2 to Grade 8 in four groups: (a) no dyslexia in either grade (no-dyslexia, *n* = 127); (b) no dyslexia in Grade 2 but dyslexia in Grade 8 (late-emerging, *n* = 18); (c) dyslexia in Grade 2 but not in Grade 8 (resolving, *n* = 15); and (d) dyslexia in both grades (persistent-dyslexia, *n* = 22). We examined group differences from age 3.5 to age 14 in (a) reading, vocabulary, phonology, letter knowledge, rapid naming, IQ, verbal memory; (b) familial and environmental risk and supportive factors; and (c) parental skills in reading, phonology, rapid naming, verbal memory, and vocabulary. Our findings showed group differences both in reading and cognitive skills of children as well as their parents. Parental education, book-reading frequency, and children's IQ, however, did not differentiate the groups. The children in the persistent-dyslexia group exhibited widespread language and cognitive deficits across development. Those in the resolving group had problems in language and cognitive skills only prior to school entry. In the late-emerging group, children showed clearly compromised rapid naming. Additionally, their parents had the most severe difficulties in rapid naming, a finding that suggests strong genetic liability. The findings show instability in the diagnosis of dyslexia. The members of the late-emerging group did not have a distinct early cognitive profile, so late-emerging dyslexia appears difficult to predict. Indeed, these children are at risk of not being identified and not receiving required support. This study suggests the need for continued monitoring of children's progress in literacy after the early school years.

Keywords: early identification, family risk for dyslexia, late-emerging dyslexia, reading disabilities, dyslexia

LATE-EMERGING AND RESOLVING DYSLEXIA: A FOLLOW-UP STUDY FROM AGE 3 TO 14

A considerable amount of research over the past decades has focused on reading disability (RD). This work has increased the understanding of the etiology and assessment of RD, as well as of the risk and protective factors for RD (for a recent review, see Snowling & Hulme, 2013). Most of the studies, however, have focused on the early phases of reading development or used relatively short follow-ups. The few studies that have followed reading development for several years have suggested that, although there is high stability in RD across grades at the group level (e.g., Compton, Fuchs, Fuchs, Elleman, & Gilbert, 2008; Landerl & Wimmer, 2008), there are—at least in English—also a considerable number of cases that move across the clinical threshold over time: children who are no longer affected (resolving RD; e.g., Catts, Compton, Tomblin, & Bridges, 2012) and children who do not develop RD until Grade 4 (late-emerging RD; e.g., Catts et al., 2012; Etmanskie, Partanen, & Siegel, in press; Leach, Scarborough, & Rescorla, 2003; Lipka, Lesaux, & Siegel, 2006). Little research has been conducted on the characteristics of resolving and late-emerging RD, although the proportion of late-emerging cases has been reported to be approximately 40% of all RD cases in English (Catts et al., 2012; Leach et al., 2003; Lipka et al., 2006). The scarcity of information on these resolving and late-emerging RD groups presents challenges to early identification and prevention efforts of RD.

Four previous studies have directly addressed the stability of RD classification (Catts et al., 2012; Etmanskie et al., in press; Leach et al., 2003; Lipka et al., 2006). The studies have varied in their identification of RD. Lipka et al. (2006) identified three types of RD on the basis of reading accuracy and letter knowledge in a sample of 44 children followed from Kindergarten to Grade 4. They found that 36% of all RD cases were late-emerging. Catts et al. (2012) followed 493 children from Kindergarten to Grade 10. They reported that approximately 25% of all RD cases had late-emerging problems in decoding. Catts et al. (2012) also found a small group of children with resolving RD (5% of all RD cases). Both Lipka et al. (2006) and Catts et al. (2012) used two measures for word-reading accuracy and none for reading fluency or spelling in the identification of RD. Etmanskie et al. (in press) used a combined measure of reading accuracy and reading comprehension. Leach et al. (2003), however, used two measures for reading accuracy, two for reading fluency, and two for spelling. They tested 161 fourth- and fifth-grade students and then examined retrospectively if the children had previously been identified by teachers as having reading difficulties. Of the 66 children with RD, 21 (32%) were identified as late-emerging. Leach et al. (2003) also identified a small group of children with resolving RD (12% of all RD cases).

All of the above studies on dyslexia stability were conducted in English. In the present study, we examined the stability of RD in Finnish, which is among the most transparent orthographies. Transparency of orthography has been found to have important effects on the development of reading skills and thus the findings in English-speaking samples may not be applicable to other, more transparent orthographies. In transparent orthographies, such as those of German or Finnish, letter–sound connections are much more consistent (Seymour, Aro, & Erskine, 2003) and children learn to decode much more quickly in these languages than children do in English (Aro & Wimmer, 2003). In Finland, for example, there are only 23 fully consistent letter–sound connections to learn for accurate decoding of all Finnish words and most children are accurate decoders after just a few weeks in school. Research on the different developmental trajectories of the aforementioned RD groups in the context of transparent orthographies is, however, completely lacking although there is correlative evidence of strong stability in reading development also in transparent languages (e.g., de Jong & van der Leij, 2002; Landerl & Wimmer, 2008; Parrila, Aunola, Leskinen, Nurmi, & Kirby, 2005). On the other hand, the correlation coefficients are still far from unity, suggesting that different developmental trajectories may also exist in transparent orthographies.

In transparent orthographies the main characteristic of readers with RD is slow reading (e.g., de Jong & van der Leij, 2003; Landerl & Wimmer, 2008; Landerl, Wimmer, & Frith, 1997; Zoccolotti et al., 2005) while reading accuracy has been shown to be an easy skill to acquire (Aro & Wimmer, 2003; Seymour, Aro, & Erskine, 2003). Therefore, unlike previous studies on RD stability in English, we focus on reading fluency. We use multiple measures for reading speed, which are age-appropriate but otherwise very similar across ages, to ensure dyslexia criteria as consistently as possible across ages. We categorize children as (a) no dyslexia, (b) late-emerging dyslexia, (c) resolving dyslexia, and (d) persistent dyslexia based on their reading speeds in Grade 2 and in Grade 8. In addition, we validate the differences between groups by comparing their reading speed performance in tasks that were not used in the RD grouping, as well as by comparing the reading speed of the follow-up sample to the level of their classmates. Finally, we will test how many of the children are expected to change dyslexia group from Grade 2 to Grade 8 randomly due to limits of measurement reliability in order to see if the changes in dyslexia groups are truly developmental. Although we do acknowledge that reading skill is continuous, the categorical approach has clinical relevance and allows comparisons to the previous research conducted in English.

In terms of identification of risk and protective factors, as well as early identification of children at risk for dyslexia, an examination of the differences among the developmental RD groups is important. Differences in cognitive profiles is one potential explanation for the differences in the emergence of RD. Children with poor early reading skills that resolve later on may have different cognitive vulnerabilities and strengths than children with late emerging or persistent dyslexia. In the early phases of reading development letter knowledge and phonological skills seem to be particularly important, as basic decoding requires solid knowledge of letters, sounds, and their connections (e.g. Georgiou, Parrila, & Papadopoulos, 2008; Puolakanaho et al., 2007). Later on, decoding becomes automatized in typically developing children. However, reading continues to be slow and laborious in poor readers, partly because many words are still decoded letter-by-letter (Eklund, Torppa, Aro, Leppänen, & Lyytinen, 2015; Marinus & de Jong, 2010). Later reading fluency is predicted by rapid naming (Lervåg & Hulme, 2009; Torppa et al., 2012, van Bergen, van der Leij, & de Jong, 2014). Relating this to the identified groups, the persistent group is expected to show problems in all reading related cognitive skills. Yet our focus is particularly on the cognitive profiles of the two unstable groups. On the one hand, the resolving group may lag behind in acquiring phonological skills and grapheme-phoneme knowledge. On the other hand, the late-emerging group can be expected to have problems particularly in rapid naming, which would not be apparent until the demands on fluency increase.

Two previous studies on the stability of dyslexia diagnosis have also compared the groups in terms of their cognitive skills (Catts et al., 2012; Lipka et al., 2006). Catts et al. (2012) concluded that all of the RD groups showed Kindergarten-age cognitive deficits in comparison to typical readers, but the groups did not differ from each other. The late-emerging group with problems in word reading alone had difficulties particularly in phonological awareness and sentence repetition. The resolving group showed problems of phonological awareness and letter identification, but since the size of this group was small ($n = 11$) and consisted of mixed cases with difficulties either in reading comprehension, in word reading, or in both, the findings call for replication. Similarly to Catts et al. (2012), Lipka et al. (2006) reported that their late-emerging group had difficulties in phonological awareness. It was suggested that the children's phonological skills were sufficient for the early grades, but that they started to fall behind when cognitive demands in reading increased. In the present study we include, in addition to phonological skills, several other skills that have been shown to be closely linked to reading development: letter knowledge, rapid naming, verbal short-term memory, and vocabulary (e.g., Puolakanaho, et al., 2007; Snowling, Gallagher, & Frith, 2003; van Bergen, de Jong, Maassen, & van der Leij, 2014). Unlike previous studies, we report performance on these skills both prior to and following school entry.

In addition to cognitive skills, other risk or supportive factors may explain developmental differences among the groups. One such factor is family risk for dyslexia, which was not examined in the previous studies on the stability of RD. The risk for dyslexia has been reported to range from fourfold (Puolakanaho, et al., 2007) to tenfold (van Bergen, de Jong, Plakas, Maassen, & van der Leij, 2012) for children with family risk compared to children without such risk. Family risk has predicted children's reading development over and above children's skills in the key cognitive precursors, such as phonological awareness, rapid naming, and letter knowledge (Puolakanaho et al., 2007; Torppa, Eklund, van Bergen, & Lyytinen, 2011). Furthermore, studies predicting children's skills with parent's skills have suggested that specific parental skills may be informative in assessing children's liability for dyslexia beyond their own cognitive development (Torppa et al., 2011; van Bergen et al., 2014a).

A third factor that could explain the differential developmental trajectories is the amount of environmental support. Leach et al. (2003) compared the groups in terms of print exposure, but their study did not find differences between the early-emerging and late-emerging groups. However, they used an author-recognition test, which is an indirect measure of children's print exposure. It remains possible, therefore, that a more direct evaluation of the amount of reading activities would find differences between the RD groups. In the present study we examine the amount of book reading children do with their parents and the amount they do alone. We also examine group differences in parental education. Finally, we examine gender distributions among the groups. Both gender and print exposure comparisons were motivated by consistent findings of a gender gap in literacy, which is often attributed to fewer reading activities among boys (see OECD, 2010a, b).

This paper examines the following research questions: What is the instability of dyslexia between Grade 2 and 8? Do children change dyslexia status more often than unreliability of diagnostic tests predicts? Do the four groups differ in (a) the development of reading speed, (b) the development of language and cognitive skills, (c) the amount of book reading, (d) gender, or (e) parental education and reading(-related) skills?

METHOD

Participants

All children (*n* = 182)[1] were participants of the Jyväskylä Longitudinal Study of Dyslexia (JLD) (see Lyytinen, et al., 2008), originally selected for one of two samples: those with family risk for dyslexia or those without it. Children at risk (*n* = 101) had a parent and one or more other close family members with dyslexia. The parents' dyslexia status was confirmed through an extensive test battery (see Leinonen, et al., 2001). All children spoke Finnish as their native language and had no mental, physical, or sensory impairments. None of the children had a standard score below 80 in both performance and verbal IQ assessed in Grade 2 (WISC-III-R; Wechsler, 1991). There were 86 girls and 96 boys in the sample. In addition to the follow-up sample, their classmates' reading skills were assessed in Grade 2 (*n* = 1356), Grade 3 (n = 2575), and Grade 7 (*n* = 1451). The classmates' data provided a reference point for typical development. All children attended mainstream public schools following the national curriculum. JLD has received ethical consent from University of Jyväskylä ethical board.

Measures

1) Of the 200 children originally screened, 18 (of whom 7 had a familial risk for dyslexia) did not wish to take part in the eighth-grade assessments.

Children's cognitive and literacy skills. The children's cognitive and literacy skills were assessed individually by trained testers prior to school entry (from age 3.5 to 6.5) and in Grades 2, 3, and 8. Children in Finland enter Grade 1 in the fall of the year they turn 7 years.

Vocabulary. At age 3.5 and 5.5, the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) was used. The Finnish translation of the BNT (Laine et al., 1993; Laine, Koivuselkä-Sallinen, Hänninen, & Niemi, 1997) contains 60 pictured items 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 (e.g. violin – an instrument, tennis racket – you play a game with it). In Grade 2, the WISC-III (Wechsler, 1991) was used.

Memory. Verbal short-term memory was assessed at age 6.5 and in Grades 3 and 8 with a forward digit span test. The measure was the number of correctly repeated number sequences of 12 items.

Phonological awareness. At ages 4.5, 5.5, and 6.5, phonological awareness was measured with a composite mean of *z* scores from four tasks: first phoneme identification, first phoneme production, segment identification, and synthesis (Torppa, et al., 2007). Cronbach's alphas were .71 at age 4.5, .58 at age 5.5, and.85 at age 6.5. In Grades 3 and 8, the common unit task was used: the task was to repeat aloud a sound that was common to two different pseudowords presented via earphones (Torppa, Georgiou, Salmi, Eklund, & Lyytinen, 2012). The score was the number of correct responses (phoneme or letter name) out of 15 items. Cronbach's alpha was .81 in Grade 3 and .85 in Grade 8.

Rapid naming. Children were asked to name as rapidly as possible, a matrix of 30 (age 5.5. years) or 50 objects ((age 6.5, and in Grades 2, 3, and 8; Denckla & Rudel, 1974)) made up from five different pictures of objects: a car, a house, a fish, a pencil and a ball. All the Finnish names for these objects are two-syllabic high-frequency words. Total naming time (in seconds) was used as the score.

Letter knowledge*.* All 29 lowercase letters (23 typically used and 6 for the rare loan words) in the Finnish alphabet were presented at ages 4.5, 5.5, and 6.5. The measure was the number of correctly named letters. Cronbach's alphas were .83 at age 4.5, .88 at age 5.5, and .93 at age 6.5.

IQ (Grade 2). Four performance-quotient subtests (Picture Completion, Block Design, Object Assembly, and Coding) and five verbal-performance subtests (Similarities, Vocabulary, Comprehension, Series of numbers, and Arithmetic) of the WISC-III-R were used. The estimate of the IQ was calculated according to the manual. The Cronbach's alpha for the composite of the subtests was .70.

Children's reading fluency. Reading fluency was assessed individually in Grades 2, 3, and 8 and in groups at school in Grades 2, 3, and 7. The Cronbach's alphas for the composites of reading fluency were .92 in Grade 2, .86 in Grade 3, and .90 in Grade 8.

Word-list reading (Grades 2, 3, and 8). In the Lukilasse nationally standardized reading test (Häyrinen, Serenius-Sirve, & Korkman, 1999), participants had 2 min (Grades 2 and 3) or 1 min (Grade 8) to read aloud as many words as possible from a 90-item (Grade 2) or 105-item (Grades 3 and 8) list. The measure of the word-list reading speed was the number of correctly read words within the time limit. The inter-rater reliability was .99.

Text reading (Grades 2, 3, and 8). Age-appropriate ordinary texts were selected with lengths of 124, 189, and 204 words (for Grades 2, 3, and 8, respectively). Total reading time was the measurement of text reading speed.

Pseudoword text reading (Grades 2, 3, and 8). Children read aloud a short text made up of 19 (Grade 2) or 38 pseudowords (Grades 3 and 8). The words and structure of the sentences resembled real Finnish in form but had no meaning. Total reading time was the measure of pseudoword reading speed.

Wordchains (Grades 2, 3, and 7). In Grades 2 and 3 the test included 79 wordchains each containing 2–4 words, and in Grade 7 it consisted of 75 wordchains each containing 4 words. The task was administered in a group context in classrooms. The child's task was to scan and mark with a pencil the boundaries in the chain where one word ends and another starts. The number of correct answers during the time limit of 2 min (Grades 2 and 3) or 3 min and 30 s (Grade 7) was used as a measure of reading speed.

Print exposure. Print exposure was assessed via parental questionnaires on the amount of book reading (Grades 2, 3, and 7) and through self-reports (Grade 7). Prior to school entry at ages 4, 5, and 6, the amount of book reading was assessed as the amount of shared book reading with parents. To produce a composite score of shared reading, we obtained parental reports of both frequency and time spent on children's reading activities in the home. Two items assessed the frequency: How often (a) the mother reads with the child, and (b) the father reads with the child. Two items covered the amount of time spent with print materials: (a) the typical duration of a reading episode (i.e., the child reads with an adult), and (b) the total time per day the child spends reading a book with an adult. Shared reading composites were derived by calculating the mean of these four item scores. In Grades 2 and 3, a composite score was derived for two items pertaining to independent book reading: (a) frequency of reading alone, and (b) the typical duration of a reading episode. Parents responded to the first item using a five-point scale (1 = not at all/seldom ... 5 = several times a day) and to the second item using a three-point scale (1 = less than 15 min/episode... 3 = longer than 45 min/episode). In Grade 7, print exposure was based on both the child's self-report and a parental report. The questions and scales were the same as in Grades 2 and

3, a total of four items. Cronbach's alpha was .79, .84, and .84 for Grades 2, 3, and 7, respectively.

