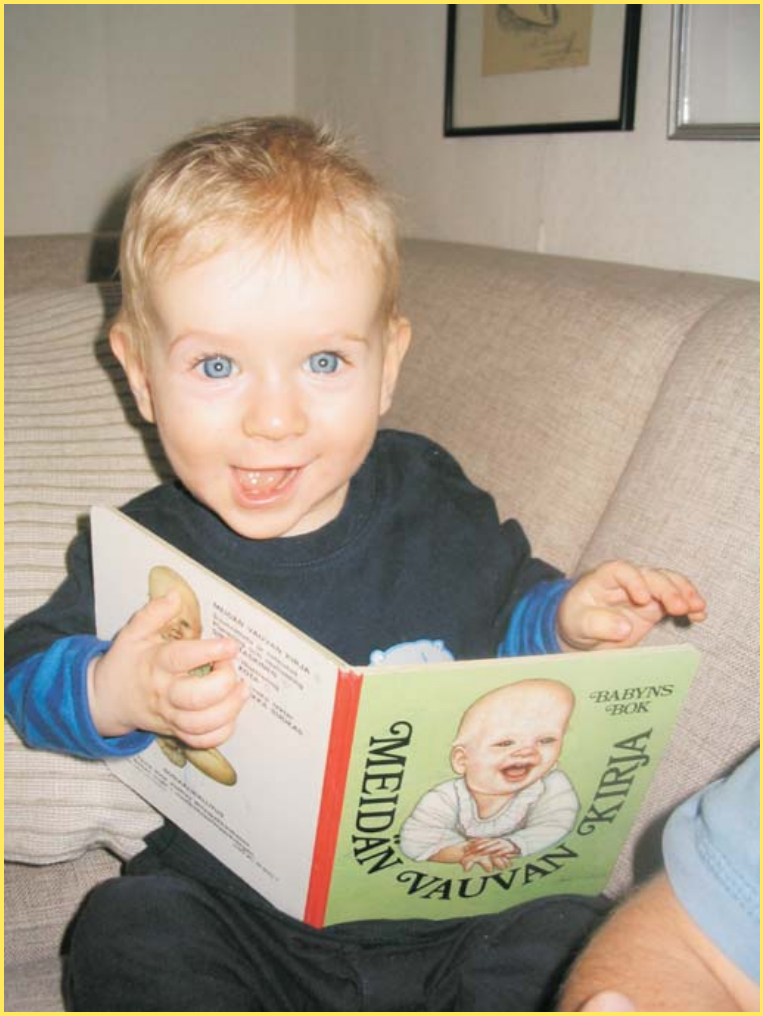
Minna Torppa

Pathways to Reading Acquisition

Effects of Early Skills, Learning Environment and Familial Risk for Dyslexia



JYVÄSKYLÄ LONGITUDINAL STUDY OF DYSLEXIA

JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH 325

Minna Torppa

Pathways to Reading Acquisition

Effects of Early Skills, Learning Environment and Familial Risk for Dyslexia

Esitetään Jyväskylän yliopiston yhteiskuntatieteellisen tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston Agora-rakennuksessa (Ag Aud. 1)
joulukuun 11. päivänä 2007 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Social Sciences of the University of Jyväskylä,
in the Building Agora (Ag Aud. 1), on December 11, 2007 at 12 o'clock noon.

UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2007

Pathways to Reading Acquisition

Effects of Early Skills, Learning Environment and Familial Risk for Dyslexia

JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH 325

Minna Torppa

Pathways to Reading Acquisition

Effects of Early Skills, Learning Environment and Familial Risk for Dyslexia

UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2007

Editors
Tapani Korhonen
Department of Psychology, University of Jyväskylä
Irene Ylönen, Marja-Leena Tynkkynen
Publishing Unit, University Library of Jyväskylä

Cover picture by Minna Torppa

URN:ISBN:9789513931025
ISBN 978-951-39-3102-5 (PDF)

ISBN 978-951-39-3019-6 (nid.)
ISSN 0075-4625

Jyväskylä University Printing House, Jyväskylä 2007

ABSTRACT

Torppa, Minna
Pathways to Reading Acquisition: Effects of Early Skills, Learning Environment and Familial Risk for Dyslexia
Jyväskylä, University of Jyväskylä, 2007, 53 p.
(Jyväskylä Studies in Education, Psychology and Social Research
ISSN 0075-4625; 325)
ISBN 978-951-39-3102-5 (PDF), 978-951-39-3019-6 (nid.)
Finnish summary: Yksilöllisiä kehityspolkuja kohti lukemisen taitoa: Varhaisten taitojen, oppimisympäristön ja sukuriskin vaikutukset
Diss.

This thesis examined the development of reading and its key predictors. A combination of traditional variable-oriented and person-oriented methods enabled a more holistic approach to the study of reading development than is usually adopted by traditional approaches. The analyses incorporated levels of early language and literacy skills, the learning environment, the child's interest in reading activities and familial risk for dyslexia.

Data from the Jyväskylä Longitudinal Study of Dyslexia (JLD) was used in the analyses where by 214 children (half of whom had familial risk for dyslexia indexed by parental incidence) and their families were followed from the child's birth until the end of third grade. This thesis incorporates data that spans early language and literacy development from 1 to 8 years of age in the domains of vocabulary, phonological awareness, rapid serial naming (RAN), letter knowledge, morphological awareness, IQ and memory. The home literacy environment was measured through parental reporting of the amount of reading and print exposure during the children's first eight years. Classroom effects were also studied from school age. Measures of the children's interest in reading were derived from parental reports spanning age two to eight.

The results suggest that development of phonological awareness skills, letter knowledge and RAN provide the strongest prediction of reading. The associations between phonological processing, letter knowledge and vocabulary development were found to be bidirectional from early on. The effects of learning environment on reading were modest as observed in previous studies. The strongest associations between home environment and child skills emerged between shared reading and vocabulary development and between letter name teaching and letter name learning. In addition, children with poor reading skills differed from children with good reading skills in the amount of early shared reading and amount of reading alone. The effect of school classroom explained a small but significant portion of reading skills. Familial risk for dyslexia increased the risk of difficulties in several early skill areas but the learning environments of children with familial risk and those of the control children were found to differ only in relation to parent's own reading activities. Familial risk for dyslexia moderated the associations between various environmental factors and between environmental factors and children's skills in that the correlations were higher in the at-risk than the control group.

Author's address Minna Torppa
Agora
P.O. Box 35
FIN-40014 University of Jyväskylä
E-mail: minna.torppa@psyka.jyu.fi

Supervisors

Professor Heikki Lyytinen (main supervisor)
Department of Psychology
University of Jyväskylä, Jyväskylä, Finland

Professor Anna-Maija Poikkeus
Department of Teacher Education
University of Jyväskylä, Jyväskylä, Finland

Professor Esko Leskinen
Department of Mathematics and Statistics
University of Jyväskylä, Jyväskylä, Finland

Reviewers

Professor Lars Bergman
Department of Psychology
Stockholm University

Professor Richard K. Wagner
Department of Psychology
The Florida State University

Opponent

Professor Richard K. Wagner
Department of Psychology
The Florida State University

Jyväskylä Longitudinal Study of Dyslexia (JLD)

ACKNOWLEDGEMENTS

This dissertation is part of the Jyväskylä Longitudinal Study of Dyslexia (JLD) belonging to the Human Development and Its Risk Factors Program at the University of Jyväskylä. This program was appointed the status of the Center of Excellence for two consecutive terms (between 1996 and 2004) by the Academy of Finland. I was very fortunate to have the chance to work with and learn from the innovative team of researchers involved in this program. Besides providing me the physical context and facilities, the membership of this research team has provided an enormous amount of warm guidance and support. I also want to thank the Finnish Graduate School of Psychology for granting me funding for a large part of my dissertation work, giving me opportunities to meet students and supervisors from other universities, and for organizing several interesting courses.