Dyslexia Criteria in Grades 2 and 8. Dyslexia criteria were based on the following tasks: (a) word list reading, (b) text reading, and (c) pseudoword text reading. First, a cut-off criterion for deficient performance was defined for each measure, using the 10th percentile in the distribution of the children without family risk (n = 81). Subsequently, a child was considered to have dyslexia if the child scored below the criterion in at least two out of three measures of reading speed. In comparison to the larger samples with classmates (n = 1386 and n = 1489 in Grade 2 and 7, respectively) the mean reading skill of children having dyslexia were at the level of the 8th and the 6th percentile in Grade 2 and 7, respectively.

Parental assessment. The literacy skills of the parents were assessed before the child's birth. In the present study we included text reading speed because it resembles the children's tasks. When the children were between ages 3 and 6, we invited the parents for reassessments to measure their reading-related cognitive skills. Because we were not able to reassess all parents, the sample size for cognitive measures is somewhat lower than for reading speed (i.e., n = 74 vs. n = 100 for the at-risk group parents and n = 45 vs. n = 81 for the control parents with typical reading skills). Comparisons of the attendees and non-attendees revealed that the educational level and age of the parents was not different There were, however, differences in parental reading skills: the average reading level of the parents who decided to attend reassessments was somewhat lower than that of the non-attendees. For one of the parents in the family risk group, the text reading task was very difficult and testing was discontinued.

Text-reading fluency. Parents read aloud two passages (218 and 128 words, respectively) as fluently and accurately as possible. A measure of reading fluency was the average reading time for the two texts. Cronbach's alpha was .96.

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

Rapid Naming. On each of three tasks, participants named, as rapidly as possible, a matrix of 50 items comprising objects, digits, or a mixture of digits, objects, and letters. In the parental assessment, stimuli were presented on a computer screen. Total naming time (in seconds) was used as the score. A mean composite score of the three standardized rapid naming scores was calculated for the analyses. Cronbach's alpha for the rapid naming composite was .86.

Verbal short-term memory. In the digit span subtest of WAIS-III (Wechsler, 1991), participants repeated strings of digits, increasing in length, in both the forward and reverse directions. Two sets of items, one for forward, the other for reverse, were used. Scaled scores were derived from the manual.

Vocabulary. In the vocabulary subtest of WAIS-III (Wechsler, 1991), participants defined 35 words in their own words. Scaled scores were derived from the manual.

RESULTS

We first classified children in four groups, according to their dyslexia status in Grades 2 and 8: (a) no dyslexia in either grade (no-dyslexia, n = 127); (b) no dyslexia in Grade 2 but dyslexia in Grade 8 (late-emerging, n = 18); (c) dyslexia in Grade 2 but not in Grade 8 (resolving, n = 15); and (d) dyslexia in both grades (persistent-dyslexia, n = 22). Because we classify children using cut-offs at two time points, which are always somewhat arbitrary (e.g. Francis et al., 2005), and because individual test scores are never 100% reliable, we first examined how many of the Grade 2 children would be expected to have changed group by

Grade 8 just by chance. To do this we did a simulation study using the reliability of the three reading tasks (measured by test-retest correlations between Grades 2 and 3). Our 1-year test-retest correlations reflect both measurement unreliability and trait stability. Therefore, they estimate reliability conservatively. Reading measures between Grade 2 and 3 correlated .80 for word list reading, .66 for pseudoword text reading, and .87 for text reading. We decided to use a test-retest correlation estimate of .80 (average of the test-retest correlations of the three tasks) and trait true score stability was set to be 1. In the simulation study we set the number of cases to be 100,000 and examined how many children would be observed to change their group if we assume that there is no true score changes but all changes are seen only in the observed scores (being thus random changes due to unreliability of measurement). In the simulation the same identification procedure with three measures and 10% cut-off was used as was used for the identification in the other analyses. The results showed that 5.6%, which would correspond to 10 children in our sample, change their group just because of the unreliability of the measures between Grades 2 and 8. As 18% of our sample (33 children) changed their diagnostic group, we conclude that, even with the conservative reliability estimate, the instability of dyslexia is not fully due to random changes across cut-offs.

Group Differences in Parental Education, Gender, and Family Risk

There were no differences between groups in IQ or parents' education (see Table 1). Children's gender was unevenly distributed in the groups, $\chi^2(3) = 11.06$, $p < .05$: there were more boys than expected in the late-emerging group (adjusted standardized residual = 2.5) and more girls in the resolving group (adjusted standardized residual = 2.4). In addition, family risk for dyslexia was unevenly distributed in the groups, $\chi^2(3) = 19.54$, $p < .001$: at-risk children were overrepresented in the persistent and late-emerging groups (adjusted standardized residual = 2.6 and 2.5, respectively) and underrepresented in the no-dyslexia group (adjusted standardized residual = -4.4).

Group Differences in Reading Speed Development

In order to examine if the groups were different in reading speed development, we conducted group comparisons using both the individually administered dyslexia criterion tasks (in Grades 2, 3, and 8) and group administered tasks (in Grades 2, 3, and 7) that were not part of the dyslexia criterion. The group tasks were also administered to children's classmates in order to obtain a reference sample. Group comparisons were conducted with one-way ANOVAs (see Figure 1, Table 2). Note that in Figure 1, there are two different distributions underlying the standardization. In the left panel for the individually administered tasks, the standardization is based on the not-at-risk group's distribution. In the right panel for the group-administered reading tasks, the standardization is based on the larger sample, which includes the classmates of the follow-up group as well. Effect sizes (Cohen's *d* computed using pooled standard deviation) are reported in Supplementary table 1.

All dyslexia groups showed poorer performance than the no-dyslexia group across measures and time-points. The persistent group stayed at the lowest level throughout the whole follow-up period. The late-emerging group read also somewhat slower than the no-dyslexia group in Grades 2 and 3 and showed a descending trajectory in the follow-up to Grades 7 and 8. The resolving group, on the other hand, did not differ in reading speed from the persistent group in Grades 2 and 3, but showed fast development in the following years. We also conducted a follow-up analysis on the developmental differences in reading speed among the groups with mixed ANOVA where we entered grade as a within-subjects factor and dyslexia group as a between-subjects factor. There was a significant Grade x Group interaction effect, $F(3, 174) = 18.50$, $p < .001$, $\eta_p^2 = .24$, which indicates group differences in the rate of reading speed development between Grades 2 and 8. The clearest difference was between the resolving and late-emerging group: the resolving group made progress in reading speed more quickly than the late-emerging group did.

Group Differences in Cognitive Skills

Next we compared the groups in terms of cognitive skills with one-way ANOVAs (see Table 3 and Supplementary Table 2, Figure 2). The persistent-dyslexia group showed poor performance in almost all assessed cognitive skills. They performed below the no-dyslexia group in all measures except vocabulary, and phonological awareness at ages 4.5 and 5.5. The strongest effect sizes for the difference between the persistent and no-dyslexia groups were found in phonological awareness from age 6.5 onwards, in rapid naming, and in letter knowledge.

The late-emerging group had problems most clearly in rapid naming speed. They performed below the no-dyslexia group in all assessments of rapid naming and also in Grade 3 verbal short-term memory. In addition, they tended to perform below the no-dyslexia group in the other cognitive skills as well (except for vocabulary), although these medium effect size differences did not reach significance. The late-emerging group and the persistent-dyslexia group differed significantly only in phonological awareness (Grade 8), although medium to strong effect sizes in favor of the late-emerging group emerged for verbal short-term memory (age 6.5) and for letter knowledge (ages 5.5 and 6.5).

The resolving group had problems in cognitive skills but only prior to school entry: they performed below the no-dyslexia group in vocabulary (ages 3.5 and 5), phonological awareness (age 6.5), rapid naming (age 5.5), and letter knowledge (all occasions). In addition, medium effect sizes emerged for all cognitive skills assessed prior to school entry in favor of the no-dyslexia group as well as for verbal short-term memory in all time-points. The resolving group did not differ from the persistent group significantly except for phonological awareness in Grades 3 and 8. However, medium effect sizes in favor of the resolving group emerged also in rapid naming (Grades 3 and 8). On the other hand, medium effect sizes in favor of the persistent group were found in vocabulary (ages 3.5 and 5). The resolving group and late-emerging group did not differ significantly from each other in any of the cognitive measures. However, there were medium effect sizes in favor of the late-emerging group before school-age in vocabulary (age 5), verbal short term memory (age 6.5) and letter knowledge (age 6.5). On the other hand, at school-age medium effect sizes were found in favor of the resolving group in phonological awareness (Grade 3) and in rapid naming (Grade 8).

Group Differences in Book Reading

Finally, the groups were compared in the amount of book reading (the amount of shared book reading with a parent prior to school entry and the amount of book reading alone after school entry). According to the pairwise comparisons, the groups did not differ in the amount of book reading although the F-test in Grade 3 was significant. The comparisons of the effects sizes suggested that the parents of the resolving group tended to read less to their 4-year olds than the late-emerging and persistent-dyslexia groups did (medium effect sizes). In addition, an effect size of .71 emerged for the comparison of the no-dyslexia group and resolving group in Grade 3, a result that indicates that the no-dyslexia children spent more time reading books than the resolving children.

Group Differences in Parental Skills

For the group comparisons in parental skills, five groups were compared instead of four because the no-dyslexia group was split into two groups: children with family risk for dyslexia and children without family risk for dyslexia. This division was made in order to provide a more detailed examination of the parental skill differences in these two separate samples. There were 3–4 children without family risk in each of the dyslexia groups whose data was omitted from this comparison resulting in five groups: not-at-risk & no-dyslexia (*n*

= 70), at-risk & no-dyslexia (*n* = 57), at-risk & late-emerging dyslexia (*n* = 15), at-risk & resolving dyslexia (*n* = 11), at-risk & persistent-dyslexia (*n* = 18). The group comparisons are reported in Table 4, Supplementary table 3, and Figure 3.

The group comparisons revealed that parents in the not-at-risk & no-dyslexia group performed significantly better than parents in all other groups in reading speed and in phoneme deletion. These parents also performed better in the verbal short-term memory task than parents in all other groups did except for those in the at-risk & resolving group. There were no significant differences in parental vocabulary although large effect sizes indicated that the parents in the at-risk persistent groups tended to have poorer vocabulary than in those in the not-at-risk & no dyslexia group did. The group comparisons in parents' rapid naming showed interesting differences between the family risk groups: the parents of the at-risk & late-emerging and the at-risk & persistent dyslexia groups were slow at rapid naming whereas the parents of the at-risk & resolving and the at-risk & no-dyslexia groups did not differ from the not-at-risk & no-dyslexia group's parents in rapid naming. The effects sizes confirmed that the parents of at-risk & late-emerging and at-risk & persistent dyslexia groups had slow rapid naming speed when they were compared with both no-dyslexia groups and with the at-risk & resolving group.

DISCUSSION

The current study investigated the stability of dyslexia in a prospective study from Kindergarten to Grade 8 in the context of a transparent orthography (Finnish). The children, half of whom had a familial risk for dyslexia, were categorized as having or not having dyslexia based on reading fluency measures in Grades 2 and 8. This yielded three groups of children with reading problems at some point, referred to as resolving, late-emerging, and persistent dyslexia. The three groups were compared with each other and with a group without dyslexia in six measures: reading fluency, language and cognitive skills, parental reading fluency and cognitive skills, parental education, and the amount of book reading. The group comparisons revealed differences both in the children's reading-related cognitive development and in a set of similar skills measured in their parents. Parental education, book reading frequency, and children's IQ, on the other hand, did not differentiate the groups.

Our findings indicated that reading status was not stable, because less than half of the RD children met the dyslexia criteria in both Grades 2 and 8. In fact, of the 55 children identified as having RD at some point, 15 (27%) met the dyslexia criteria in Grade 2 only (resolving), and 18 (33%) only in Grade 8 (late-emerging). The investigation of reading fluency using the group-administered tasks that were external to the dyslexia criteria, validated the groups. The previous longitudinal studies examining the stability of dyslexia were conducted in English (Catts et al., 2012; Etmanskie et al., in press; Leach et al., 2003; Lipka et al., 2006). In spite of differences in orthographic complexity between this study and previous ones, we found roughly the same proportion of children with late-emerging RD as Catts et al. (2012) and Leach et al. (2003). Nevertheless, the proportion of the resolving group was twice as large than the group in Leach et al. (2003) and four times as large than what was found in Catts et al. (2012). Such cases were not reported in Lipka et al. (2006).

The letter–sound connections in Finnish, which are easier to learn than in English, could enable more children to catch up despite early cognitive difficulties. This suggestion is supported by cross-linguistic comparisons which have shown that dyslexic children's reading is less severely impaired in low-complexity orthographies than in high-complexity ones (Landerl, et al., 2012). In addition, the use of reading speed as a measure of RD and the longer follow-up period may explain why the proportion of resolving RD is higher in the present study. Although typical Finnish children are fluent readers already in the spring of Grade 2, reading fluency continues to develop rapidly. Grade 2 spring is an interesting assessment time because at this point in Finnish schools a pedagogical shift occurs: starting from Grade 3 the emphasis on learning to read changes into learning by reading and children are expected to read more and the demands for reading speed increase. It seems that for some children, however, the development of reading fluency takes longer but that they can catch up later on.

The process of identifying these groups raises a number of questions: Can these groups of children be identified early on? What intrinsic or extrinsic factors can help children to overcome reading impairments? What factors cause them to succumb to reading impairments later on? The examination of the cognitive differences between the groups showed, in line with the body of literature on early cognitive precursors of dyslexia (e.g., Puolakanaho et al., 2007; Snowling et al., 2003; van Bergen et al., 2014b), the close link of rapid naming, letter knowledge, and phonological awareness to RD. The findings for verbal short-term memory and vocabulary were not as consistent, because all RD groups showed moderate difficulty in verbal short-term memory tasks and only the resolving group had clear early vocabulary difficulties. The cognitive difficulties were limited to skills closely linked to reading. There were indeed no group differences in IQ.

The persistent-dyslexia group had early and persisting deficits across the cognitive foundations of reading, as expected. Their performance in early phonological awareness and expressive vocabulary, however, was not significantly poorer than in the typically reading group. This result, which contradicts previous studies (Catts et al., 2012; Lipka et al., 2006) on the stability of RD, can be explained by differences in the orthography and in the RD classification criteria. The role of phonological awareness in transparent orthographies has been shown to be limited to the very beginning of reading acquisition and particularly to reading accuracy (e.g. de Jong & van der Leij, 2002; Landerl & Wimmer, 2008).The present study adopted RD criteria that uses reading fluency measures because the reading accuracy approaches a ceiling even with nonword reading measures in Grade 2. The studies conducted in English, however, used mainly reading accuracy measures (e.g., Lipka et al., 2006) or reading accuracy and comprehension measures (e.g., Etmanski et al., in press) in their RD criteria.

The late-emerging group differed significantly from the no-dyslexia group especially in rapid naming prior to and after school entry. This finding was expected because rapid naming has been shown to be a strong predictor of reading speed measures (e.g., Puolakanaho et al., 2007; van Bergen et al., 2014a). The skills of the late-emerging group seemed to be sufficient for the early grades, but not for reaching the typical level of fluency in reading in later grades. This finding is in accordance with the idea that the major bottleneck in reading development in Finnish is in reading speed and rapid naming whereas in the case of English the development of reading accuracy may also be problematic and is linked to phonological skills. Some of the previous studies on dyslexia stability in English (e.g. Catts et al., 2012; Etmanskie et al., in press) included in their assessment reading comprehension. For comparison, we additionally looked at reading comprehension in the late-emerging group in Grades 2, 3, and 9. Their comprehension skills were age appropriate, which is in line with previous findings (e.g. Torppa et al., 2007) that in Finnish it is possible to obtain adequate reading comprehension, despite slow reading.

The resolving group showed difficulties in phonological awareness, letter identification, rapid naming, and vocabulary prior to school entry. Surprisingly, the resolving group had the lowest level of expressive vocabulary. By school age, however, the cognitive differences between the resolving and no-dyslexia groups had disappeared, suggesting that these children suffered from a developmental delay rather than from permanent cognitive deficits. Another explanation for the fast catch-up of the resolving group may be that school entry meant a clear improvement in the environmental support for reading-related skills. Although our measures of parental education and the reported amount of shared reading did not show significant group differences, more sensitive measures of the home environment might have done so.

Comparisons between the groups in terms of parental skills also revealed interesting differences. First, as expected, children with a familial risk for dyslexia were overrepresented in the dyslexia groups. Second, parental skills were different in the groups. Interestingly, the parents of the late-emerging and persistent group had slower naming rates than the parents of the other groups, a result which matches the findings at the child level. This finding suggests that the late-emerging and persistent group had stronger vulnerability for developing difficulties in rapid naming and reading fluency. These findings support previous studies that show that parental rapid naming is predictive of their offspring's naming and reading fluency (Torppa et al., 2011; van Bergen et al., 2014b). It thus supports the notion that parental skills are informative of their offspring's liability for dyslexia (van Bergen et al., 2014b).

Finally, the gender difference between the late-emerging (22% girls) and resolving (80% girls) groups was striking. This finding is in line with the evidence that girls outperform boys in reading in upper grades (OECD, 2010a, b) and that fewer girls have reading disabilities (Rutter et al., 2004). In the present data, in Grade 2 dyslexia was as prevalent among boys and as it was among girls, whereas in grade 8, 65% of the dyslexic adolescents were male. One explanation is that girls are more motivated to do schoolwork (Li & Lerner, 2011) and to read. Our related finding of no group differences in the amount of book reading, however, does not support the link between book reading and skill development. However, a more comprehensive measurement of print exposure, also including digital reading and school engagement, might show different results.

It has been proposed that in the diagnosis of specific learning disabilities (DSM-5) (see Tannock, 2013), diagnostic criteria should include the early onset of symptoms of the disability. The late-emerging group is interesting in relation to this proposal, because they do not meet this criterion. As a result, they did not fulfill the proposed dyslexia criteria, despite the observation that their group mean in Grade 8 reading fluency was two standard deviations below those of the unaffected adolescents. Tannock (2013) states that the symptoms "may not become fully manifest until the learning demands exceed the individual's limited capacities" (p.19). Based on the current findings, the early symptoms of the late-emerging group are mild and may not be evident in the early grades, even if reading is assessed more than once (e.g., in Grades 2 and 3). However, slow naming speed in children and their parents seems to be a warning sign that reading speed may develop slower later on.

There are certain limitations in this work that need to be considered. First, it should be noted that our findings call for replication, because the late-emerging and resolving groups were rather small. Second, because the data came from a family risk study (see Lyytinen et al., 2008), it includes a higher prevalence of dyslexia than expected in the general population. It is therefore not suited for estimating the prevalence of persistent, resolving, and late-emerging dyslexia in population. Third, the instability of the RD definition is partially attributable to the use of a categorical approach (see Francis et al., 2005). However, our simulations showed that only 5.6% of the changes are due to random changes across cut-off criterion due to unreliability of the measures. It should be noted that the clinical question regarding the stability of dyslexia status supports the use of a categorical approach. Additionally, adopting such an approach allowed comparisons with previous investigations. It should also be noted that there are different ways of defining categories. The low achievement approach we used seems to be one of the most stable and reliable ones, although the reliability of the diagnostic tests used is also critical (Brown Waesche, Schatshneider, Maner, Ahmed, & Wagner, 2011). Our reading fluency tests showed high reliability and the group differences were also validated with external reading speed measures.

In conclusion, even in a language environment where children read very accurately after two years of reading instruction, we found that reading status was not yet stable at this age. This raises several clinical implications. First, it is important to continue following children's literacy development beyond the early grades. Second, support needs to be provided not only for those who receive an early diagnosis, but also for those who begin lagging behind later in their development. Only continuous follow-ups can detect children who fall behind later on. If an official diagnosis is needed to access extra support, which is the case in several countries, children with late-emerging dyslexia will be deprived of the intervention and adaptations they need.

ACKNOWLEDGEMENTS

This research has been supported by several funding agencies over the years. The current funding comes from the Academy of Finland (projects #264264 and #276239). Elsje van Bergen's work was supported by a Rubicon Fellowship (446-12-005) from the Netherlands Organisation for Scientific Research (NWO) and a Junior Research Fellowship at Oriel College, Oxford. There are no conflicts of interest regarding this work. Funding sources have had no role in the collection, analysis, and interpretation of data; in the writing of the report or in the decision to submit the paper for publication. We want to express our gratitude to all the families, children, teachers, schools, and researchers who have participated in this study. Many thanks also to Professor Asko Tolvanen for statistical assistance and Matthew Wuethrich for the language proofing of this manuscript.

REFERENCES

Aro, M., & Wimmer, H. (2003). Learning to read: English in comparison to six more regular orthographies. *Applied Psycholinguistics, 24*, 621-635. doi: 10.1017.S0142716403000316

Brown Waechse, J.S., Schatshneider, C., Maner, J.K., Ahmed, Y., & Wagner, R.K. (2011). Examining agreement and longitudinal stability among traditional and response-to-intervention-based definitions of reading disability using the affected-status agreement statistic. *Journal of Learning Disabilities* , *44*, 296-307. doi: 10.1177/0022219410392048

Catts, H. W., Compton, D., Tomblin, J. B., & Bridges, M. S. (2012). Prevalence and nature of late-emerging poor readers. *Journal of Educational Psychology, 105*, 166-181. doi: 10.1037/a0025323

Compton, D. L., Fuchs, D., Fuchs, L. S., Elleman, A. M., & Gilbert, J. K. (2008). Tracking children who fly below the radar: latent transition modeling of students with late-emerging reading disability. *Learning and Individual Differences, 18*, 329 –337. doi:10.1016/j.lindif.2008 .04.003

de Jong, P. F., & van der Leij, A. (2002). Effects of phonological abilities and linguistic comprehension on the development of reading. *Scientific Studies of Reading, 6*, 51–77. doi: 10.1207/S1532799XSSR0601_03

de Jong, P.F., & van der Leij, A. (2003). Developmental changes in the manifestation of a phonological deficit in dyslexic children learning to read a regular orthography. *Journal of Educational Psychology, 95,* 22-40. doi: 10.1037/0022-0663.95.1.22

Denckla, M. B., & Rudel, R. G. (1974). Rapid “automatized” naming of pictured objects, colors, letters and numbers by normal children. *Cortex*, *10*, 471-479.

Eklund, K., Torppa, M., Aro, M., Leppänen, P.H., & Lyytinen, H. (2015). Literacy skill development of children with familial risk for dyslexia through grades 2, 3, and 8. *Journal of Educational psychology,107,* 126-140. doi: 10.1037/a0037121.

Etmanskie, J.M., Partanen, M., & Siegel, L. (in press). A longitudinal examination of the persistence of late emerging reading disabilities. *Journal of Learning Disabilities. doi:* 10.1177/0022219414522706

Francis, D. J., Fletcher, J. M., Stuebing, K. K., Lyon, G. R., Shaywitz, B. A., and Shaywitz, S. E. (2005). Psychometric approaches to the identification of LD: IQ and achievement scores are not sufficient. *Journal of Learning Disabilities 38*, 98–108. doi: 10.1177/00222194050380020101

Georgiou, G., Parrila, R., & Papadopoulos, T. C. (2008). Predictors of word decoding and reading fluency in English and Greek: a cross-linguistic comparison. *Journal of Educational Psychology*, 100, 566–580. doi: 10.1037/0022-0663.100.3.566

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

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

Laakso, M.L., Poikkeus, A.M., Eklund, K., & Lyytinen, P. (2004). Children's interest in early shared reading and it's relation to later language and letter knowledge in children with and without genetic risk for dyslexia. *First Language, 24,* 323-345. doi:10.1177/0142723704046041.

Laine, M., Goodglass, H., Niemi, J., Koivuselkä-Sallinen, P., Tuomainen, J. & Marttila, R. (1993). Adaptation of the Boston Diagnostic Aphasia Examination and the Boston Naming Test into Finnish. *Scandinavian Journal of Logopedics & Phoniatrics, 18,* 83–92. doi:10.3109/14015439309101353

Laine, M., Koivuselkä-Sallinen, P., Hänninen, R. & Niemi, J. (1997). *Bostonin nimentätesti*.[Finnish translation of the Boston Naming Test] Helsinki: Psykologien Kustannus Oy.

Lervåg, A., & Hulme, C. (2009). Rapid naming (RAN) taps a basic constraint on the development of early reading fluency. *Psychological Science, 20, 1040-1048.* doi: 10.1111/j.1467-9280.2009.02405.x

Landerl, K., Ramus, F., Moll, K., Lyytinen, H., Leppänen, P. H. T., Lohvansuu, K., … Schulte-Körne, G. (2012). Predictors of developmental dyslexia in European orthographies with varying complexity. *Journal of Child Psychology and Psychiatry, 54*, 686-694. doi: 10.1111/jcpp.12029

Landerl, K. & Wimmer, H. (2008). Development of word reading fluency and spelling in a consistent orthography: an 8-year follow-up. *Journal of Educational Psychology, 100*, 150-161. doi:10.1037/0022-0663.100.1.150

Landerl, K., Wimmer, H., & Frith, U. (1997). The impact of orthographic consistency on dyslexia: a German-English comparison. *Cognition, 63*, 315-334. doi: 10.1016/S0010-0277(97)00005-X

Leach, J. M., Scarborough, H. S., & Rescorla, L. (2003). Late-emerging reading disabilities. *Journal of Educational Psychology, 95,* 211–224. doi:10.1037/0022-0663.95.2.211.

Leinonen, S., Müller, K., Leppänen, P. H. T., Aro, M., Ahonen, T., & Lyytinen, H. (2001). Heterogeneity in adult dyslexic readers: relating processing skills to the speed and accuracy of oral text reading. *Reading and Writing: An Interdisciplinary Journal, 14*, 265-296.doi: 10.1023/A:1011117620895

Li, Y. & Lerner, R. M. (2011). Trajectories of school engagement during adolescence: Implications for grades, depression, delinquency, and substance use. *Developmental Psychology*, *47*, 233-247. doi:10.1037/a0021307

Lipka, O., Lesaux, N., & Siegel, L. (2006). Retrospective analyses of the reading development of Grade 4 students with reading disabilities: risk status and profiles over 5 years. *Journal of Learning Disabilities, 39*, 364–378. doi:10.1177/00222194060390040901

Lyytinen, H., Erskine, J., Ahonen, T., Aro, M., Eklund, K., Guttorm, T., … Viholainen, H. (2008). Early identification and prevention of dyslexia: Results from a prospective follow-up study of children at familial risk for dyslexia. In G. Reid, F. Manis, & L. Siegel (Eds.), *The Sage handbook of dyslexia* (pp. 121–146). Thousand Oaks, CA: Sage.

Marinus, E. & de Jong,P.F. (2010). Variability in the word reading performance of dyslexics: effects of word length and digraph presence. *Cortex, 46*, 1259-1271. doi:10.1016/j.cortex.2010.06.005

OECD (2010a). *PISA 2009 Results: What Students Know and Can Do: Student Performance in Reading, Mathematics and Science (Volume I),* PISA, OECD Publishing. doi:10.1787/9789264091450-en

OECD (2010b). *PISA 2009 Results: Learning to Learn – Student Engagement, Strategies and Practices (Volume III),* PISA, OECD Publishing. doi:10.1787/9789264083943-en

Parrila, R., Aunola, K., Leskinen, E., Nurmi, J.-E., & Kirby, J. R. (2005). Development of individual differences in reading: results from longitudinal studies in English and Finnish. *Journal of Educational Psychology, 97*, 299-319. doi:10.1037/0022-0663.97.3.299

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P.H.T., Poikkeus, A.-M., Tolvanen, A., Torppa, M., & Lyytinen, H. (2007). Very early phonological and language skills: estimating individual risk of reading disability. *Journal of Child Psychology and Psychiatry, 48*, 923-931. doi: 10.1111/j.1469-7610.2007.01763.x

Reynolds, C. R. & Kamphaus, R. W. (1992). *BASC. Behavior Assessment System for Children. Manual.* Circle Pines, MN: American Guidance Services, Inc.

Rutter, M., Caspi, A., Fergusson, D., Horwood, L. J., Goodman, R., Maughan, B., Moffitt, T. E., Meltzer, H., & Carroll, J. (2004). Sex differences in developmental reading disability: new findings from 4 epidemiological studies. *Journal of American Medical Association*, *291*, 2007-2012. doi:10.1001/jama.291.16.2007

Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94,* 143–174.

Snowling, M. J. & Hulme, C. (2013). Children's reading impairments: from theory to practice. *Japanese Psychological Research*, *55*, 186-202. doi:10.1111/j.1468-5884.2012.00541.x

Snowling, M. J., Gallagher, A., & Frith, U. (2003). Family risk of dyslexia is continuous: individual differences in the precursors of reading skills. *Child Development*, *74*, 358-373. doi: 10.1111/1467-8624.7402003

Tannock, R. (2013). Rethinking ADHD and LD in DSM-5: Proposed changes in diagnostic criteria. *Journal of Learning Disabilities*, *46*, 5-25. doi:10.1177/0022219412464341

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

Torppa, M., Georgiou, G. K., Salmi, P., Eklund, K., & Lyytinen, H. (2012). Examining the double-deficit hypothesis in an orthographically consistent language. *Scientific Studies of Reading*, *16*, 287–315. doi:10.1080/10888438.2011.554470

Torppa, M., Tolvanen, A., Poikkeus, A.-M. Eklund, K., Lerkkanen, M.-K., Leskinen, E., & Lyytinen, H. (2007). Reading development subtypes and their early characteristics. *Annals of Dyslexia*, *57*, 3-52. doi: 10.1007/s11881-007-0003-0 van Bergen, E., de Jong, P.F., Maassen, B., & van der Leij, A. (2014a). The effect of parents' literacy skills and children's preliteracy skills on the risk of dyslexia. *Journal of Abnormal Child Psychology, 42*, 1187-1200. doi: 10.1007/s10802-014-9858-9

van Bergen, E., de Jong, P. F., Plakas, A., Maassen, B., & van der Leij, A. (2012). Child and parental literacy levels within families with a history of dyslexia. *Journal of Child Psychology and Psychiatry, 53,* 28-36. doi:10.1111/j.1469-7610.2011.02418.x

van Bergen, E., van der Leij, A, & de Jong, P.F. (2014b). The intergenerational multiple deficit model and the case of dyslexia. *Frontiers in Human Neuroscience, 8*, 346. doi: 10.3389/fnhum.2014.00346

Wechsler, D. (1991). *Wechsler Intelligence Scales for Children* (3rd ed.). Sidcup, United Kingdom: The Psychological Corporation.

Zoccolotti, P., De Luca, M., Di Pace, E., Gasperini, F., Judica, A., & Spinelli, D. (2005). Word length effect in early reading and in developmental dyslexia. *Brain and Language, 93,* 369-373. doi:10.1016/j.bandl.2004.10.010

Table 1. Characteristics of Parents and Children in the Four Groups.

	No-dyslexia		Late-emerging		Resolving		Persistent	
	n = 127		*n* = 18		*n* = 15		*n* = 22	
	M	SD	M	SD	M	SD	M	SD
Mother	4.52	1.38	4.59	1.70	3.92	1.24	4.12	1.50
Father	3.72	1.42	4.06	1.71	3.64	.81	3.75	1.39
Children								
IQ	100.74	10.93	100.83	6.04	97.47	9.10	95.00	10.37
Family risk	44.9%		83.3%		73.3%		81.8%	
Girls	49.6%		22.2%		80.0%		45.5%	

Note.

[a)] Parental education was classified using a 7-point scale (see Laakso, Poikkeus, Eklund, and Lyytinen, 2004).

Table 2. Descriptive Statistics and Group Comparisons in Reading Speed.

	No-dyslexia		Late-emerging		Resolving		Persistent			
	M	SD	M	SD	M	SD	M	SD	F	df
Reading speed, individual assessment[a]										
Grade 2	6.09^{1}	1.70	4.14^{2}	.92	2.84^{3}	.58	2.33^{3}	.68	58.27***	3,174
Grade 3	6.66^{1}	1.65	4.80^{2}	.67	4.56^{2}	.94	3.33^{3}	.91	41.82***	3,178
Grade 8	9.56^{1}	1.52	6.44^{3}	.47	8.43^{2}	1.17	5.67^{3}	1.19	67.25***	3,178
Reading speed, group assessment[b]										
Grade 2	$.20^{1}$	.80	$-.31^{2}$	.56	$-.94^{3}$	.43	-1.38^{3}	.61	32.99***	3,161
Grade 3	$.48^{1}$	1.05	$-.19^{2}$	.44	$-.65^{2,3}$	.64	-1.21^{3}	.62	23.94***	3,171
Grade 7	$.30^{1}$	.90	$-.87^{2}$	.49	$-.56^{2}$	.66	-1.44^{3}	.60	30.87***	3,144

[a)] Reading speed, individual assessment = Arithmetic mean of the number of read letters/second in Word list, Text and Pseudoword text reading.

[b)] Reading speed, group assessment = Z-score value in Wordchain task calculated with the mean and standard deviation values of the classmates (N=1537, 2757 and 1693 at Grade 2, 3, and 7, respectively).

Note. Groups with different superscripts (^{1,2,3}) differed from each other in post hoc pairwise comparisons where Dunnett T3 corrections were used (because the variances were not equal).

*** $p \leq .001$

Table 3. Descriptive Statistics and RD Group Comparisons in Language, Cognitive Skills and Print Exposure.