The existence of the JLD data that I was able to employ in this dissertation is the result of great effort on the part of the researchers and students and also the families who kindly worked with us for almost ten years. Without their participation, the findings reported here and several others would not have been published. Special thanks also go to Tarja Etelälahti, Kirsti Eklund and Kenneth Eklund for their work in the data collection.

The completion of this dissertation depended heavily on the kind instruction and assistance of several people. First, I wish to thank my three supervisors, Prof. Heikki Lyytinen, Prof. Anna-Maija Poikkeus and Prof. Esko Leskinen. Prof. Heikki Lyytinen asked me to join the project in Spring 2000 and since then has provided me with possibilities to learn, travel and work as a part of a research group. He has also provided new ideas and encouraged me to develop my own areas of interest. I greatly value his open-mindedness, innovativeness and approachability. Prof. Anna-Maija Poikkeus has taught me the most about writing a scientific report. In addition to her talent in teaching writing and scientific thinking, her support and encouragement at some difficult times has been crucial for the completion of this work. I also wish to thank Prof. Esko Leskinen for the support and direct help with the analyses in the papers included in this dissertation and furthermore for the work that he has done to advance the methodological skills in our field which indirectly has helped me and several others in our research. I am also grateful to the other co-authors of the individual papers: Marja-Leena Laakso, Kenneth Eklund, Marja-Kristiina Lerkkanen, Anne Puolakanaho, Paavo Leppänen and Asko Tolvanen. In particular, I wish to thank Asko Tolvanen for his extensive instruction with regard to modeling with LISREL and M-plus and for his valuable support and encouragement in times of struggle with the analyses. Thanks also to Matthew Wuethrich and Jane Erskine for polishing the language of the manuscripts with great skill, flexibility, and efficiency. In addition, I would like to express my gratitude to the Nyrkki-group and to the whole JLD gang who have become more close friends than merely colleagues.

Finally, my very special thanks go to Jussi, Onni, and Olavi for reminding me patiently about priorities and realities of life. The past years have been rather eventful for several reasons and many thanks and apologies belong also to other members of our families.

LIST OF PUBLICATIONS

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

II 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.

III 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.

CONTENTS

ABSTRACT
LIST OF PUBLICATIONS

1 INTRODUCTION 11
1.1 Prediction of reading acquisition 12
Early language and literacy skills 12
Learning environment and child's reading interest 14
Familial risk for dyslexia 15
Gene-Environment interplay and literacy development 16
1.2 The dynamic interactive view on individuals development 17
1.3 Aims of the empirical studies 20

2 METHOD 22
2.1 Participants 22
2.2 Measures 23

3 OVERVIEW OF THE ORIGINAL STUDIES 26
3.1 Study I: Modeling the early paths of phonological awareness and factors supporting its development in children with and without familial risk for dyslexia 26
3.2 Study II: Predicting delayed letter name knowledge and its relation to grade 1 reading achievement in children with and without familial risk for dyslexia. 27
3.3 Study III: Reading development subtypes and their early characteristics 29

4 GENERAL DISCUSSION 32
4.1 The intertwined development of language and literacy skills 33
4.2 Learning environment and child's reading interest in relation to skill development 35
4.3 Familial risk for dyslexia and gene-environment interplay in relation to skill development 35
4.5 Limitations and suggestions for future research 38
Familial risk and genes 38
On measuring the environment 39
Methodological evaluation 40
4.6 Some concluding remarks 42

TIIVISTELMÄ 43

REFERENCES 46

1 INTRODUCTION

Although the Finnish education system is very efficient (e.g., OECD, 2004) and our written language system is relatively easy to acquire (in comparison to several other languages; Seymour, Aro, & Erskine, 2003), Finnish children are not exempt from difficulties in the acquisition of fluent reading skill and reading difficulties are also prevalent among Finnish adults. In recent years, numerous researchers have searched for the predictors of reading difficulties but mainly in the context of English language. To date, the strongest evidence points to (a) familial risk for dyslexia, that is, incidence of developmental dyslexia among close relatives (e.g. Gilger, Pennington, & DeFries, 1991; Pennington, Gilger, Pauls, Smith, Smith, & DeFries, 1991; Scarborough, Dobrich, & Hager, 1991; Snow, Burns, & Griffin, 1998; Snowling, Gallagher, & Frith, 2003) and (b) the early development of language and literacy skills, especially phonological awareness, letter knowledge, rapid naming and more general language abilities such as vocabulary (e.g. Adams 1990; Byrne, 1998; Elbro, Borstrøm, & Petersen, 1998; Gallagher, Frith, & Snowling, 2000; Holopainen, Ahonen, & Lyytinen, 2001; Lonigan, Burgess, & Anthony, 2000; Pennington & Lefly, 2001; Scarborough, 2001; Snow et al., 1998; Vellutino, Fletcher, Snowling, & Scanlon, 2004; Wimmer, Mayringer, & Landerl, 1998, 2000; Wimmer & Mayringer, 2002).

In predicting a skill such as reading, which can only be learned through interaction with a literate society, the effects of the learning environment should not be omitted from predictive considerations. In modern literate societies such as Finland, where literacy is highly valued and where all children have access to efficient reading instruction at school, the probability that a child will have a very deprived exposure to written language is low. Many intriguing questions, however, remain. For instance, is the variation at the 'high end' of environmental support associated with the development of reading and reading related skills? What aspects of the learning environment are important and what is the role of the child's own interest for and motivation to attend to reading activities? It has previously been shown that in addition to the genetic effects, there is a significant environmental impact on various language and

literacy skills (e.g., Castles, Datta, Gayan, & Olson, 1999; Harlaar, Spinath, Dale, & Plomin, 2005; Petrill, Deater-Deckard, Schatschneider, & Davis, 2005).

Even though studies concerning the early predictors of reading development are plentiful, relatively few have investigated the predictive value of children's early language and literacy skills while simultaneously taking into account the children's learning environments, early skills and familial risk for dyslexia. The goal of the present study was to employ a more holistic approach to account for these different levels of a developing child and his/her environment. Since the follow-up of child skills began before the first year of life, the data collection has also spanned a longer time period than in most previous studies. The research design of the Jyvaskyla Longitudinal Study of Dyslexia (JLD) provided a unique opportunity to investigate the developmental pathways toward reading acquisition of children with and without familial risk of dyslexia. Its longitudinal design allowed simultaneous investigation of the development of children's language and literacy skills, environment and interest between birth and 8 years of age.

Asking questions at both the level of associations between variables and the level of individuals' development as a dynamic system required more from the data analysis than typically offered by the traditional variable-oriented statistical methods. Therefore, in each of the Studies I-III, a combination of variable-oriented and person-oriented methods was used. We utilized some newer statistical tools that gave a better chance to investigate reading-related learning paths focusing on the development of individual children instead of using only group means and variances.