	No-dyslexia		Late-emerging		Resolving		Persistent			
	M	SD	M	SD	M	SD	M	SD	F	df
Vocabulary										
3.5 years	19.46^{1}	5.99	18.72^{1,2}	7.00	14.93^{2}	5.16	17.60^{1,2}	4.83	2.93*	3,179
5.0 years	35.16^{1}	6.21	33.33^{1,2}	7.72	30.40^{2}	7.57	34.15^{1,2}	4.55	2.77*	3,174
Grade 2	10.36	2.87	10.72	2.58	10.20	2.34	9.55	2.13	0.66	3,176
Verbal short-term memory										
6.5 years	5.50^{1}	1.27	5.56^{1,2}	1.20	4.60^{1,2}	1.12	4.67^{2}	1.68	4.32**	3,177
Grade 2	6.44^{1}	1.11	5.94^{1,2}	.72	5.73^{1,2}	.96	5.73^{2}	1.08	4.79**	3, 175
Grade 3	7.71^{1}	1.31	6.61^{2}	1.14	6.73^{1,2}	1.58	6.73^{2}	1.72	7.13***	3,177
Grade 8	7.95^{1}	1.58	7.28^{1,2}	1.27	6.93^{1,2}	1.44	6.76^{2}	1.51	5.42**	3,177
Phonological awareness										
4.5 years^{z}	-.02	.80	-.51	.74	-.52	.94	-.46	.47	4.59**	3,179
5.5 years^{z}	-.15	.79	-.42	.63	-.60	.78	-.46	1.07	2.26	3,180
6.5 years^{z}	-.01^{1}	.91	-.59^{1,2}	.97	-.82^{2}	.94	-.70^{2}	.80	7.49***	3,177
Grade 3	9.54^{1}	3.43	7.28^{1,2,3}	3.75	9.79^{1,2}	3.26	5.73^{3}	3.33	9.11***	3,177
Grade 8	10.20^{1}	3.43	8.61^{1,2}	3.15	9.07^{1,2}	2.55	5.95^{3}	3.53	10.56***	3,178

Rapid naming										
5.5 years	42.41[1]	10.35	55.46[2]	20.83	54.50[2]	20.64	53.10[2]	17.62	9.47***	3,178
6.5 years	68.86[1]	18.55	85.19[2]	25.83	83.78[1,2]	14.39	87.19[2]	32.07	8.01***	3,176
Grade 3	46.34[1]	6.94	51.65[2]	7.47	48.79[1,2]	7.77	54.72[2]	11.66	8.81***	3,177
Grade 8	36.56[1]	5.37	41.12[2]	6.45	37.76[1,2]	4.07	41.09[2]	4.84	7.35***	3,178
Letter knowledge										
4.5 years	9.30[1]	7.83	5.22[1,2]	6.22	3.53[2]	4.19	3.95[2]	4.44	6.35**	3,178
5.5 years	15.04[1]	7.12	11.12[1,2]	8.35	7.73[2]	6.58	6.85[2]	5.81	11.71***	3,178
6.5 years	18.28[1]	7.74	14.11[1,2]	7.58	9.73[2]	6.40	10.55[2]	5.39	11.49***	3,176
Amount of book reading										
4.0 years	9.49	2.31	10.31	2.70	8.86	1.46	9.88	1.76	1.21	3,167
5.0 years	9.41	1.99	9.38	2.53	8.71	2.27	9.47	2.21	.49	3,167
6.0 years	9.42	2.61	10.34	2.73	8.97	2.61	9.31	1.78	1.07	3,167
Grade 2	1.97	.65	1.96	.54	1.82	.58	1.91	.42	.27	3,155
Grade 3	2.23	.61	2.00	.45	1.77	.68	1.97	.50	3.66*	3,157
Grade 7	2.89	1.02	2.70	.85	3.04	1.16	2.72	.78	.44	3,149

Note. Groups with different superscripts ([1,2,3]) differed from each other in post-hoc pairwise comparisons, with either Bonferroni or Dunnett T3 corrections, depending on equality of the variances. z =a composite mean of standardized scores

* $p \le .05$, ** $p \le .01$, *** $p \le .001$

Table 4

Descriptive Statistics and RD Group comparisons of Parental Measures

	Not at-risk No-dyslexia		At-risk No-dyslexia		At-risk Late-emerging		At-risk Resolving		At-risk Persistent			
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*df*
Text-reading fluency (s.)	29.62^{1}	2.70	40.55^{2}	10.13	42.70^{2}	8.29	39.61^{2}	9.15	40.85^{2}	7.56	31.65***	4,181
Phoneme deletion	11.43^{1}	.99	9.21^{2}	2.10	8.70^{2}	2.26	9.44^{2}	1.67	8.73^{2}	2.37	10.57***	4,117
Rapid naming(s.)	39.16^{1}	8.46	$43.32^{1,2}$	8.15	53.44^{3}	8.80	$41.36^{1,2}$	5.63	$49.28^{2,3}$	9.58	7.58***	4,118
Verbal STM	14.73^{1}	3.68	11.57^{2}	2.55	10.80^{2}	1.87	$12.78^{1,2}$	3.07	10.37^{2}	3.66	7.41***	4,116
Vocabulary	54.24	5.63	49.72	7.52	49.90	9.51	50.22	8.41	48.91	6.73	2.57*	4,117

Note. Groups with different superscripts differed from each other in post-hoc pairwise comparisons, with either Bonferroni or Dunnett T3 corrections, depending on equality of the variances. Note. In reading fluency there were larger *n*s: in Control No-dyslexia n=70 in At-risk No -dyslexia n= 56, in Late-emerging n=15, for the resolving n=11, and for the Persistent n=18. For the parental cognitive measures *n*s were: in Control No-dyslexia n=37 in At-risk No -dyslexia n= 43, in Late-emerging n=10, for the resolving n=10, and for the Persistent n=11.

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

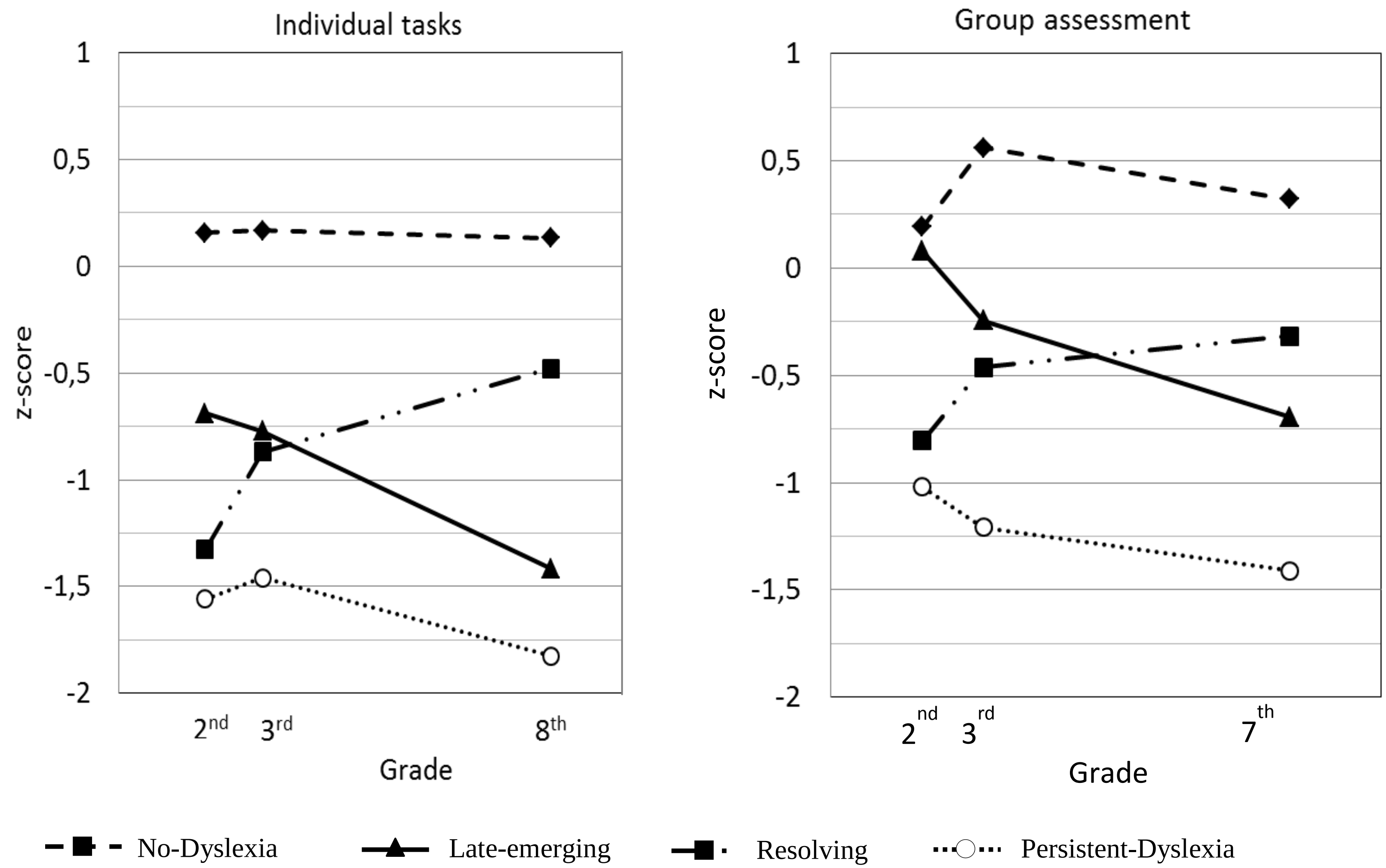
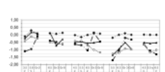


Figure 1. Development of Reading Speed of the RD Groups in Individually Administered and Group Tasks.



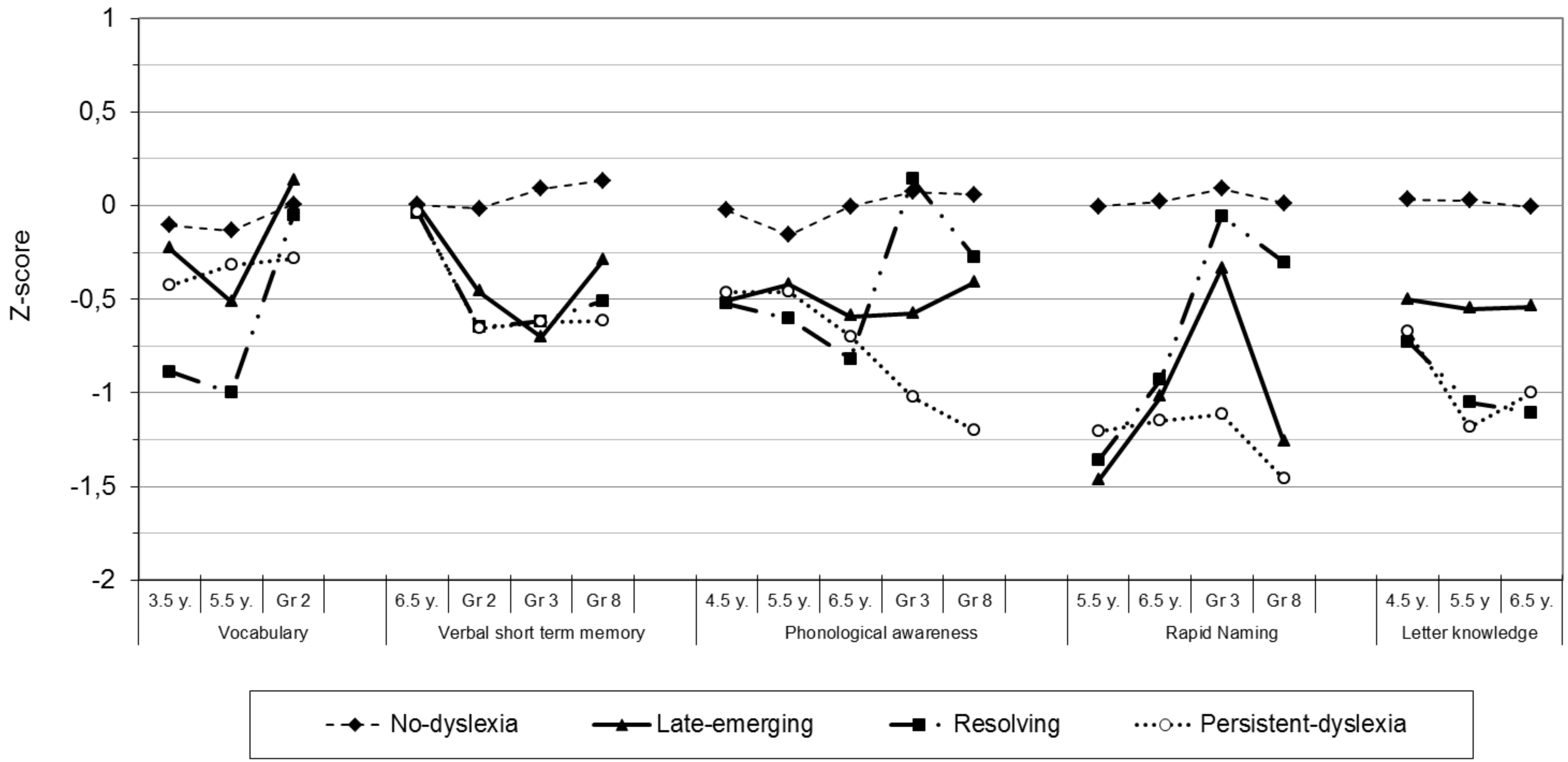


Figure 2. Development of Language and Cognitive Skills in the RD Groups

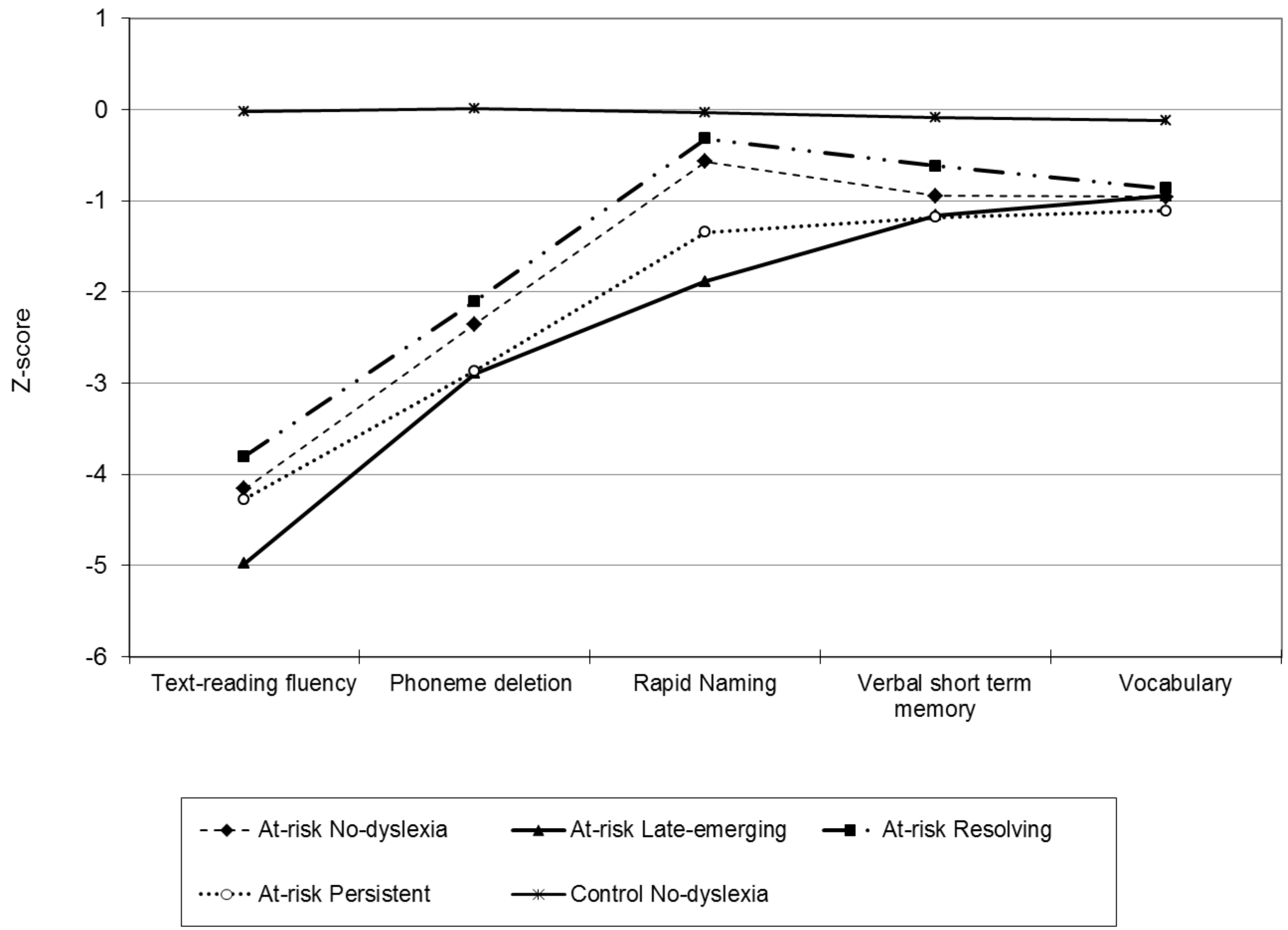


Figure 3. Parental Skills by Risk group and RD Group.

IV

EARLY COGNITIVE PREDICTORS OF PISA READING IN CHILDREN WITH AND WITHOUT FAMILY RISK FOR DYSLEXIA

by

Kenneth Eklund, Minna Torppa, Sari Sulkunen, Pekka Niemi, & Timo Ahonen, 2016

Submitted manuscript

Early Cognitive Predictors of PISA Reading in Children with and without Family Risk for Dyslexia

Kenneth Eklund[a], Minna Torppa[b], Sari Sulkunen[c], Pekka Niemi[d], and Timo Ahonen[a]

[a] Department of Psychology, University of Jyväskylä, Finland

[b] Department of Teacher Education, University of Jyväskylä, Finland

[c] Department of Languages, University of Jyväskylä, Finland

[d] Department of Psychology, University of Turku, Finland

ABSTRACT

This study examines family risk for dyslexia, gender, early cognitive skills, and school age reading fluency as predictors of PISA reading. Children (n = 158) were followed from age 2 to 15. Prediction of PISA reading was examined separately in four groups formed according to family risk status (familial incidence of dyslexia vs. not) and gender. Among High-risk boys (n = 42), age 3.5 years Language skills, Phonological awareness, and Letter knowledge explained 73% of PISA reading, whereas among Low-risk boys (n = 40) none of the 3.5 years cognitive predictors was significant. Among High-risk (n = 46) and Low-risk girls (n = 30) Language skills was the only significant cognitive predictor, explaining 36% and 32%, respectively. Reading fluency was associated with PISA reading in all groups, but predicted it above the cognitive predictors only among High-risk girls. Findings warrant further research on family risk and gender as possible moderators of associations between early cognitive predictors and PISA reading.