1.1 Prediction of Reading Acquisition

In this section, previous findings concerning key predictors of reading acquisition in the domains of early skills, learning environment and familial risk for dyslexia will briefly be described. More detailed description linked to the specific research questions of Studies I-III can be found in the introduction of the respective articles.

Early Language and Literacy Skills

The strongest early skill predictors of later word recognition or decoding have repeatedly been shown as phonological awareness and letter knowledge (e.g. Adams 1990; Byrne, 1998; Elbro et al., 1998; Gallagher et al., 2000; Lonigan et al., 2000; Pennington & Lefly, 2001; Scarborough, 2001; Snow et al., 1998; Vellutino et al., 2004). This is understandable since knowledge of the written language code (letter names and sounds) and awareness of the fact that language is composed of smaller segments, ultimately of phonemes (phonological awareness) form the basis of the ability to grasp the principle of grapheme-phoneme correspondence and consequently, to decode text. Problems in

phonological processing have also been considered as the major causal explanation for dyslexia (e.g., Lyon, Shaywitz, & Shaywitz, 2003; Stanovich & Siegel, 1994).

In addition, especially in highly consistent orthographies such as Finnish or German, relatively strong predictive associations have been observed also between word reading and serial naming speed (e.g., Holopainen et al., 2001; Wimmer et al., 1998, 2000; Wimmer & Mayringer, 2002). In transparent languages, the ease with which reading accuracy can be attained (e.g., Seymour et al., 2003) has shifted the focus towards identification of reading difficulties with measures of reading fluency. Rapid Serial Naming, assessed using the Rapid Automatized Naming Test (RAN; Denckla & Rudel, 1976), measures the efficiency of serial speech sound retrieval from memory. It is therefore no surprise that rapid naming correlates strongly with reading, particularly when reading fluency is the outcome measure. In a recent analysis of the JLD data predicting 2nd grade reading difficulties with measures from time points 3.5, 4.5, and 5.5 years, the best early predictors were letter knowledge, phonological awareness, and rapid naming (Puolakanaho, et al., 2007).

The predictors of *reading comprehension* appear to be at least partly separate from those of *decoding* skill (e.g. Bishop & Snowling, 2004; Catts, Adlof, Hogan, & Weismer, 2005; Catts, Hogan, & Fey, 2003; Leach, Scarborough, & Rescorla, 2003; Muter, Hulme, Snowling, & Stevenson, 2004; Nation & Nordbury, 2005; Oakhill, Cain, & Bryant, 2003; Phillips & Lonigan, 2005; Tunmer & Hoover, 1992). Individuals with poor reading comprehension skills (in the absence of word recognition difficulties) typically perform below-average on a wide range of other than primarily phonological oral language measures, especially in tasks that tap vocabulary, listening comprehension, semantics, and morphosyntax (e.g. Cain, Oakhill, & Bryant, 2004; Lyytinen, Aro, Holopainen et al., 2006; Nation, Clarke, Marshall, Durand, 2004; Roth, Speece & Cooper, 2002; Stothard & Hulme, 1995; Sénéchal & LeFevre, 2002; Storch & Whitehurst, 2002). In addition, poor comprehension has often been associated with deficits in short term memory and problems in 'higher level skills,' such as poor inference making and comprehension monitoring (e.g. Cain et al., 2004). Some poor comprehenders also perform below average in general cognitive ability (Nation et al., 2004).

Vocabulary skills represent a skill area that appears to predict both reading comprehension and decoding (e.g. Catts, Fey, Tomblin, & Zhang, 1999; Nation & Snowling, 2004). Prospective follow-up studies have found that children with familial risk for dyslexia perform on average at a lower level than control children, not only in phonological awareness, letter knowledge and rapid serial naming, but also on tasks measuring vocabulary (Elbro et al., 1998; Gallagher et al., 2000; Lyytinen et al., 2004; Lyytinen et al., 2006; Scarborough, 1990; Snowling et al., 2003). Whilst it is argued that vocabulary growth is a critical feature of the restructuring process for phonological representations (e.g. Fowler, 1991; Metsala & Walley, 1998), both phonological awareness (e.g. Bowey, 2001; McBride-Chang, Wagner, Muse, Chow, & Shu, 2005) and

phonological memory (e.g. Gathercole, Willis, Emslie, & Baddeley 1992) have been shown to predict vocabulary skills.

Learning Environment and Child's Reading Interest

Studies demonstrating the role played by the learning environment with regard to children's language and literacy development have employed a large repertoire of measures that tap different aspects of the environment (e.g. Burgess, 1997, 2002; Bus, van Ijzendoorn, & Pellegrini 1995; Crain-Thoreson & Dale, 1992; Frijters, Barron, & Brunello, 2000; Lyytinen, Laakso, & Poikkeus, 1998; Payne, Whitehurst, & Angel, 1994; Scarborough et al., 1991; Scarborough & Dobrich, 1994; Sénéchal & LeFevre, 2002). Before school entry, variation in features of the home literacy environment (HLE) has been the keenest focus of interest. The three components that Lundberg (1991) includes in his "informal literacy socialization" model cover most of these aspects: 1) exposure to written language (e.g., shared reading experiences), 2) access to written language (e.g., books available, library visits) and 3) positive models (e.g., parent's own reading activities and attitudes). In the analyses reported in this thesis, we employed this division of home literacy environment (HLE) aspects provided by Lundberg (1991) but supplemented by three additional factors of children's learning environment which have been shown to be relevant to literacy and language development. These are letter name teaching (e.g. Sénéchal & LeFevre, 2002), school classroom effect (McCoach, O' Connell, Reis, & Levitt, 2006; Rowan, Correnti, & Miller, 2002) and parental education (e.g., Laakso, Poikkeus, Eklund & Lyytinen, 1999).

Of the HLE measures, parent-child shared book reading has gained the most interest. The context of shared reading is believed to be particularly beneficial to children's language development as it draws the partners into reciprocal interaction and, in turn, activates the child's own input and comments (Lewis & Gregory, 1987). In addition, the clearly defined reference context of shared reading helps to maintain joint focus (Dunham, Dunham, & Curwin, 1993) and contains sophisticated linguistic models (ones with great lexical diversity, syntactic complexity and a high rate of topic continuing replies, e.g., Hoff-Ginsberg, 1991). The early exposure to shared reading experiences has been found to be positively, albeit moderately, associated with e.g., receptive and expressive vocabulary (Frijters, et al., 2000; Griffin & Morrison, 1997; Lyytinen et al., 1998; Payne et al., 1994; Sénéchal & LeFevre, 2002; Sénéchal et al., 1998); syntactic comprehension and knowledge of print conventions (Crain-Thoreson & Dale, 1992). The overall effect of shared reading on literacy and language skills has been estimated at approximately 8 % (Bus et al, 1995; Scarborough & Dobrich, 1994). The evidence for the positive effects of shared reading is clearest for the oral language domain whereas for the learning of letters, direct teaching of letter symbols is generally required (Sénéchal & LeFevre, 2002).