Keywords: PISA reading literacy, family risk for dyslexia, cognitive predictor, development, longitudinal study

1. INTRODUCTION

It is well documented that a substantial proportion, 34%–66%, of children with a family history of dyslexia have severe difficulties in reading and spelling acquisition during their first grades at school (Pennington & Lefly, 2001; Puolakanaho et al., 2007; Scarborough, 1990; Snowling, Callagher, & Frith, 2003), and for most individuals these difficulties sustain into adolescence even in transparent orthographies (Eklund, Torppa, Aro, Leppänen, & Lyytinen, 2015; Landerl & Wimmer, 2008; Torppa, Eklund, van Bergen, & Lyytinen, 2015). In our prior report from the Jyväskylä Longitudinal Study of Dyslexia (JLD), concerning reading development subtypes, we found not only that children with a family history of dyslexia were overrepresented in the subgroup of slow decoders, but also that twice as many children with family risk for dyslexia compared to control children, 17.3% vs. 9.2%, were in the group of poor readers, with poor performance in both word recognition and reading comprehension in Grade 2 (Torppa et al., 2007). In the present study, we extended our investigation to include Grade 9 (age 15) and broadened our reading outcome from reading fluency and reading comprehension to PISA reading literacy. We examined to what extent children's performance in PISA reading could be predicted by family risk for dyslexia, gender, development of early language, phonological awareness, verbal short term memory, rapid naming, and letter knowledge before school age, as well as by development of reading fluency at school age.

1.1. PISA Reading Literacy

The OECD Program for International Student Assessment (PISA), conducted once every three years from the year 2000, was to "set up to measure how well young adults near the end of compulsory schooling are prepared to meet the challenges of today's knowledge societies" (OECD, 2002, p. 3). Reading is one of the three target areas assessed in PISA, the other two being mathematics and science. In reading, PISA intends to assess skills which go beyond decoding and reading comprehension, i.e. reading literacy, that involve "an individual's capacity to: understand, use, reflect on and engage with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society" (OECD, 2009, p. 14). In other words, decoding and reading comprehension are seen as basic skills that enable readers to employ reading as a tool for the acquisition of new information, although, to make full use of printed material, other skills are needed as well. The skills claimed to be required for success in PISA reading literacy tasks include decoding, knowledge of words, grammar and other linguistic skills, textual structures and features, and metacognitive knowledge (OECD, 2009). To assess these skills, several texts which challenge students' ability to find, select, interpret and evaluate information are included in the PISA reading tasks (OECD, 2009).

Research on cognitive prerequisites, not to mention predictors, related to PISA reading literacy is limited. This is understandable as "improving the quality of education" (OECD, 2002, p.12) has been the major policy initiative in the Organization for Economic Co-operation and Development (OECD), not the origin of students literacy skills per se. According to a recent study by Arnbak (2012), concurrently measured word recognition and vocabulary, the basic building blocks for reading comprehension according to the lexical quality hypothesis (Perfetti & Hart, 2001), together explained about 40% of PISA reading scores. Likewise, Artelt, Schiefele, and Schneider (2001) showed that concurrently measured decoding speed explained about 13% of the variance in PISA reading literacy.

1.2. Cognitive Predictors of Reading Comprehension

Efficient decoding has generally been seen as necessary for reading comprehension – one has to decipher letter strings, first in words and ultimately in sentences and texts, to be able to understand their meaning. Well automatized word reading skills free up resources for higher-level processing (Perfetti, 1985), supporting reading comprehension. Empirical findings have revealed a strong link between fluent word reading skills and reading comprehension (for a recent meta-analysis of factors affecting the strength of this relationship, see García & Cain, 2014). The link is particularly strong in the early grades, after which its role is diminished, particularly in transparent orthographies (for a meta-analysis in different orthographies, see Florit & Cain, 2011), although not ceasing to exist (Artelt et al., 2001; Verhoeven & van Leeuwe, 2008). On the other hand, according to the Simple View of Reading (Gough & Tunmer, 1986), reading comprehension is the product of two separate, although closely related skills, decoding and language comprehension, meaning that a subgroup of poor comprehenders without difficulties in decoding also exists. Accordingly, several studies have shown that at least average text comprehension is possible also for struggling readers (Catts, Adlof, & Weismer, 2006; Nation, Clarke, Marshall, & Durand, 2004; Torppa et al., 2007).

A large, high quality lexicon, in addition to word decoding, is the cornerstone of comprehension according to the lexical quality hypothesis (Perfetti & Hart, 2001), and numerous studies have shown a strong link between vocabulary and reading comprehension (e.g. Muter, Hulme, Snowling, & Stevenson, 2004; Nation & Snowling, 2004; Torppa et al., 2007; Verhoeven & van Leeuwe, 2008). Vocabulary has been reported to account for the variability of subsequent reading comprehension even after taking into account the effect of word reading (e.g. Olson et al., 2011). Besides vocabulary, linguistic processes involved in the comprehension of oral language, such as parsing sentences, drawing interferences, and integration of information (Hoover & Gough, 1990; Verhoeven & Leeuwe, 2008), as well as semantic knowledge, syntactic knowledge, and background knowledge have been shown to be tightly connected to reading comprehension (for a review on low-progress readers, see Tan, Wheldall, Madelaine, & Lee, 2007).

1.3. Effects of Family Risk for Dyslexia

Children with family risk for dyslexia are at elevated risk for performing poorly in word reading and possibly also in PISA reading literacy. These children comprise two different groups: those who go on to fulfill the criteria for dyslexia at school age and those who are defined as normal readers despite their family risk. Children with dyslexia have, by definition, poor word reading skills: "Dyslexia is a specific learning disability… characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities" (Lyon, Shaywitz, & Shaywitz, 2003, p. 2). They have also been shown to be capable of sight word reading or processing large chunks of graphemes later in their development than their age-mates (Eklund et al., 2015; Zoccolotti et al., 2005). Therefore, owing to their compromised word reading skills, they probably have less free capacity for reading comprehension. In addition, children with dyslexia are likely to read less, which in turn is expected to affect the growth of their vocabulary and also their background knowledge (Lyon et al., 2003). Finally, following the idea of the generalist genes hypothesis (same genes which are largely behind learning abilities and disabilities are also behind cognitive abilities and disabilities, including language skills) (Kovacs & Plomin, 2007; Plomin & Kovacs, 2005), children with dyslexia are expected to show signs of compromised development in the various cognitive skills needed to achieve adequate skills, not only in word reading, but also in reading literacy. Empirical findings have confirmed that children with dyslexia have compromised skills in phonological awareness, rapid automatized naming, and letter knowledge (e.g. Boets et al., 2010; Snowling et al., 2003, Snowling, Muter, & Carroll, 2007; Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010; van Bergen et al., 2010; van Bergen, de Jong, Plakas, Maassen, van der Leij, 2012). They have also been shown to have deficient skills in early receptive and expressive vocabulary (e.g. Snowling et al., 2007; Torppa et al., 2010) and verbal short term memory (Boets et al., 2010; Pennington & Lefly, 2001) already before school age, potentially further hindering their reading comprehension skills. In fact, English-speaking family-risk children with dyslexia have been shown to have lower reading comprehension skills than their age-mates at 12-13 years of age (Snowling et al., 2007).

However, it is not only the family risk children with dyslexia who are in risk of compromised reading literacy skills. According to the idea of multiple risk factors and a continuous vulnerability risk distribution, the non-dyslexic offspring of parents with dyslexia are also expected to inherit some of the risk factors from their parents (Pennington, 2006; Pennington et al., 2012; Snowling et al., 2003). Children with family risk who do not fulfill the criteria of dyslexia have usually been shown to perform between the level of controls and children with dyslexia in several pre-literacy and literacy skills both prior to and after school entry (e.g. Pennington & Lefly, 2001; Snowling et al., 2003; van Bergen et al., 2010, 2012), although these differences have not always been statistically significant (Boets et al., 2010; Eklund et al., 2015, Torppa et al., 2010). According to a recent meta-analysis and review by Snowling and Melby-Lervåg (2016), both the children with family risk for dyslexia who did and did not develop reading problems showed significant difficulties not only in the prerequisites of word identification skills but also in broader language skills (i.e. vocabulary knowledge and grammar) before school age, which, however, they had tended to overcome by the time of formal schooling. Whether this catching-up leads to age-appropriate reading comprehension or literacy skills remains an open question. Thus far, only one study has shown that family-risk children without reading difficulties perform at the same level as typical readers without family risk in reading comprehension at 12-13 years of age (Snowling et al., 2007). All in all, as family risk for dyslexia seems to add variability in several prerequisites of reading ability as well as in the early language skills of children with family risk, stronger associations between these early skills and reading literacy skills could be expected for these high-risk children compared to low-risk children, i.e., those without family risk.

1.4. Effects of Gender

The strength of the relationships between early cognitive skills and reading literacy could be also affected by gender. A greater number of males with reading problems has usually been reported both in clinical and research samples (Hawke, Olson, Willcutt, Wadsworth, & DeFries, 2009; Quinn & Wagner, 2015; Rutter et al., 2004), while the ratio between males and females has been shown to increase along with the severity of reading impairment (Quinn & Wagner, 2015). However, no clear reason for such gender differences has been found in genetic etiology studies of reading difficulties (Hawke, Wadsworth, & DeFries, 2006; Hawke, Wadsworth, Olson, & DeFries, 2007). Slightly larger variability in reading performance among males has been suggested as an explanation for the higher prevalence of reading difficulties (Hawke et al., 2009), leaving, however, the origin of this larger variance unspecified. Gender differences have also been clear in PISA reading performance, where girls have outperformed boys in every OECD country in recent assessments 2009 and 2012 (OECD, 2011; OECD, 2013, see also Chiu & McBride-Chang, 2006). Moreover, glaring differences have been observed among those on the lowest reading proficiency level (OECD, 2011). Finally, a meta-analysis of reading achievement in large-scale studies between 1970 and 2002 concluded that female secondary school students outperformed their male peers by, on average, 0.19 standard deviation units in reading achievement, with the largest gender gap (effect size = 0.32) in PISA reading literacy (Lietz, 2006), the outcome measure of the present study.

1.5. The Present Study

Although various cognitive skills have been shown to predict reading accuracy, fluency, and comprehension, long-term predictions of these skills for adolescent reading literacy are unknown. PISA reading is an interesting outcome because, on the one hand, a wide range of skills besides decoding and reading comprehension are needed to perform well in it, and, on the other hand, it is set up to measure the skills that are needed to meet the challenges of today's knowledge societies (OECD, 2002).

This study addresses three questions. First, what is the effect of family risk for dyslexia and gender on PISA reading and its cognitive predictors? Second, how well is PISA reading predicted by cognitive skills at 3.5

years of age? Third, does reading fluency in school add to the explained variance of PISA reading beyond the effects of cognitive skills before school age? We compare four groups of children: (1) Boys with family risk, (2) Girls with family risk, (3) Boys without family risk, and (4) Girls without family risk, to see whether the effects are similar or different for boys and girls with and without family risk.

2. MATERIAL AND METHODS

2.1. Participants

All participants (n = 158) were Finnish-speaking and recruited as part of the Jyväskylä Longitudinal Study of Dyslexia (JLD) in which 200 children have been followed from birth (Lyytinen et al., 2008). Children were originally selected for one of two groups: with family risk for dyslexia or without it. Altogether, 159 students participated in the PISA reading assessment at Grade 9, but one participant was removed owing to a serious inflammation in his central nervous system at age three, which severely affected his language skills for two years. For this study, the children were further allocated into four groups according to their family risk status and gender: (1) High-risk boys (n = 42), (2) High-risk girls (n = 46), (3) Low-risk boys (n = 40), and (4) Low-risk girls (n = 30). Characteristics of the groups are presented in Table 1. There were no differences between the groups in parents' age or education, or in children's Grade 2 verbal and performance IQ.

2.1.1. Family Risk: Screening of Families

The children were originally selected as participants for the JLD from among 9 368 newborns in the province of Central Finland between April 1993 and July 1996. For a child to be included in the family-risk group (n = 108) one or the other of the parents had to show deficient performance in oral text reading or spelling, and in phonological and orthographic processing. In addition, a reported onset of literacy problems during the early school years and a first-degree relative with corresponding difficulties were required for inclusion in the family-risk group. In the group without family risk, neither parent (n = 92) had a reported family history of dyslexia and both had a z-score above -1.0 in all the reading and spelling tasks described above. The IQ of all parents had to be 80 or above (for full details of the recruitment process, see Leinonen et al., 2001).

2.1.2. Attrition

Altogether, 159 students from the original sample of 200 participants took part in the PISA reading assessment in Grade 9. Attrition in the high- and low-risk groups, 18.5% and 22.8%, respectively, was similar. No significant differences either in early cognitive predictors before school age or in literacy skills at school age were observed between students who attended or did not attend the PISA reading assessment.

2.2. Measures

Trained testers assessed children's skills individually in a laboratory setting at age 2.0, 3.5, 5.0, 5.5, and 6.5 years, as well as in school-classes after school entry in the year the children turned 7 in Grades 1 (Spring term), 2 (Spring), 3 (Spring), 8 (Fall), and Grade 9 (Spring). In addition, children were tested at home at age 2.5 years and parents reported on their child's language skills at ages 2.0 and 2.5. To obtain comprehensive and reliable measures, we calculated composite scores (arithmetical means) for each skill domain using z-scored values (with respect to the mean and standard deviation of the low-risk group) for all the tasks in each skill domain and at each assessment. The measures used in the calculation of the composite scores are described below (for full details of measures, see Pennala et al., 2013)

Language skills. *At 2.0–2.5 years.* A composite mean (Cronbach $\alpha = 0.91$) was calculated from eight different measures: Mastery of Inflections, Vocabulary Production, and Mean Length of Longest Utterances from the Finnish (Lyytinen, 1999) toddler version of the MacArthur Communicative Development Inventories (MCDI) (Fenson et al., 1994) at 2.0 and 2.5 years (3 + 3 measures), and the expressive and comprehension language scale scores from the Reynell Developmental Language Scales (RDLS) (Reynell & Huntley, 1987) at 2.5 years.

At 3.5 years. A composite mean (Cronbach α = 0.80) was calculated from four different measures: Peabody Picture Vocabulary Test – Revised (PPVT) (Dunn & Dunn, 1981), the subtest of Comprehension of Instructions of the Developmental Neuropsychological Assessment (NEPSY) (Korkman, Kirk, & Kemp, 1998), the Boston Naming Test (BNT) (Kaplan, Goodglass, & Weintraub, 1983), and the Mastery of Finnish Inflectional Morphology (Lyytinen et al., 2001).

At 5.0–5.5 years. A composite mean (Cronbach α = 0.83) was calculated from five different measures: the four tests administered at 3.5 years were repeated, and the vocabulary scale of the WPPSI-R (Wechsler Preschool and Primary Scale of Intelligence-R; Wechsler, 1991) was added as the fifth measure.

Verbal short term memory. *At 3.5 years.* A composite mean was calculated from two tasks (Cronbach α = 0.62): Digit Span (Gathercole & Adams, 1994), and Sentence Repetition (NEPSY, Korkman et al., 1998). *At 5.0–5.5 years.* A composite mean was calculated from three tasks (Cronbach α = 0.74): Digit Span (Gathercole & Adams, 1994) and Syllable Span (both computerized) at 5.0 years, and Sentence Repetition (NEPSY, Korkman et al., 1998) at age 5.5 years. *At 6.5 years.* Verbal short term memory was assessed with a Digit Span task (Gathercole & Adams, 1994).

Phonological awareness. *At 3.5 years.* The composite mean was derived from performance in three tasks (Cronbach α = 0.66): from two computer-based tasks, i.e. Syllable-level Segment Identification, and Word-level Segment Identification (Puolakanaho, Poikkeus, Ahonen, Tolvanen, & Lyytinen, 2003), and from the Phonological Processing: Word Segment Identification task of the Developmental Neuropsychological Assessment battery (NEPSY, Korkman et al., 1998). *At 5.5 years.* The composite mean of phonological awareness comprised five tasks (Cronbach α = .80): computer-based Initial Phoneme

Identification and Production, and Syllable-level Segment Identification (Puolakanaho et al., 2003), Word/Pseudoword Segmentation (Pennala et al., 2013), Phonological Processing: Word Segment Identification, and Word Segment Deletion (NEPSY, Korkman et al., 1998). *At 6.5 years.* The composite mean of phonological awareness comprised five tasks (Cronbach α = .84): computer-based Initial Phoneme Identification and Production, and Phoneme and Syllable-level Segment Identification (Puolakanaho et al., 2003), Word/Pseudoword Segmentation (Pennala et al., 2013), and Initial Phoneme Naming and Initial Phoneme Deletion (Poskiparta, Niemi, & Lepola, 1994).