The positive models that parents provide to their child through their own literacy practices and attitudes may have an indirect influence on their child's

development (Bus et al., 1995; Lundberg, 1991; Scarborough, et al., 1991; Snow, et al., 1998). It has been suggested that a child who frequently observes his or her parents' frequent and enjoyable engagement in literacy activities is likely to be more interested in participating in shared reading activities (Lyytinen et al., 1998), more motivated to learn about letters and more persistent in the face of difficulty (Scarborough et al., 1991; Snow, et al., 1998). In the light of empirical findings, parents' literacy-related behaviours, as well as the mere access to print materials appear to have a smaller impact on the child's literacy and language development than parent-child shared reading experiences (Payne et al., 1994; Scarborough et al., 1991; Scarborough & Dobrich, 1994).

After school entry a new environmental variation emerges; the effect of being a member of a certain classroom. In addition to the effect of teacher differences, there are also differences in other classroom characteristics (e.g. number of pupils, or number of pupils with special needs) which may support or hinder the children's learning. In certain cases, the proportion of variance in children's reading skills accounted for by classroom membership has been suggested to be even larger than individual differences. In a study by Rowan et al. (2002) approximately 60 % of variance in student reading growth was accounted for by classroom and 27-28% by individual characteristics. Because the analyses that can separate classroom and individual variance require large samples of school classes, they are rarely employed in studies of dyslexia. In Study III of the present work we were able to assess and control for the effect of school classroom membership.

In addition to the various features of the environment, several researchers have stressed the importance of children's own literacy interest in understanding the dynamics between environmental factors and children's language and literacy development (e.g., Lonigan, 1994; Scarborough, & Dobrich, 1994). A child who is highly interested in reading activities is probably in a better position to develop a strong foundation for literacy development than a child who is not as motivated or interested (Bus et al., 1995; Dunning et al., 1994; Laakso, et al., 1999; Lyytinen, et al., 2001; Scarborough & Dobrich, 1994; Whitehurst & Lonigan, 2001). Children's literacy interest is related to how much time they spend on reading activities and how actively they inquire into the meanings of print (Crain-Thoreson & Dale, 1992; Scarborough & Dobrich, 1994; Whitehurst & Lonigan, 2001) although the direction of cause and effect is unclear (Bus et al., 1995; Lonigan, 1994; Scarborough & Dobrich, 1994). Child's interest in reading has been shown to be associated with syntactic comprehension, vocabulary and print conventions (Crain-Thoreson & Dale, 1992, Laakso et al., 1999; Lyytinen et al., 1998), with letter knowledge (Frijters et al., 2000) and reading development (Scarborough et al., 1991).

Familial Risk for Dyslexia

Even though reading is a characteristic of a literate society and as such closely twinned with the cultural environment, the prerequisites to read and to become a fluent reader relate also to the innate characteristics of a person. Behavioral

and molecular genetic research has confirmed that reading difficulties have a hereditary basis (e.g., Cardon et al., 1994; Finucci, Guthrie, Childs, Abbey, & Childs, 1976; Fisher et al., 1999; Hallgren, 1950; Olson, Datta, Gayan, & DeFries, 1999; Taipale, et al., 2003). Children from families where several members have reading disabilities has been found to run a higher than normal risk of facing difficulties in learning to read (Gilger et al., 1991; Pennington et al., 1991; Scarborough et al., 1991; Snow et al., 1998; Snowling et al., 2003). The risk of dyslexia has been reported to rise from few percentages among the general population to about 50 % when dyslexia runs in the family with a parent and his/her relative(s) has been affected (e.g. Lyytinen et al., 2004). It should be noted, however, that familial risk does not equal to genetic risk since family members share both genes and environment (short discussion about this matter below).

Gene-Environment Interplay and Literacy Development

In complex behavioral disorders such as developmental dyslexia, the etiology is multifactorial involving risk and protective factors that are both genetic and environmental (e.g. Pennington, 2006, Plomin, 1994, Rutter, Dunn, Plomin, et al., 1997; Rutter, & Silberg, 2002, Rutter et al., 2006). That is, the source of the total risk of a child growing up in a family with dyslexia may not be fully genetic. It has been found that parents with reading difficulties read less themselves (Bus et al., 1995; Elbro et al., 1998; Scarborough et al., 1991; Snowling, 2000) and have less positive attitudes towards reading - especially parents with more severe problems (Leinonen et al., 2001). Contrary to the assumptions, however, differences have not emerged between families with and without reading difficulties in the amount or quality of parent-child shared reading (Elbro et al., 1998; Gallagher et al., 2000; Laakso et al., 1999; Scarborough et al., 1991; Snowling, 2000).

Although the measures of shared reading, access to reading materials, parental models, letter name teaching and parental education are referred to as environmental measures in the present thesis, they are not and should not be considered as pure environmental effects. Environmental risk factors necessarily also include a genetic component (as the familial risk includes an environmental component), through gene-environment interaction (GxE) and correlation (R_{GE}) (Plomin, 1994, Rutter et al., 1997; Rutter, & Silberg, 2002, Rutter et al., 2006). GxE refers to one's sensitivity to environmental influences due to one's genetic makeup and R_{GE} refers literally to the correlation between genes and environment. In short, genetic risk may be correlated with the environmental risks that one experiences. The process behind the development of R_{GE} has been described as active, evocative, or passive. The active process refers to a situation where one actively selects environments based on one's genetic make-up. The evocative process refers to a situation where the environment reacts to the properties of an individual depending on his/her genetic make-up. The passive process refers to a situation where one's

environment matches with one's genetic make-up, e.g. through genetic similarity between a child and his/her parents.

Consideration of the GxE and R_{GE} processes in relation to reading development and dyslexia leads to various presumptions about the total familial risk for dyslexia. For instance, parents' reading skills and parental attitudes toward reading (possibly affected by the parents' genetic makeup) may lead to differences in their children's environment. Since children share genes with their parents, the home literacy environment children experience probably correlates with their genetic makeup due to the genetic similarity between parents and their children. The child's innate differences are also likely to trigger different behaviors from the environment (via evocative or reactive R_{GE}). For instance, how much a parent believes his/her child is interested in language-related games or shared reading may influence how a parent provides such materials and activities. In addition, from early on, how much a child actively selects their environment (active R_{GE}) affects their development. For instance, how much do children draw their parents into shared reading and the world of books and letters and how much do they clearly prefer other types of activities? Unfortunately, we were unable to directly test the GxE and R_{GE} processes in our data. In the present work, the information concerning high risk of reading difficulties due to having close relatives with dyslexia was used as a proxy for genetic vulnerability of a child.

1.2 The Dynamic Interactive View on Individuals Development

The view of the nature of human development as a dynamic process occurring in interaction with the environment is not new and has been described with somewhat varying concepts and emphases (e.g. Allport, 1937; Bergman, Magnusson, & El-Khouri, 2003; Gottlieb, 1991, 1998, 2003; Pennington, 2006; Nesselroade, 2001; Sameroff & MacKenzie, 2003). According to this view, human development is best understood through the interactions between the system and its environment. The parts of the system take their meaning from their interactions among other parts of the system rather than from themselves as such. This developmental dynamic between an organism and its environment is complex and unique for each individual, beginning from the complexity of gene functioning.