Rapid naming. *At 3.5, 5.5 and 6.5 years.* RAN objects was presented using the standard procedure (Denckla & Rudel, 1976). The test was scored as the time taken to name 30 items at ages 3.5 and 5.5 years and 50 items at age 6.5 years.

Letter knowledge. *At 3.5 and 5.0–5.5 years.* Four sets of uppercase letters from a total of 23 different letters were presented to the child, whose task was to name each of the letters. Testing was discontinued if the child was unable to name any of the items in a given set of 6 letters. The total number of correctly named letters was used as the measure. *At 6.5 years.* We presented all 29 letters used in Finnish and asked the children to name them. (For full details of measures, see Torppa, Poikkeus, Laakso, Eklund, & Lyytinen, 2006).

IQ. *At 5.0 years.* A short-form of the WPPSI-R (Wechsler Preschool and Primary Scale of Intelligence-R; Wechsler, 1989) was administered that consisted of three verbal quotient subtests (Vocabulary, Arithmetic, and Comprehension) and three performance quotient subtests (Block Design, Object Assembly, and Picture Completion). The children's verbal and performance IQs were estimated on the basis of these subtests according to the standard guidelines given in the manual.

Reading fluency. Arithmetic means of z-scored values (with respect to the mean and standard deviation of the low-risk group) were calculated for the composite measure of reading fluency separately for each grade (Cronbach's α was .93, .88, .91, and .88, for Grades 1, 2, 3, and 8, respectively). *In Grade 1.* At the end of the spring semester, two lists of individually presented words and two lists of pseudowords (altogether 36 items), and an age-appropriate text were used to assess oral reading fluency. *In Grades 2, 3, and 8.* We used three oral reading tasks: A word list reading (standardized reading test (Lukilasse; Häyrinen, Serenius-Sirve, & Korkman, 1999), text reading, and pseudoword text reading. (For full details of the reading measures in Grade 1, see Pennala et al., 2010, and for those in Grades 2, 3 and 8, see Eklund et al., 2015).

PISA reading. *In Grade 9.* The tasks were adopted from PISA reading link items which are used repeatedly in each cycle of the survey to ensure measurement comparability (OECD, 2010a, p. 26). The test booklet contains 8 different sections, including texts, tables, graphs, and figures. Students were given 60 minutes to read and answer several questions per section. Of the questions, 15 were multiple choice and 16 required a written response. Moreover, 12 of the questions required students to access and retrieve information, 12 to integrate and interpret information, and seven to reflect on and evaluate information. A total mean score for all the PISA reading items was calculated. Cronbach's alpha for the total score in this sample was .85.

2.3. Distributions and Analyses

The normality of distributions was inspected across all participants and also separately within each group. Most of the distributions of the composite scores used in the analyses approximated the normal distribution. However, slightly skewed distributions were found for Rapid naming (age 3.5, 5.5 and 6.5 years), Letter knowledge (3.5 and 6.5 years), Reading fluency (Grade 1, 2, and 8), and PISA reading in Grade 9. In addition, a slightly skewed distribution was found for Phonological awareness (3.5 years) when the distributions were inspected separately within each group. Logarithmic transformations normalized the distributions in all measures except Letter knowledge at 3.5 years, which was subsequently recoded into three categories. In addition, one outlier in four measures, two outliers in four measures, and five outliers in two measures were moved to the tails of the distributions before the analyses to avoid overemphasizing their effects on the results. The order of the participants was retained and no participants were dropped from the sample.

We examined group differences in cognitive skills, reading fluency, and PISA reading with One-Way ANOVAs, where post hoc pairwise comparisons with Bonferroni or Dunnett's T3 corrections (depending on the equality of the variances) were used to examine which groups differed from each other. In addition, pairwise group comparisons were conducted by calculating effect sizes (*Cohen's d*) using the pooled standard deviation of the two groups being compared as the denominator. Hierarchical regression analyses were performed to examine the effects of the predictors on PISA reading. To reduce the risk of overfitting the regression models into the data we chose, instead of using all the possible measures of early cognitive skills at different ages, the earliest age where predictors from all cognitive domains were available, i.e. 3.5 years. In step one, we added Language skills, Verbal short term memory, Phonological awareness, Rapid naming, and Letter knowledge to assess how well the cognitive predictors at age 3.5 years explained the outcome variance of PISA reading. In step two, we added Reading fluency from Grades 1, 2, 3, and 8 into the model to see whether reading fluency at school age added to the predictive power of the early cognitive predictors. All measures fulfilling the .05 probability level of the *F*-value were added one by one into the model in STEPWISE fashion in both steps. Missing values in single predictors were imputed with mean substitution option in the regression analyses.

3. RESULTS

3.1. Group Differences

In Table 2, we present the means, standard deviations, and group comparisons for PISA reading, the cognitive predictors, and reading fluency. In Table 3, we present the effect sizes for the contrasts between each pair of groups.

In PISA reading, High-risk boys performed significantly worse than Low-risk girls. The performance of the High-risk girls and Low-risk boys was in between that of the High-risk boys and Low-risk girls, and did not significantly differ either from that of the latter two groups or from each other. The effect sizes between both groups of boys (Low- and High-risk) and Low-risk girls were moderate to high (.62 and .98, respectively), suggesting a partial non-overlap in the PISA reading distributions of these groups. A post hoc univariate analysis of variance (UNIANOVA) showed that the main effects of group and gender were both significant ($F(1, 154) = 4.00$, $p < .05$ and $F(1, 154) = 10.51$, $p < .01$, respectively) in PISA reading, whereas the interaction effect group x gender was not $F(1, 154) = 0.22$, $p > .05$). Figure 1 shows the PISA reading distributions in the four groups. It can be seen, first, that the distribution for the Low-risk girls lacked the lower tail (z-scores below -1) present in the distributions of the other three groups. According to Levene's test, the group variances differed significantly from each other ($F(3, 154) = 3.08$, $p < .05$). Pair-wise comparisons of the groups showed that among the Low-risk girls the variance was smaller than in any of the other groups and that the variances in the other groups did not differ significantly from each other. Second, bars representing high performing individuals (z-scores above +1) were completely missing in the High-risk boys' distribution.

Comparisons of the group differences in the early cognitive skills revealed that High-risk boys scored the lowest. They performed significantly poorer than Low-risk girls in Language skills from age 2 years onwards, in Verbal short term memory and Rapid naming at 5.5 years, and in Phonological awareness and Letter knowledge at 5.0–6.5 years. Although the group differences were not significant, the effect sizes were also moderate in Verbal short term memory at 3.5 years, Phonological awareness at 3.5 years, and Rapid naming at 6.5 years. When High-risk boys were compared to Low-risk boys, the effect sizes were moderate in favor of Low-risk boys in Language skills and Phonological awareness from 3.5 years onwards, and Verbal short term memory, Rapid naming, and Letter knowledge from 5.0–5.5 years onwards. However, Low-risk boys scored significantly better than High-risk boys only in

Language skills at 5.0–5.5 years. Finally, while no differences were observed between the High-risk boys and High-risk girls, the effect sizes between these two groups were moderate in favor of girls in Language skills at 2.0–5.5 years.

High-risk girls scored lower than Low-risk girls in Phonological awareness at age 6.5 years and Letter knowledge at 5.0–6.5 years. In addition, effect sizes were moderate between these two groups in Language skills and Verbal short term memory at all ages, and in Letter knowledge, Phonological awareness, and Rapid naming from 5.0–5.5 years onwards. No significant differences were found between High-risk girls and Low-risk boys, but moderate effect sizes in favor of Low-risk boys were found in Phonological awareness at 3.5 and 5–5.5 years, and in Rapid naming and Letter knowledge at 5.0–6.5 years.

In all the assessed cognitive pre-reading skills, the Low-risk girls scored highest. Not only were their skills better than those in both High-risk groups, as reported above, but in comparison with the Low-risk boys, moderate effect sizes in their favor were also observed in Language skills from age 3.5 years onwards, in Verbal short term memory (all assessments), in Phonological awareness from 5.5 years onwards, and in Letter knowledge at 6.5 years, although the difference between the two groups was significant only in Language skills at 2–2.5 years.

In Reading fluency the High-risk groups (boys and girls) performed more poorly than the Low-risk groups (boys and girls): in Grade 1, both High-risk groups were significantly slower readers than Low-risk girls and Low-risk boys, and in Grade 2 slower than Low-risk boys. In addition, the effect sizes of both High-risk groups were moderate to high in all grades when compared to the Low-risk groups in Reading fluency. No differences in Reading fluency were found either between the High-risk groups (boys vs. girls) or between the Low-risk groups (boys vs. girls), and the effect sizes for these comparisons were low throughout Grade 1 to Grade 8.

Levene's homogeneity test of variances showed differences in the variances between the four groups in their raw scores (presented in Table 2) for Phonological awareness (age 5.5 years, $F(3,154) = 4.38$, $p < .01$), Rapid naming s (5.5 years, $F(3,153) = 4.17$, $p < .01$), Letter knowledge (5–5.5 years, $F(3,154) = 3.28$, $p < .05$ and 6.5 years, $F(3,154) = 3.80$, $p < .05$), Reading fluency in Grades 1 ($F(3,153) = 5.50$, $p < .01$), and in PISA reading ($F(3,154) = 3.08$, $p < .05$). In all these measures, the variance was larger in both the High-risk groups, except for PISA reading, where it was larger in Low-risk boys, in addition to both the High-risk groups, than in Low-risk girls. However, after the Logarithmic transformations no differences remained in any of the variances between the groups. Therefore, the transformed variables were used in the correlation and regression analyses reported below.

3.2. Prediction of PISA Reading

The correlations between the cognitive predictors and reading fluency with PISA reading are presented separately for the four groups in Table 4. Hierarchical regression analyses with stepwise inclusion of predictors were performed separately in each of the four groups. In step one, we entered all the measures at age 3.5 years to see how well cognitive skills at that age predicted PISA reading. In the second step, we entered reading fluency in each grade, to see if reading fluency in school age added to the prediction of PISA reading. Summaries of the results of the regression analyses are presented in Table 5.

In the High-risk boys, Language skills (age 2.0–5.5 years), Verbal short term memory (3.5 and 5.5 years), Phonological awareness and Letter knowledge (3.5–6.5 years), Rapid naming (3.5 and 6.5 years), and Reading fluency (Grade 1) correlated significantly with PISA reading. In the regression analyses, Language skills, Phonological awareness and Letter knowledge from age 3.5 years explained 73% of the variance in PISA reading in Grade 9 ($F(3, 38) = 34.07$, $p < .001$). Scatterplots between these three cognitive predictors and PISA reading confirm that the high explanatory power was not due to single outliers (see Figure 2). Reading fluency at school age did not add any significant power to the prediction.

In High-risk girls, Language skills (age 2.0–5.5 years), Verbal short term memory and Letter knowledge (3.5–6.5 years), and Phonological awareness and Rapid naming (5.5–6.5 years) correlated significantly with PISA reading. In addition, Reading fluency in Grades 2, 3, and 8 correlated significantly with PISA reading. In the regression analyses, Language skills at 3.5 years explained 34% of the variance in PISA reading ($F(1, 44) = 25.21$, $p < .001$). Reading fluency in Grade 8 added 15% to the prediction ($F(1, 43) = 13.36$, $p < .001$).

Among both Low-risk groups we found fewer significant correlations than in both High-risk groups. In Low-risk boys, Language skills (age 5.0–5.5 years) and Rapid naming (6.5 years) were the only measures of cognitive skills that correlated significantly with PISA reading. At school age, Reading fluency in Grades 2 and 3 correlated significantly with PISA reading. In the regression analyses, none of the cognitive measures at age 3.5 years was a significant predictor, although Reading fluency in Grade 3 explained 11% of the outcome variance of PISA reading. Among Low-risk girls, Language skills (age 3.5–5.5 years), Phonological awareness (5.5 years), and Letter knowledge (6.5 years) correlated significantly with PISA reading. In addition, Reading fluency in Grades 1, and 2 correlated significantly with PISA reading. In the regression analyses, Language skills at 3.5 years explained 32% of the variance in PISA reading in Grade 9 ($F(1,28) = 13.49$, $p < .01$). Reading fluency at school age did not add any significant power to the prediction.

4. DISCUSSION

In this study, we examined cognitive predictors of PISA reading literacy measured at 15 years of age, from age 2 onwards. The focus was on the effect of family risk for dyslexia, various cognitive skills before school age, and reading fluency at school age as predictors of PISA reading. To see whether the effects were similar for boys and girls with and without family risk, we compared four groups of children: 1) boys with family risk, 2) girls with family risk, 3) boys without family risk, and 4) girls without family risk. The group comparisons revealed clear effects of both family risk for dyslexia and gender on cognitive predictors, reading fluency, and their predictive associations with PISA reading.

4.1. Group Differences in Cognitive Skills, Reading Fluency and PISA Reading Literacy

We found salient differences between High-risk boys and Low-risk girls, on the one hand, and between High-risk and Low-risk boys, on the other hand, in all the included cognitive skills. Similar, albeit smaller, differences emerged from the comparisons between High-risk girls and both low-risk groups. Children with family risk for dyslexia have been shown to express delayed development in language (articulation, vocabulary knowledge, and grammar), as well as in pre-reading skills (phonological awareness, rapid naming, and letter knowledge), and impairments have been more severe for children who end up with reading difficulties than for children with family risk but typical reading skills (for a review, see Snowling & Melby-Lervåg, 2016, see also Torppa et al., 2010 for group differences in Finnish). Previous research has not reported on differences between family-risk children compared to control children separately for boys and girls, and therefore we cannot make direct comparisons between our results and previous findings. Taken together, however, our results suggest higher vulnerability for boys with family risk, and therefore that gender should be taken into account in future studies on the effects of family risk on pre-reading skills.

Not surprisingly, both boys and girls with family risk for dyslexia (High-risk groups), showed poorer reading fluency than low-risk children, especially during the first two grades, but also later on in grades 3 and 8, as evidenced by the moderate to high effect sizes. This was expected, as a large proportion (36% altogether) of the participants with family risk for dyslexia had encountered reading disability by the end of Grade 2 (Puolakanaho et al., 2007).

For family-risk children, the risk for dyslexia has been reported to range between fourfold and tenfold depending on the criteria applied (Puolakanaho et al., 2007; van Bergen et al., 2012), and compromised reading skills have been shown to be persistent (Eklund et al., 2015; Landerl & Wimmer, 2008), although a subgroup of children was able to resolve from early difficulties (Torppa et al., 2015).

While the family-risk children were expected to show poorer skills in language, pre-literacy skills, and reading fluency, expectations for PISA reading literacy performance were less self-evident. In accordance with the Simple View of Reading, children with family risk for dyslexia are expected mainly to show deficient performance in word reading, which would not necessarily lead to poor reading comprehension (Catts et al., 2006; Nation et al., 2004; Torppa et al., 2007). On the other hand, the generalist genes hypothesis (Kovacs & Plomin, 2007; Plomin & Kovacs, 2005) states that family risk children would show broad signs of deficiencies, including language skills, which could affect their reading comprehension and reading literacy skills as well. Accordingly, family risk children with reading disability have been shown to have poor reading comprehension skills at 12-13 years of age in English (Snowling et al., 2007).

Our findings indicated that both gender and family risk affected PISA reading literacy: first, boys performed more poorly than girls in both the High-risk and Low-risk groups, second, High-risk boys performed significantly more poorly than Low-risk girls, and third, the effect size between the High-risk girls and the Low-risk girls was moderate in favor of the Low-risk girls. The poor performance of boys, in both the High-risk and Low-risk groups, is in line with earlier findings of gender differences in PISA reading performance, where girls outperformed boys in every OECD country in the recent 2009 and 2012 assessments, especially on the lowest reading proficiency level (OECD, 2011; OECD, 2013). In addition, both High-risk and Low-risk boys showed poorer language skills than High-risk girls, most evidently at age 2–2.5 years. In the

High-risk groups moderate effect sizes were also found in favor of girls through-out the early language development before school age. Language skills have generally been seen as one of the cornerstones of reading comprehension (Perfetti & Hart, 2001), and they have also been shown to explain a big portion of PISA reading literacy (Arnbak, 2012). Moreover, in comparison with the Low-risk girls both the High-risk groups showed deficient reading fluency, the other important factor when explaining success in PISA reading tasks (Arnbak, 2012). As no measures outside cognitive skills and reading fluency were available in the present study, the possible effects of other factors such as school engagement and reading activity on PISA reading literacy, its predictors or the associations between these two, remain unclear. Girls have been found to be more engaged in school and to perceive more support from teachers, and this engagement has been found to partially mediate the effects of gender and teacher support on girls' better academic performance (Lam et al., 2012). In addition, according to the PISA 2009 results, reading engagement and reading for enjoyment was higher for girls than boys in all the European countries (OECD, 2010b; Sulkunen, 2013), providing self-generated opportunities to practice reading skills, as suggested by Guthrie and Wigfield (2000).

4.2. Prediction of PISA Reading Literacy

We were also interested in how well the early cognitive skills, on the one hand, and reading fluency at school age, on the other hand, predicted PISA reading literacy. Strong and systematic correlations across all ages were found between early cognitive measures and PISA reading literacy for both girls and boys with family risk for dyslexia. Strong associations were expected due to the continuous vulnerability of dyslexia risk (Pennington, 2006; Pennington et al., 2012; Snowling et al., 2003), and were evident in the increased variability observed in the high-risk groups in word identification skill (e.g. Eklund et al., 2015, Snowling et al., 2003) as well as language skills (Snowling & Melby-Lervåg, 2016), both of which are needed for success in PISA reading tasks (Arnbak, 2012).

However, only among the High-risk boys separate cognitive risks accumulated additively, resulting not only in a strong prediction but also poor performance in PISA reading literacy: 73% of the variance in PISA reading was explained by language skills, phonological awareness, and letter knowledge assessed as early as at 3.5 years of age. This is in line with our earlier finding that the prediction of literacy skills in Grade 2 was not improved by measures at age 4.5 and 5.5 years after entering phonological and language skills at 3.5 years into the model (Puolakanaho et al., 2008). The present results extend this previous finding by showing a similar predictive pattern for Grade 9 literacy skills, although only among High-risk boys. For High-risk girls such an accumulative effect was not present, as language skills was the only significant early cognitive predictor of PISA reading.

For both low-risk groups, the associations of the early cognitive skills with PISA reading literacy were fewer and substantially weaker. Due to lower genetic vulnerability of the children in these groups compared to the offspring of families with dyslexia we expected to find smaller variances in these skills, possibly explaining the weaker associations: prevalence estimates of dyslexia vary, depending on criteria used, from 4% to10%, compared to the 34%–66% probability of having deficient skills for children with a family history of dyslexia (Pennington & Lefly, 2001; Puolakanaho et al., 2007; Scarborough, 1990; Snowling et al., 2003). However, although smaller variances among the Low-risk groups were found, no differences emerged in the variances between the Low- and High-risk groups in the transformed measures used in the correlation and regression analyses. Another possibility is that the Low-risk children have had sufficient environmental support to even out possible genetic differences. Although no differences have usually been found in children's home literacy environment between children with and without family risk for dyslexia (Snowling & Melby-Lervåg, 2016; Torppa et al., 2007), less variation in parental reading models was found among the parents of the Low-risk groups compared to the parents of the affected children (Torppa et al., 2007). Finally, due to their earlier acquired and therefore better reading skills, low-risk children have probably also had better possibilities for practicing their reading skills (e.g. Eklund et al., 2015), which, according to a recent meta-analysis by Mol and Bus (2011), enhances reading comprehension skills.

High-risk boys showed a descending trend along with grade in the strength of the association between reading fluency (Grades 1, 2, 3, and 8) and PISA reading (Grade 9), whereas the opposite was true for High-risk girls. Among High-risk boys, reading fluency in Grade 1 explained 14% of PISA reading literacy, but after Grade 1 the effect of reading fluency on PISA reading was no longer significant. Among High-risk girls, the effect of reading fluency increased from non-significant (Grade 1) to explaining 28% (Grade 8) of the variance in PISA reading. Our current finding of opposite developmental trajectories in the associations between reading fluency and PISA reading literacy is in line with our earlier finding on reading fluency development: we identified a Late-emerging group, 74% of whom were boys, that showed a descending trajectory in reading fluency and a Resolving dyslexia group, 83% of whom were girls, with an ascending trajectory in reading fluency (Torppa et al., 2015).

Moreover, for High-risk girls, unlike High-risk boys, reading fluency added significantly to the explained variance of PISA reading after taking into account the early cognitive predictors. This, together with found weak associations between reading fluency and PISA reading among High-risk boys, could be interpreted as a failure of education to reduce inter-individual differences emerging before school start among boys, contrary to girls. In addition to teaching and enhancing reading skills, schools strive at improving students' reading literacy by training metacognitive strategies, expanding prior knowledge, and increasing vocabulary by keeping up motivation in learning. These factors have been shown to have a positive association with reading comprehension (Artelt et al., 2001) and are included in the Core curriculum for basic education 2004 (Finnish National Board of Education, 2004). In Finland

54% of children are unable to decode at all when they enter school (Torppa et al., 2013), whereas among children with family risk for dyslexia this percentage is 61% (Jyväskylä Longitudinal Study of Dyslexia, unpublished). Therefore, the latter group enters Grade 1 with a significant delay, and it is of great interest whether or not education can narrow this gap. Lerkkanen, Rasku-Puttonen, Aunola, and Nurmi (2004) suggest that this is possible: in their study, disabled readers benefited best from reading instruction at school during Grade 1. Our study further suggests that this benefit is limited to the early grades. Among both Low-risk groups the strength of the association between reading fluency across Grades 1–8 and PISA reading in Grade 9 was relatively stable, explaining 9–16% of its variance, which is comparable with the 13% found earlier by Artelt and colleagues (2001).

4.3. Limitations

We took a number of precautions to guard against the possible effects caused by the small sample size. First, we took effect sizes into account when drawing conclusions and discussing our results. Second, in hierarchical regression analyses a small sample size in relation to the number of predictors may lead to overfitting the data for associations which do not in fact exist in the population. We counteracted this risk by minimizing the number of independent variables by selecting one age instead of multiple ages as our time point for predictors. Third, we did our best to rely not solely on the results of the hierarchical regressions, but also to take into account the pairwise correlations when interpreting our results and drawing conclusions. Another option, pooling groups, would have meant losing the nuanced picture of the effects of gender and family risk described above. Larger groups would, of course, have been preferable, but screening families and carrying out a follow-up with 200 children over 15 years already required considerable resources.

4.4. Conclusions

To conclude, we would stress the importance of taking both family risk for dyslexia and gender seriously as strong risk markers of problematic reading development. A rather deterministic picture of development for boys with family risk for dyslexia emerged, as no less than 73% of the variance in PISA reading literacy was explained by cognitive skills at age 3.5 years. This does not, however, mean that all high-risk boys will fall behind the typical developmental trajectories of cognition starting from the early years of life. Instead, our results suggest that family-risk boys who show poor cognitive skills in their early development are very likely to show poor literacy skills in adolescence, and therefore should be relatively easy to identify. Special emphasis should be placed on enhancing their language and phonological skills, as these play a crucial role in their later literacy development. We have previously shown that when family-risk status, phonological awareness, rapid naming, and letter knowledge are known, we can reliably estimate individual risk for reading disability (accuracy and fluency) in Grade 2 (Puolakanaho et al., 2007). Based on the present results, we suggest that language skills also need to be taken into account if we want to predict reading literacy skills in adolescence. In addition, our results suggest that gender is a significant confounder affecting the genetic influences on reading outcomes, as argued by Snowling and Melby-Lervåg (2016) as well as Quinn and Wagner (2013). However, as no clear reason for gender differences has been found in genetic etiology studies of reading difficulties (Hawke et al., 2006, 2007), environmental or gene-environment interactional factors need also to be studied in order to gain more understanding on this issue.

REFERENCES

Arnbak, E. (2012). To what extent do basic skills predict students' PISA reading score? In N. Egelund (Ed.), *Northern Lights on PISA 2009: focus on reading* (pp. 75–90). TemaNord 2012:501. Nordic Council of Ministers.

Artelt, C., Schiefele, U., & Schneider, W. (2001). Predictors of reading. *European Journal of Psychology of Education, 16*, 363–383.

Boets, B., De Smedt, B., Cleuren, L., Vandewalle, E., Wouters, J., & Ghesquie`re, P. (2010). Towards a further characterization of phonological and literacy problems in Dutch-speaking children with dyslexia. *British Journal of Developmental Psychology, 28,* 5–31.

Catts, H. W., Adlof, S. M., & Weismer, S. E. (2006). Language deficits in poor comprehenders: A case for the simple view of reading. *Journal of Speech, Language, and Hearing Research*, *49*, 278–293.

Chiu, M. M. & McBride-Chang, C. (2006). Gender, context, and reading: A comparison of students in 43 countries. *Scientific Studies of Reading, 10*, 331–362.

Denckla, M. B. & Rudel, R. G. (1976). Rapid 'automatized' naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia*, *14*, 471–479.

Dunn, L. M. & Dunn, L. M. (1981). *Peabody Picture Vocabulary Test-Revised.* Circle Pines, MN: American Guidance Service.

Eklund, K., Torppa, M., Aro, M., Leppänen, P., & Lyytinen, H. (2015). Literacy skill development of children with familial risk for dyslexia through Grades 2, 3, and 8. *Journal of Educational Psychology*, *107*, 126–140.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D., & Pethick, S. J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59*, Serial No. 242.

Finnish National Board of Education. (2014). *Core curriculum for basic education 2014*. Next Print: Helsinki.

Florit, E. & Cain, K. (2011). The Simple View of Reading: Is it valid for different types of alphabetic orthographies? *Educational Psychology Review, 23*, 553–576.

García, J. R. & Cain, K. (2014). Decoding and reading comprehension: a meta-analysis to identify which reader and assessment characteristics influence the strength of the relationship in English. *Review of Educational Research, 84*, 74–111.

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

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

Guthrie, J. T. & Wigfield, A. (2000). Engagement and motivation in reading. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research. Volume III* (pp. 403–422). New Jersey: Lawrence Erlbaum Ass.

Hawke, J. L., Olson, R. K., Willcutt, E. G., Wadsworth, S. J., & DeFries, J. C. (2009). Gender ratios for reading difficulties. *Dyslexia, 15*(3), 239–242.

Hawke, J. L., Wadsworth, S. J., & DeFries, J. C. (2006). Genetic influences on reading difficulties in boys and girls: The Colorado Twin Study. *Dyslexia, 12*, 21–29.

Hawke, J. L., Wadsworth, S. J., Olson, R. K., & DeFries, J. C. (2007). Etiology of reading difficulties as a function of gender and severity. *Reading and Writing, 20,* 13–25.

Hoover, W. A. *&* Gough, P. B. (1990). The simple view of reading, *Reading and Writing, 2*, 127–160.

Häyrinen, T., Serenius-Sirve, S., & Korkman, M. (1999). *Lukilasse. Lukemisen, kirjoittamisen ja laskemisen seulontatesti ala-asteen luokille 1–6* [Screening test for reading, spelling and counting for the grades 1–6]. Helsinki: Psykologien Kustannus Oy.

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

Korkman, M., Kirk, U., & Kemp S. (1998). *NEPSY: A developmental neuropsychological assessment.* San Antonio, TX: The Psychological Corporation.

Kovacs, Y. & Plomin, R. (2007). Learning abilities and disabilities: Generalist genes, specialist environments. *Current Directions in Psychological Science, 16*, 284–288.

Lam, S., Jimerson, S., Kikas, E., Cefai, C., Veiga, F. H., Nelson, B., … Zollneritsch, J. (2012). Do girls and boys perceive themselves as equally engaged in school? The results of an international study from 12 countries. *Journal of School Psychology, 50*, 77–94.

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

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

Lerkkanen, M-K., Rasku-Puttonen, H., Aunola, K., & Nurmi, J-E. (2004). Predicting reading performance during the first and the second year of primary school. *British Eduational Research Journal, 30*, 67– 92.

Lietz, P. (2006). A meta-analysis of gender differences in reading achievement at the secondary school level. *Studies in Educational Evaluation 32,* 317–344.

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). A definition of dyslexia. *Annals of Dyslexia, 53,* 1–14.

Lyytinen, H., Ahonen, T., Eklund, K., Guttorm, T. K., Laakso, M-L., Leinonen, S., ...Viholainen, H. (2001). Developmental pathways of children with and without familial risk for dyslexia during the first years of life. *Developmental Neuropsychology, 20,* 535–554.

Lyytinen, H., Erskine, J., Ahonen, T., Aro, M., Eklund, K., Guttorm, T., … Viholainen, H. (2008). Early identification and prevention of dyslexia: Results from a prospective follow-up study of children at familial risk for dyslexia. In G. Reid, F. Manis, & L. Siegel (Eds.), *The Sage handbook of dyslexia* (pp. 121–146). Thousand Oaks, CA: Sage.

Lyytinen, P. (1999). *Varhaisen kommunikaation ja kielen kehityksen arviointimenetelmä* [The assessment tool of early communication and language development]. Jyväskylän yliopiston Lapsitutkimuskeskus ja Niilo Mäki Instituutti. Jyväskyla: Yliopistopaino.

Mol, S. E. & Bus, A. G. (2011). To read or not to read: a meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin, 137*, 267–296.

Muter, V., Hulme, C., Snowling, M., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology, 40*, 665–81.

Nation, K., Clarke, P., Marshall, C. M., & Durand, M. (2004). Hidden language impairments in children: Parallels between poor reading comprehension and specific language impairment? *Journal of Speech, Language, and Hearing Research, 47*, 199–211.

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

OECD. (2002). *Reading for change: Performance and engagement across countries: results from PISA 2000. Executive summary*. PISA: OECD Publishing.

OECD. (2009*). PISA 2009 assessment framework***. Key competencies in reading, mathematics and science***.** PISA: OECD Publishing.

OECD. (2010a). *PISA 2009 results: Learning trends: changes in student performance since 2000 (Volume V).* PISA: OECD Publishing.

OECD. (2010b). *PISA 2009 results: Learning to learn. student engagement, strategies and practices (Volume III)*. PISA: OECD Publishing.

OECD. (2011), *PISA 2009 at a glance*. PISA: OECD Publishing.

OECD. (2013). *PISA 2012 results: What students know and can do – student performance in mathematics, reading and science (Volume I, Revised edition*). PISA: OECD Publishing.

Olson, R. K., Keenan, J. M., Byrne, B., Samuelsson, S., Coventry, W. L., Corley, R., …, Hulslander, J. (2011). Genetic and environmental influences on vocabulary and reading development. *Scientific Studies of Reading, 15*, 26–46.

Pennala, R. Eklund, K., Hämäläinen, J., Martin, M., Richardson, U., Leppänen, P. H. T., & Lyytinen, H. (2013). Precursors and consequences of phonemic length discrimination problems in children with reading disability and with familial risk for dyslexia. *Journal of Speech, Language, and Hearing Research, 56,* 1462–1475.

Pennala, R. Eklund, K., Hämäläinen, J., Richardson, U., Martin, M., Leiwo, M., Leppänen, P. H. T., & Lyytinen, H. (2010). Perception of phonemic length and its relation to reading fluency in children with familial risk for dyslexia at the three first grades in school. *Journal of Speech, Language, and Hearing Research, 53,* 710–724.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101,* 385–413.

Pennington, B. F., Santerre-Lemmon, L., Rosenberg, J., MacDonald, B., Boada, R., Friend, A., … Olson, R. K. (2012). Individual prediction of dyslexia by single versus multiple deficit models. *Journal of Abnormal Psychology, 121*, 212–224.

Perfetti, C. A. (1985). *Reading ability.* New York: Oxford University Press.

Perfetti, C. & Hart, L. (2001). The lexical quality hypothesis. In L. Verhoeven, C. Elbro, & P. Reitsma (Eds.), *Precursors of functional literacy* (pp. 189–214). Amsterdam: John Benjamins.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101,* 385–413.

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

Plomin, R. & Kovacs, Y. (2005). Generalist genes and learning disabilities. *Psychological Bulletin*, *131*, 592–617.

Poskiparta, E., Niemi, P., & Lepola, J. (1994). *Diagnostiset testit 1. Lukeminen ja kirjoittaminen.* [The diagnostic tests 1. Reading and spelling.] Turun yliopisto. Oppimistutkimuksen keskus.

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

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P. H. T., Poikkeus, A.-M., … Lyytinen., H. (2008). Developmental links of very early phonological and language skills to the 2nd grade reading outcomes: Strong to accuracy but only minor to fluency. *Journal of Learning Disabilities, 41*, 353–370.

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

Quinn, J. M. & Wagner, R. K. (2015). Gender differences in reading impairment and in the identification of impaired readers: Results from a large-scale study of at-risk readers. *Journal of Learning Disabilities, 48*, 433–445.

Reynell, K. & Huntley, M. (1987). *Reynell developmental language scales* (2nd Ed.). Windsor, UK: NFER Nelson.

Rutter M., Caspi A., Fergusson D., Horwood, L.J., Goodman, R., Maughan, B., … Carrol, J. (2004). Sex differences in developmental reading disability: New findings from 4 epidemiological studies. *JAMA, 291*, 2007–2012.

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

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

Snowling, M. J. & Melby-Lervåg, M. (2016). Oral language deficits in familial dyslexia: A meta-analysis and review. *Psychological Bulletin, 142*, 498–545.

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

Sulkunen, S. (2013). Adolescent literacy in Europe – an urgent call for action. *European Journal of Education, 48*, 528–542.

Tan, K. H., Wheldall, K., Madelaine, A., & Lee, L. W. (2007). A review of the simple view of reading: Decoding and linguistic comprehension skills of low-progress readers. *Australian Journal of Learning Disabilities, 12*, 19–30,

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

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities, 43*, 1–14.

Torppa, M., Parrila, R., Niemi, P., Lerkkanen, M.-K., Poikkeus, A.-M., & Nurmi, J.-E. (2013). The double deficit hypothesis in the transparent Finnish orthography: A longitudinal study from kindergarten to grade 2. *Reading and Writing*, *26*, 1353–1380.

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

Torppa, M., Tolvanen, A., Poikkeus, A-M. Eklund, K., Lerkkanen, M-K., Leskinen, E., & Lyytinen, H. (2007). Reading development subtypes and their early characteristics. *Annals of Dyslexia, 57*, 3–32.

van Bergen, E., de Jong, P. F., Plakas, A., Maassen, B., & van der Leij, A. (2012). Child and parental literacy levels within families with a history of dyslexia. *Journal of Child Psychology and Psychiatry, 53*, 28–36.

van Bergen, E., de Jong, P. F., Regtvoort, A., Oort, F., Otterloo, S., & van der Leij, A. (2010). Dutch children at family risk of dyslexia: Precursors, reading development, and parental effects. *Dyslexia, 17,* 2–18.