Adoption of the dynamic interactive view of human development is very challenging with regard to study designs, measurement strategies and data analysis. Variable-oriented methods aim to maximize the prediction across all individuals and may therefore provide results that are not well suited to provide generalizations to any given individual. Drawing inferences about individuals' based solely on aggregated statistical data may lead to erroneous conclusions (known as ecological fallacy) since it is improbable that all members of a group exhibit characteristics of the group at large (e.g. Bergman,

2001; Bergman, Magnusson, & El- Khouri, 2003; Magnusson, 2001; von Eye & Bogat, 2006). The interactive complexity assumed by dynamic models leads to a paradox in the use of traditional statistical analyses group means and variances because the outcome of the analysis we want to generalize, does not describe in detail any given individual (e.g. Allport, 1937). Or as Gottlieb [2003, p.339] describes: "*…generalizations from individual differences do not illuminate individual development*". That is, to understand human development, we should focus on individual development from a multivariate and interactionist perspective, viewing individuals at different levels simultaneously.

In the present thesis, an attempt was made to step closer to the complex nature of the evolvement of developmental dyslexia by a) including both environmental and genetic risk/protective factors into the analysis, b) by examining skill development longitudinally in several domains of development simultaneously, and c) by adopting analysis strategies that would match with the more holistic research questions. This led us to combine variable-oriented and person-oriented techniques.

Variable-oriented and person-oriented analysis techniques are at their best in different situations (e.g. von Eye & Bogat, 2006). The traditional variable-oriented analysis techniques are well-suited to the description of associations between variables. Questions concerning the predictive power of measures of early skill on subsequent skills across individuals can be answered with variable-oriented methods such as regression analysis or variance analysis. These methods do, however, assume that all individuals are homogeneous in how the predictors operate among each other and on the outcome. The person-oriented approach, in contrast, describes differences between individuals in the measured variables and in their associations. In person-oriented methods, types or groups of individuals who share the same levels and/or similar associations between variables are identified. The assumption of the person-oriented approach is that the population is heterogeneous in how the predictors operate among each other and on the outcome. But can the dynamic system and its environment be studied at several levels simultaneously and the unique transformed into scientific generalizations? The holistic, dynamic, or interactionistic view has been criticized for being too general and leading to suggestions that everything is connected to everything and leaving no space for scientific testing of hypotheses about relationships of specific phenomena. The following solutions and clarifications have been provided:

First, the inclusion of all levels of human functioning into one study is not possible. Developmental studies should, however, make an effort to include several levels and recognize the dynamic interactive framework or alternatively take into account the limitations if one is working only at one level (e.g. Magnusson & Törestad, 1993).

Second, a constantly changing dynamic system can be studied through the analysis of the current position of the system at a given time ("state") (e.g. Bergman & El-Khouri, 2001). In longitudinal data, the "state of the system" (e.g. profile) can be examined at several time points and the change from one state to another may be followed across individuals.

Third, even though at a detailed level each individual is unique, at a more global level, there may be only a few more frequently observed typical patterns of behavior or development (also described with the concept of attractors) (e.g. Bergman & El-Khouri, 2001). That is, any given state of a process may be partially specific to an individual and partially common to several individuals. As Bergman and El-Khouri (2001) stated "*A meaningful coherence and structure can often be found in individual growth and in the process characteristics of different individuals.*" A person oriented approach is often operationalized as an examination of developmental profiles of individuals and as a search for similarities across individuals.

Fourth, statistical advances are needed to fit the method to the research questions of human development and not the other way round. In the recent years, progress has been made in areas of statistical analysis methods (e.g. Bergman et al., 2003; Molenaar, Huizenga, & Nesselroade, 2003; Muthén, 2006; Nagin & Tremblay, 2001; Nesselroade, 2001). Traditional cluster analysis for instance has been challenged on the validity of the clustering solution (it should be noted that wrongly formed sub-groupings may also lead to ecological fallacy) but the newer techniques provide tests for the solutions and provide more flexible possibilities for formulations of the underlying model of the sub-grouping. These models do not limit themselves to only linear relationships between variables and do not assume identical structure for every individual in the data. In the present thesis these newer techniques were applied and combined with more traditional variable-oriented approaches.

In reading research, the variable-oriented approach has been favored over person-orientation. It has been shown, however, that there is apparent individual heterogeneity in how reading skills develop (Catts et al., 2003; Leach et al., 2003; Nation et al., 2004; Shankweiler, Lundquist, Katz, et al., 1999) and that individuals with reading difficulties may have different language and cognitive profiles (e.g. Morris, Stuebing, Fletcher et al., 1998; Lyytinen et al., 2006). That is, not all individuals with reading difficulties manifest the same pattern of difficulties or strengths with respect to word reading accuracy, fluency, or comprehension, for instance. This heterogeneity leads to difficulties concerning the search for predictors or precursors of reading difficulties since not all people have the same underlying combinations of difficulties or risks. Examination of the heterogeneous profiles of the JLD children's language and literacy skills and their association with early reading and spelling ability (Lyytinen et al., 2006), suggested that there are at least three routes to difficulties in reading acquisition, with the most explicit routes being characterized by problems in phonological awareness, naming speed and letter knowledge.

1.3 Aims of the Empirical Studies

This thesis focused on the heterogeneity of the development of phonological awareness, letter knowledge and reading. An attempt was made to describe and predict this heterogeneity with a more holistic approach than previously, i.e. by including several aspects of risks and protective factors within individuals and their environments (see Figure 1 for the general framework of association investigated in Studies I-III). In the data analysis, the aim was to select the most advanced statistical techniques to answer the research questions.

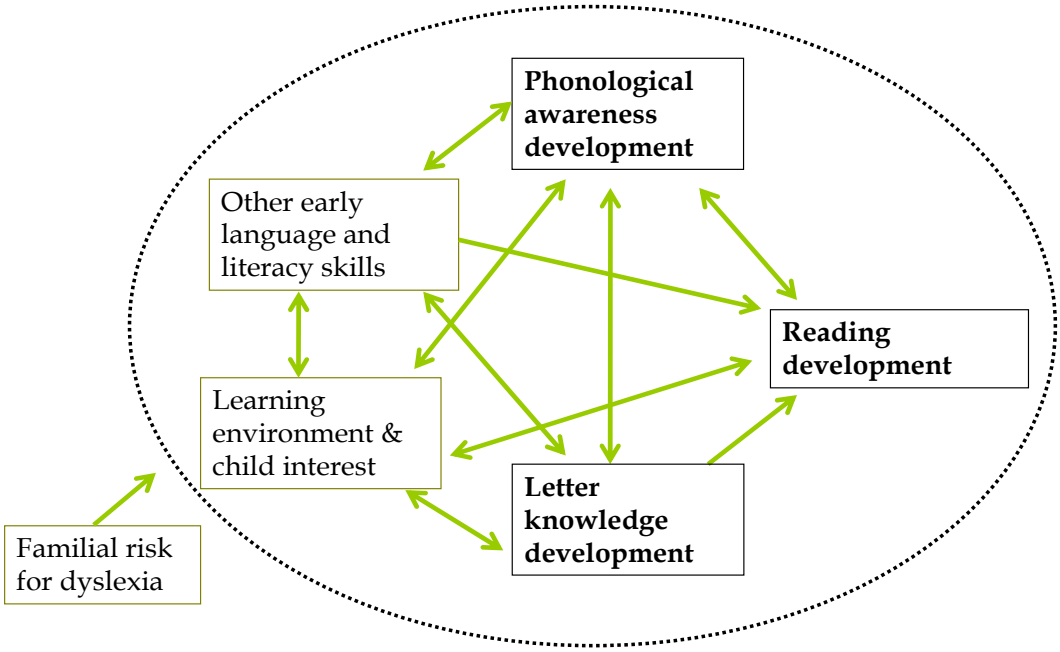


FIGURE 1 The general framework of associations examined in Studies I-III.