Verhoeven, L. & van Leeuwe, J. (2008). Prediction of the development of reading comprehension: A longitudinal study. *Applied Cognitive Psychology, 22*, 407–423.

Wechsler, D. (1989). *Wechsler Preschool and Primary Scale of Intelligence-Revised.* San Antonio, TX: The Psychological Corporation.

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

Zoccolotti, P., De Luca, M., Di Pace, E., Gasperini, F., Judica, A., & Spinelli, D. (2005). Word length effect in early reading and in developmental dyslexia. *Brain and Language, 93,* 369–373.

Table 1. Characteristics of Parents and Their Children in the Four Groups.

	Group								
	High-risk boys (n = 42)		High-risk girls (n = 45-46)		Low-risk boys (n = 39-40)		Low-risk girls (n = 29-30)		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*
Parents									
Mother's Age	29.69	4.60	29.15	4.35	30.90	4.26	28.93	3.86	1.60
Mother's Education[a]	4.40	1.62	4.06	1.32	4.70	1.22	4.50	1.46	1.52
Father's Age	32.45	5.70	31.29	5.10	33.62	5.01	32.60	5.46	1.40
Father's Education[a]	3.79	1.52	3.53	1.01	3.88	1.32	3.47	1.46	0.82
Children									
Verbal IQ[b]	99.05	11.68	98.43	12.40	102.00	11.00	102.10	11.84	1.04
Performance IQ[b]	98.90	12.78	99.67	13.46	100.10	15.34	105.41	13.29	1.48

[a)] Parental education was classified using a 7-point scale: 1 = only comprehensive school (CS); 2 = CS and short-term vocational courses; 3 = CS and a vocational school degree; 4 = CS and a vocational college degree; 5 = CS and a lower university degree / a polytechnic degree; 6 = upper secondary general school and a lower university degree / a polytechnic degree; 7 = CS or upper secondary general school and a higher university degree (Master's or Doctorate-level degree).

[b)] Children's verbal and performance IQ was estimated using the Wechsler Intelligence Scale for Children—Third Edition (WISC—III; Wechsler, 1991).

Table 2. Means, Standard Deviations and Group Comparisons in Early Cognitive Skills, Reading Fluency and PISA Reading.

	Group								
	High-risk boys (n = 37-42)		High-risk girls (n = 41-46)		Low-risk boys (n = 37-40)		Low-risk girls (n = 27-30)		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	F(3,125-141)
Language skills									
2.0–2.5 years	-0.37 ^{x}	0.86	0.03 ^{x,y}	0.67	-0.17 ^{x}	0.86	0.35 ^{y}	0.67	5.48 **
3.5 years	-0.43 ^{x}	0.82	-0.17 ^{x,y}	0.81	-0.06 ^{x,y}	0.75	0.18 ^{y}	0.76	3.60 *
5.0–5.5 years	-0.58 ^{x}	0.88	-0.17 ^{x,y}	1.03	-0.04 ^{y}	0.61	0.20 ^{y}	0.72	5.48 **
Verbal short term memory									
3.5 years	-0.16	0.92	-0.16	0.84	-0.10	0.86	0.28	0.76	1.89
5.0–5.5 years	-0.37 ^{x}	0.77	-0.30 ^{x,y}	1.00	-0.06 ^{x,y}	0.72	0.19 ^{y}	0.84	3.14
6.5 years	0.13	1.11	-0.24	1.06	-0.12	1.06	0.31	1.00	1.96
Phonological awareness									
3.5 years	-0.38	0.81	-0.23	0.81	0.04	0.70	-0.06	0.88	2.11
5.5 years	-0.51 ^{x}	0.94	-0.34 ^{x,y}	1.00	-0.06 ^{x,y}	0.57	0.18 ^{y}	0.72	4.70 **
6.5 years	-0.48 ^{x}	0.95	-0.21 ^{x}	0.90	-0.15 ^{x,y}	0.71	0.33 ^{y}	0.74	5.46 **

Rapid naming									
3.5 years	0.02	0.80	0.11	0.92	-0.15	0.83	0.10	1.13	0.55
5.0–5.5 years	-0.91 [x]	2.04	-0.53 [x,y]	1.62	-0.00 [x,y]	0.97	0.11 [y]	0.98	3.70 *
6.5 years	-0.53	1.52	-0.47	1.63	0.02	1.08	0.12	0.75	2.33
Letter knowledge									
3.5 years	-0.11	0.89	-0.18	0.80	0.02	1.00	0.12	1.02	0.72
5.0–5.5 years	-0.47 [x]	1.19	-0.38 [x]	1.07	0.02 [x,y]	0.89	0.28 [y]	0.89	4.33 **
6.5 years	-0.53 [x]	1.19	-0.48 [x]	1.12	-0.04 [x,y]	0.89	0.34 [y]	0.76	5.65 **
Reading fluency									
Grade 1, spring	-0.80 [x]	1.41	-1.01 [x]	1.68	0.11 [y]	0.86	0.05 [y]	0.84	7.82 ***
Grade 2, spring	-0.39 [x]	0.78	-0.56 [x]	0.90	0.19 [y]	0.96	-0.08 [x, y]	0.93	5.39 **
Grade 3, spring	-0.43	0.77	-0.37	1.05	0.12	0.92	0.06	0.95	3.59 *
Grade 8, fall	-0.53	0.95	-0.44	1.10	-0.05	0.92	0.03	0.74	3.16 *
PISA reading									
Grade 9	-0.26 [x]	0.91	0.14 [x,y]	0.87	-0.04 [x,y]	1.06	.49 [y]	0.58	4.45 **

Note. Groups with a different superscript letter ([x] or [y]) were significantly different in the post hoc pair-wise comparisons of the ANOVA F tests ($p \leq .05$). Bonferroni or Dunnett's T3 corrections were used depending on equality or inequality of the variances.

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

Table 3. Estimates of Effect Sizes (Cohen d) between Groups in Early Cognitive Skills, Reading Fluency and PISA Reading.

	High-risk boys vs. Low-risk girls	High-risk boys vs. Low-risk boys	High-risk boys vs. High-risk girls	High-risk girls vs. Low-risk girls	High-risk girls vs. Low-risk boys	Low-risk boys vs. Low-risk girls
Language skills						
2.0–2.5 years	**-0.93**	-0.23	-0.52	-0.48	0.26	-0.67
3.5 years	-0.77	-0.47	-0.31	-0.44	-0.14	-0.32
5.0–5.5 years	**-0.97**	-0.71	-0.43	-0.42	-0.15	-0.36
Verbal short term memory						
3.5 years	-0.52	-0.07	0.00	-0.55	-0.07	-0.47
5.0–5.5 years	-0.69	-0.42	-0.08	-0.55	-0.28	-0.32
6.5 years	-0.17	0.23	0.34	-0.53	-0.11	-0.42
Phonological awareness						
3.5 years	-0.38	-0.55	-0.19	-0.20	-0.36	0.13
5.5 years	**-0.82**	-0.58	-0.18	-0.60	-0.34	-0.37
6.5 years	**-0.95**	-0.39	-0.29	-0.66	-0.07	-0.66

Rapid naming						
3.5 years	-0.08	0.21	-0.10	0.01	0.30	-0.25
5.0–5.5 years	-0.64	-0.57	-0.21	-0.48	-0.40	-0.11
6.5 years	-0.54	-0.42	-0.04	-0.47	-0.35	-0.11
Letter knowledge						
3.5 years	-0.24	-0.14	0.08	-0.33	-0.22	-0.10
5.0–5.5 years	-0.71	-0.47	-0.08	-0.67	-0.41	-0.29
6.5 years	**-0.87**	-0.47	-0.04	**-0.86**	-0.43	-0.46
Reading fluency						
Grade 1, spring	-0.73	-0.78	0.14	**-0.80**	**-0.86**	0.07
Grade 2, spring	-0.36	-0.66	0.20	-0.52	**-0.96**	0.29
Grade 3, spring	-0.57	-0.65	-0.07	-0.43	**-0.92**	0.06
Grade 8, fall	-0.66	-0.51	-0.09	-0.50	**-0.92**	-0.10
PISA reading						
Grade 9	**-0.98**	-0.22	-0.45	-0.47	0.19	-0.62

Note. Large (≥ .80) effect sizes bolded. Effect sizes were estimated with Cohen's *d* computed using pooled standard deviation.

Table 4. Correlations of Early Cognitive Skills and Reading Fluency with PISA Reading in the Four Groups.

	PISA reading			
	Group			
	High-risk boys (n = 38-42)	High-risk girls (n = 41-46)	Low-risk boys (n = 37-40)	Low-risk girls (n = 29-30)
Language skills				
2.0–2.5 years	.47**	.66***	.06	.08
3.5 years	.57***	.65***	.12	.57**
5.0–5.5 years	.60***	.53***	.37*	.58***
Verbal short term memory				
3.5 years	.55***	.59***	.33	.22
5.0–5.5 years	.47***	.57***	.22	.22
6.5 years	.10	.54***	.23	.20
Phonological awareness				
3.5 years	.67***	.15	.11	.24
5.5 years	.47**	.52***	.11	.58***
6.5 years	.59***	.43**	.21	.42
Rapid naming				
3.5 years	-.55***	-.15	-.22	-.29
5.0–5.5 years	-.24	-.31*	-.28	-.21
6.5 years	-.33*	-.42**	-.42**	-.31
Letter knowledge				
3.5 years	.67***	.35*	-.07	.06
5.0–5.5 years	.52***	.38*	.14	.35
6.5 years	.58***	.41**	.22	.48**
IQ				
5.0 years	.54***	.53***	.01	.42*
Reading fluency				
Grade 1, spring	.37*	.28	.15	.37*
Grade 2, spring	.12	.37*	.35*	.40*
Grade 3, spring	.18	.55***	.35*	.31
Grade 8, fall	.16	.53**	.30	.30

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

Table 5. Summaries of Hierarchical Regression Analyses Predicting PISA Reading in Grade 8 with Early Cognitive Skills and Reading Fluency at School Age.

	Group							
	High-risk boys (n = 42)		High-risk girls (n= 46)		Low-risk boys (n =40)		Low-risk girls (n = 30)	
Predictor	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1: 3.5 years								
Phonological awareness	.44***	.67***						
Letter knowledge	.19***	.46***						
Language skills	.09***	.35***	.36***	.60***			.32**	.57***
Step 2: School age								
Reading fluency, Gr 3					.12*	.34*		
Reading fluency, Gr 8			.15***	.40***				
Total R^2 / Adjusted R^2	.73*** / .71***		.51*** / .49***		.12* / .09*		.32** / .30**	

Note. Only significant predictors fulfilling the .05 *F*-probability criteria in at least one of the four groups are presented in the table.

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

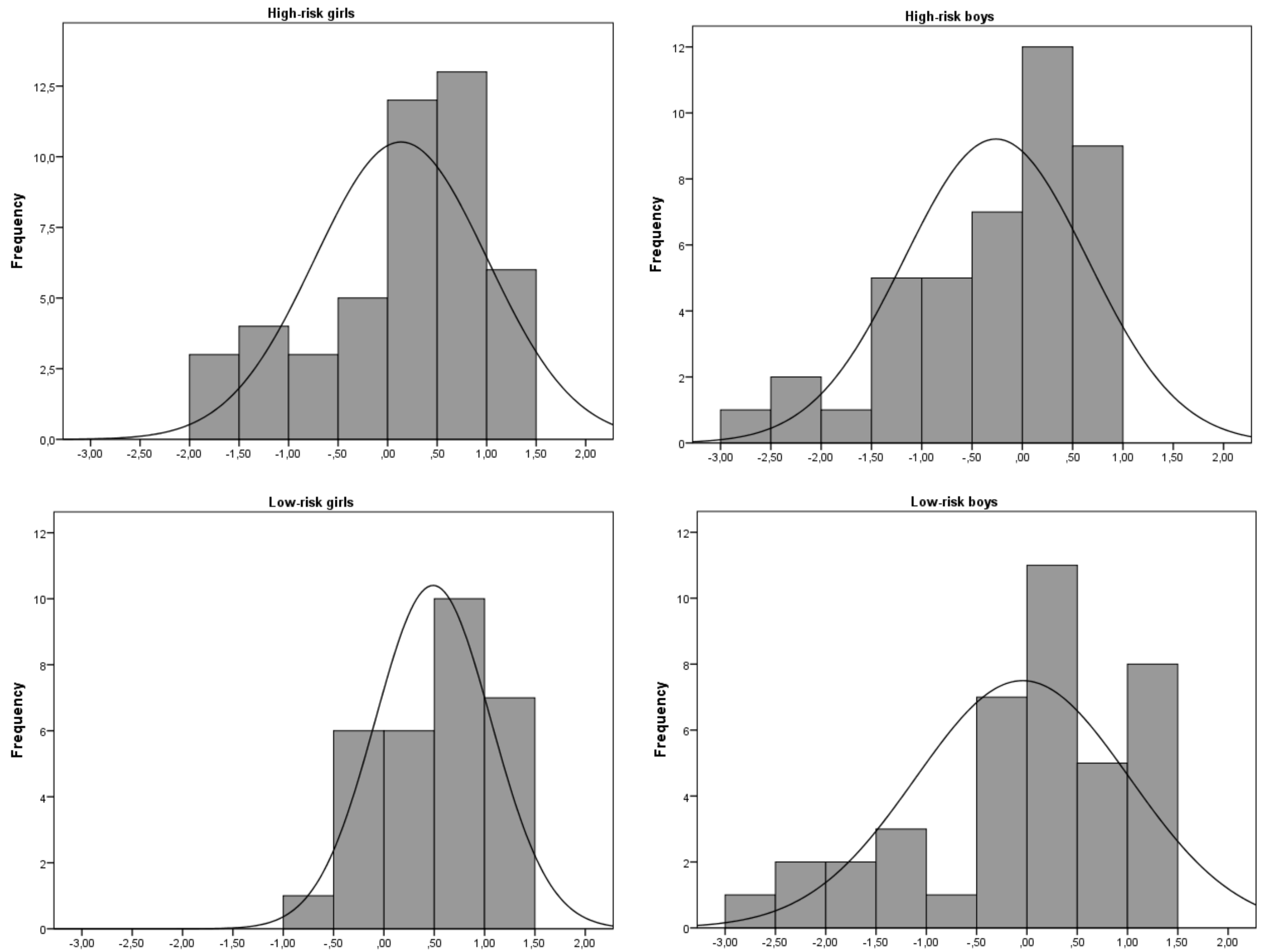


Figure 1. Distributions of PISA Reading z-scores in the Four Groups.

Note. Logarithmic transformations were applied to these z-scores before further analyses (correlations and regressions) to

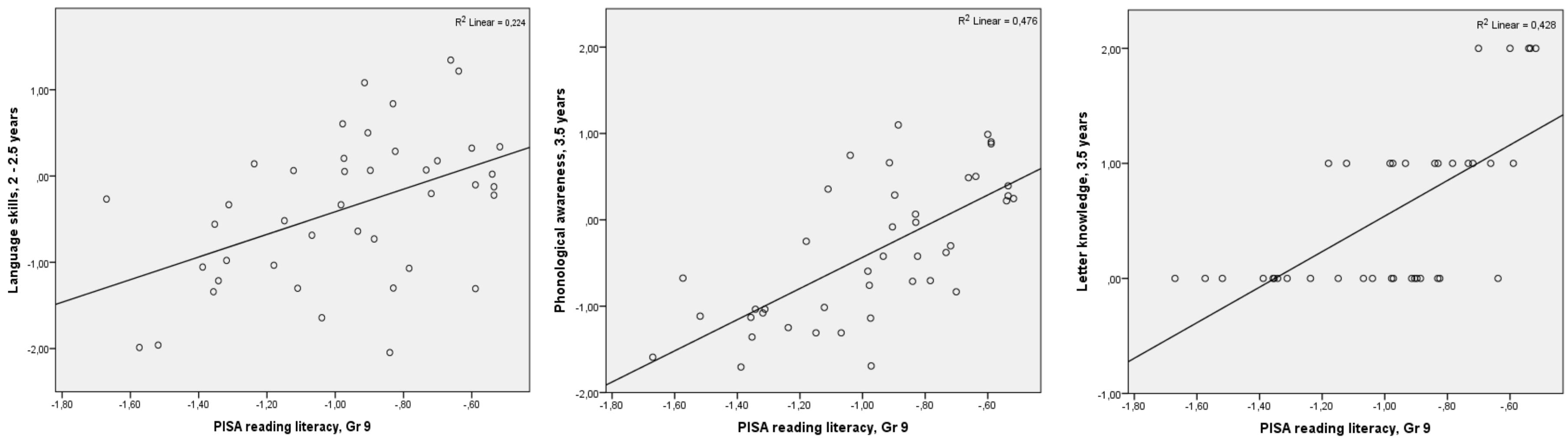


Figure 2. Scatterplots of the cognitive predictors and PISA reading literacy in the group of High-risk boys.

Note: Letter knowledge recoded into three categories because of skewness of the raw scores.

Acknowledgements
The study and the preparation of the manuscript were supported by grants from the Academy of Finland (SA 264264, SA 276239). We express our gratitude to all the families, children, teachers, and researchers who participated in this study.