Study I focused on the development of phonological awareness (PA) before school age. The aim was to examine PA development and its precursors in a multivariate longitudinal model that includes both relevant cognitive and environmental predictors. The longitudinal associations between PA development and several measurements of a) learning environment, b) child interest and c) child's early skill development were examined. Familial dyslexia risk was taken into account and separate models were fitted for at-risk children and the control children.

In Study II, the development of letter knowledge was the focus of interest. Even though letter knowledge is one of the strongest predictors of reading, few longitudinal studies have focused on letter knowledge development. This study included several measurements of letter knowledge within an age range that has the potential to capture the learning process (4.5 – 6.5 years) and a comprehensive set of known letter knowledge predictors. Focus was on the individual heterogeneity in letter name learning and prediction of deficient

letter knowledge development. Further, the effects of letter name knowledge on beginning reading skills were then examined. We also examined whether predictors of slow letter name learning were similar for children with and without familial risk for dyslexia.

In Study III the aim was to test the reading subtype hypothesis derived from the *Simple view of reading* (Gough & Tunmer, 1986). The goal was to identify reading difficulty subtypes by using a design and methodological tools which enabled us to overcome some of the limitations of earlier studies i.e., small sample sizes, single time point designs not addressing the classroom effect and use of the more traditional, most typically cut-off score-based sub-typing analysis. The second goal was to examine the extent to which children following different reading development profiles manifest differences in early skill development and reading experiences.

2 METHOD

2.1 Participants

Data were drawn from the Jyväskylä Longitudinal Study of Dyslexia (JLD), a prospective follow-up of children from birth to school age. The JLD seeks to identify early language development and precursors of dyslexia (for the most recent review of results, see Lyytinen et al., 2004). From four successive age cohorts of families invited for screening, a total of 214 families from the city of Jyväskylä and its surrounding communities in the Province of Central Finland joined the study prior to the birth of their children. Half of the participating families included a parent who had been diagnosed with dyslexia and who also reported similar problems among immediate relatives. The children from these families are referred to as the at-risk group. The control group comprised children from families whose parents gave no personal or familial report of reading or spelling difficulties. Parents also underwent extensive cognitive and literacy-based assessment (see Leinonen et al., 2001 for full details). All the children were native Finnish speakers and had no mental, physical, or sensory handicaps. The JLD attrition rate was low, with 199 of 214 families continuing to participate in the project until the end of the project when the children had completed the 3rd grade. These data were used in all of the studies.

In Study III, we also employed information regarding the JLD children's school classmates. When the JLD children entered school (in the year they turned seven years of age), group assessments of the first two of the four age cohorts were conducted in schools for the whole classrooms. The third and fourth JLD age cohorts were assessed individually (n = 77). Altogether 1803 children participated in the group tests. Group tests were administered twice during the first grade (November and April) and twice during the second grade (November and April). Children who participated in only one of the four group assessments were excluded from the data. The data used in the analyses for Study III comprised 1750 children from 93 classes. Of these children, 191 were JLD follow-up participants.

2.2 Measures

Table 1 describes the measures and assessment phases of Studies I-III. In all of the studies the design was longitudinal. More detailed descriptions of the measures are available in the original papers.

In Study I, phonological awareness development was studied across time by using latent growth curve analysis (LGC). To examine development across time with the estimates of trajectory slope and intercept as performed in LGC, the measures have to be identical across time. Phonological awareness was measured by three tasks: synthesis, identification and blending which were assessed at 4.5, 5.5, and 6.5 years. Selection of other skill measures, letter knowledge, vocabulary and beginning reading was guided by previous findings on their associations to phonological awareness. The operationalizations of the home literacy environment (HLE) and child's reading interest were based on the most reliable combinations of questionnaire items.

In Study II, letter knowledge development was studied across time using four time points between 4.5-6.5 years. Measures of several early skills, HLE factors and child's reading interest from earlier age phases were used to predict slow letter name learning. Selection of predictors was based on previous findings and theory.

Study III examined whether reading subgroups suggested previously with the use of cut-off criterions or traditional cluster analysis can be found by using a more sophisticated classification analysis (mixture modeling), longitudinal data and a large sample where controlling of the classroom effect is possible. Reading comprehension and fluent word recognition were assessed by measures available from children's group tests from 1st and 2nd grade. In addition, the early development and learning environments of the JLD follow-up children within each obtained reading subgroup were described. A wide range of measures was selected to this description based on previous findings.

TABLE 1 Assessment phases and methods used in the studies of the dissertation

Measures	Child's age	Study I	Study II	Study III
Early language and cognitive skills				
Letter knowledge	3.5 y			X
	4.5 y	X	X	X
	5.0 y		X	X
	5.5 y	X	X	X
	6.5 y		X	X
Phonological awareness	3.5 y		X	X
	4.5 y	X		X
	5.5 y	X		X
	6.5 y	X		X
Vocabulary	1 - 1.5 y			X
	2.5 y			X
	3.5 y	X	X	X
	5 - 5.5 y	X		X
Rapid naming	3.5 y		X	X
	5.5 y			X
	6.5 y			X
Morphological awareness	3.5 y			X
	5 y			X
Memory	3.5 y		X	X
	5.5 y			X
	6.5 y			X
Performance IQ	5.0 y		X	
	8.0 y			X
Verbal IQ	8.0 y			X
Environmental measures and interest				
Shared reading	2 y	X		X
	4 y	X	X	X
	5 y	X		X
	6 y	X		X
	7 y			X
	8 y			X
Access to reading materials	4 y	X		
	5 y	X		
	6 y	X		
Teaching of letters	4.5 y		X	
Parental reading habits	0 y	X		

(continues)

(TABLE 1 continues)

Measures	Child's age	Study I	Study II	Study III
Parental education	0 y	X	X	
School classroom membership	1st – 2nd grade			X
Child's interest in reading	2 y	X		
	4 y	X	X	
	5 y	X		
	6 y	X		
Reading alone	4 y			X
	5 y			X
	6 y			X
	7 y			X
	8 y			X
<u>Reading skills</u>				
Reading accuracy	6.5 y	X		
Reading fluency	1st grade		X	X
	1st grade		X	X
	2nd grade			X
	2nd grade			X
Reading comprehension	1st grade		X	X
	2nd grade			X
	2nd grade			X

3 OVERVIEW OF THE ORIGINAL STUDIES

3.1 Study I: Modeling the early paths of phonological awareness and factors supporting its development in children with and without familial risk for dyslexia

In this study the development of phonological awareness (PA) between ages 4.5 and 6.5 years was modeled in association with the development of vocabulary and letter knowledge, home literacy environment (HLE), children's reading interest and beginning reading skill in children with and without familial risk of dyslexia. The aim was to present a longitudinal model of the development of phonological awareness and skills shown to be related to its development, together with environmental measures and information on familial risk for dyslexia. Figure 2 depicts the associations investigated.

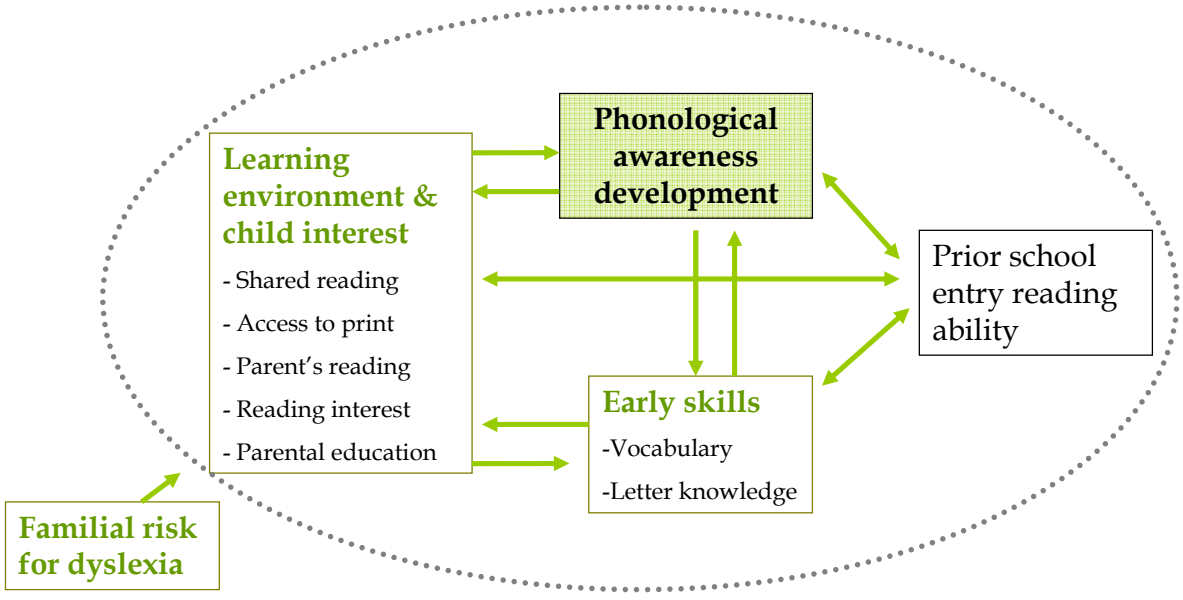


FIGURE 2 Description of Study I.

We asked: 1) What pattern of association exists between PA development, vocabulary and literacy skills (i.e. letter knowledge and beginning reading) before school age? 2) What is the role of different aspects of home literacy environment and children's reading interest in the early skill development of PA, vocabulary and literacy skills? 3) Does familial risk for dyslexia risk have an effect on the development of skills, reading interest, HLE factors, or on the pattern of associations?

The participants were 186 JLD follow-up children. Of these children, approximately half had a familial background of reading difficulties (the at-risk group) and the other half came from families without such background (the control group). The data with several measures and assessment time points were analyzed within an SEM framework and a latent growth curve analysis was employed.

The results suggested that the longitudinal associations between vocabulary, letter knowledge and PA development between ages 3.5 years and 6.5 years of age are reciprocal. Beginning reading skill was found to be associated with both letter knowledge and PA. Of the HLE factors, shared reading was found to be a significant predictor of subsequent vocabulary and its effect on PA was mediated by vocabulary. The effect of familial risk on the skill levels was evident, favoring the controls, but the pattern of effects of vocabulary and letter knowledge on PA development was highly similar in children with and without familial risk for dyslexia. On the other hand, familial risk was not found to have an effect on the HLE factors or child's reported interest in reading, except that parent's own reading activities were rarer in the at risk group than in the controls. However, in the at-risk group the HLE factors and children's reading interest had stronger associations with each other and with skill development than in the control group and vocabulary predicted children's reading interest in the at-risk group only.

It may be concluded that this study gave support to the previous findings of reciprocal associations between the development of vocabulary, PA and letter knowledge. The associations appear to be similar irrespective of familial risk for dyslexia. The effects of home environment, measured as parental reports of frequencies of activities, are rather small on skill development. It should be noted that the association is reciprocal; it is also likely that the child's skills affect the literacy experiences that she or he receives, not that the literacy environment alone affects the child's skills.

3.2 Study II: Predicting delayed letter name knowledge and its relation to grade 1 reading achievement in children with and without familial risk for dyslexia

In this study our goal was to add to the literature on letter name knowledge predictors as despite the existence of a consensus that letter knowledge is one of

the best predictors of subsequent reading skill, research concerning the cognitive basis of letter knowledge is surprisingly scarce (de Jong & Olson, 2004). We examined how letter knowledge develops before entry to formal instruction and the extent to which individual variability is seen around the average developmental curve. Second, we were interested in how children with heightened risk for problems in reading and pre-reading skills (i.e. children with familial risk for dyslexia) learn letter names as compared to children without such risk. Third, we examined which preceding language skills and environmental factors differentiate children with differing paths in letter knowledge development. Fourth, we examined the predictive association between children's letter knowledge trajectories and reading development during Grade 1. Figure 3 depicts the association investigated.

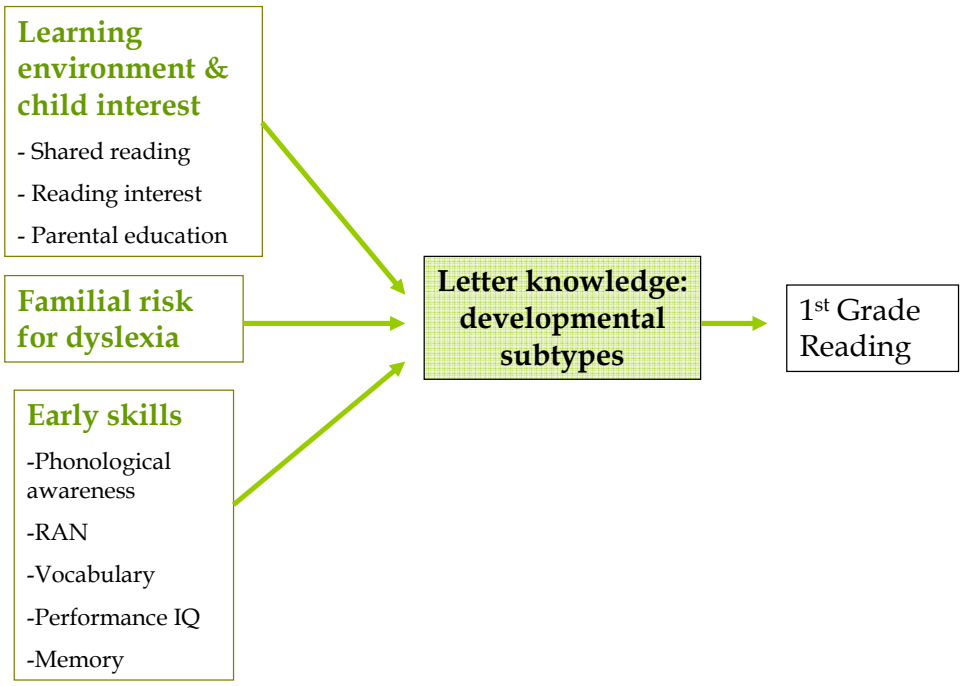


FIGURE 3 Description of Study II

Letter knowledge was assessed longitudinally at ages 4.5, 5.0, 5.5, and 6.5 years, the preceding language skills and environmental factors at ages 3.5 and 4.5 years and reading achievement at the beginning and end of Grade 1. The analyses were conducted on a longitudinal data set involving children with and without familial risk for dyslexia. Trajectory analysis was employed to identify heterogeneous clusters of children in letter knowledge development (e.g. Nagin & Tremblay, 2001).

Three separate letter knowledge clusters were identified; a cluster with a delayed learning curve (n =63), a cluster with an approximately linear growth curve (n = 73) and a cluster with precocious development (already showing high ability by age 4.5, n = 51). The members of the delayed cluster were predominantly children with familial risk for dyslexia and the members of the precocious cluster were predominantly non-risk group children. In terms of

language and cognitive skills, delayed letter knowledge was predicted by phonological sensitivity, phonological memory and rapid naming skills. Environmental predictors included level of maternal education and the amount of home-based letter name teaching. Familial risk for dyslexia also made a significant contribution to the predictive relationships. Membership of the delayed cluster was a better predictor of poor reading performance at Grade 1 than membership of any of the alternative clusters. Almost all the children who subsequently experienced difficulties in beginning reading were children with a delayed letter name learning curve, irrespective of whether they belonged to the at-risk or the non-risk group.

This study endorses the view that letter name knowledge development is, by far, not solely dependent upon the amount of letter name teaching or other types of environmental exposure. Instead, a variety of language and cognitive capacities, in particular, phonological processing, play an integral part in the optimal learning of letter names. The findings underline the effect of familial risk of dyslexia. For children with familial risk for dyslexia, genetic vulnerability appears to manifest early in problems of phonological processing which, in turn, leads to delayed letter learning and a high probability of subsequent problems in beginning reading. The findings of the present study suggest that parental teaching of letter names and, to a lesser extent, high IQ, may, however, compensate for the risk. It should be noted, however, that even though the correlations between beginning reading skills and letter knowledge as early as 4.5 or 5.0 years of age were high, the analysis of individual trajectories showed that the information with regard to the number of letter names known by a child at an early age did not yield highly reliable predictions at the level of the individual. This is because the shapes of individual growth trajectories vary and, once begun, growth may be extremely rapid. Furthermore, problems in beginning reading did not characterize all children in the delayed cluster. This study suggest that a more accurate prediction is possible by taking account of the growth pattern of children's skill level and by emphasizing the later assessment points than by simply predicting from a simple assessment at an early age.

3.3 Study III: Reading development subtypes and their early characteristics

In this study our goal was to test whether the subgroups of reading development based on the assumptions derived from the 'Simple view' of reading can be found empirically. Previously, a few studies have shown that there are indeed children with difficulties in either word recognition or reading comprehension, or with difficulties in both or in neither. However, these previous studies have used mainly arbitrary cut-off scores or less advanced clustering techniques with rather small sample sizes. In this study involving

longitudinal data for 1750 children, we used a newer technique for subtype identification, mixture modelling. In addition, unlike previous studies, we were able to control for classroom membership effect.

We examined whether heterogeneous developmental paths can be identified based on profiles of 1st through 2nd grade word recognition and reading comprehension skills after controlling for the classroom membership effect. This analysis was based on the data of the JLD follow-up participants and their classmates (n=1750). Secondly, we studied what kind of early language and literacy skill profiles and reading experiences characterize the children in the follow-up with differing reading development. Our analyses also included comparisons of the reading development of children with and without familial risk for dyslexia. These analyses were based on the JLD follow-up data between ages 1 and 8 years. Figure 4 depicts the association investigated.

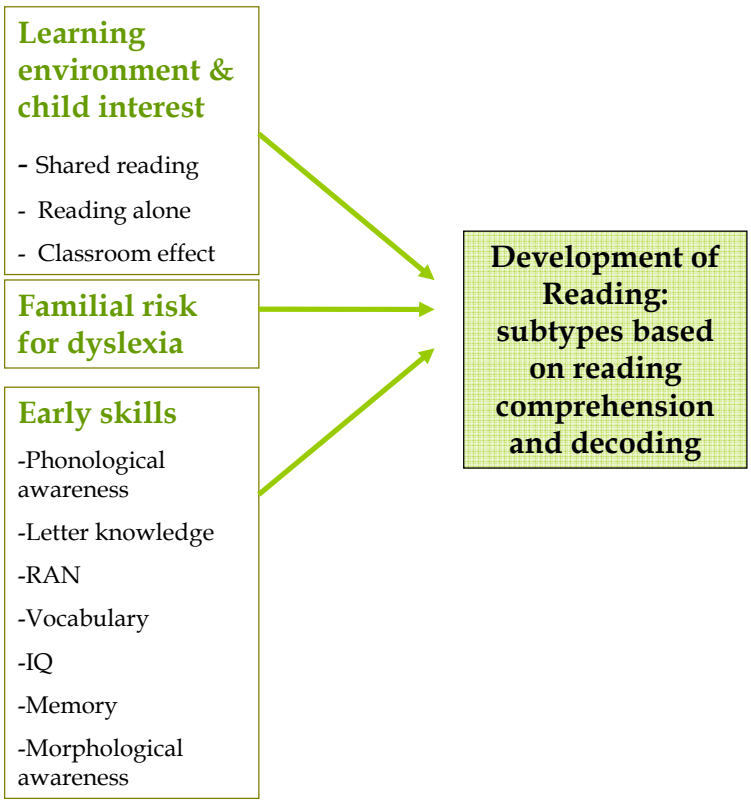


FIGURE 4 Description of study III

The 2-level mixture modelling procedure resulted in five distinct reading subtypes: (1) 'poor readers' with poor skills in both word recognition and reading comprehension, (2) 'slow readers' with somewhat below average word recognition combined with faster than average growth in reading comprehension, (3) 'poor comprehenders' with average word recognition combined with slower than average reading comprehension development, (4) 'average readers' with average skills in both word recognition and reading

comprehension and (5) 'excellent readers' with high level of performance in both reading skills. The effect of classroom membership on reading skills was small but statistically significant: from 4 % to 10 % depending on the assessment time point and reading skill was due to classroom membership effect. The children with familial risk for dyslexia performed on average at a lower level in all reading tasks than both their classmates and controls and they were over-represented in the slow decoders subtype.

Early language and literacy skill development and reading experience were found to differentiate between the reading subtypes. Children with average or good level reading profiles had higher skill levels in several early language and literacy tasks from early on than children of the other three reading subtypes. The differences between the subtypes were most evident in the tasks of phonological awareness, letter knowledge, rapid naming and vocabulary. The poor readers lagged behind the other subtypes particularly in these tasks. These differences increased over time and became clearly noticeable after age 5. The slow decoders displayed a level of rapid naming performance similar to the poor readers but significantly outperformed the poor readers in phonological awareness and letter knowledge at age 6.5. Vocabulary skills were the most compromised early skill of the poor comprehenders. The comparisons of reading experiences indicated that children with the strongest reading skills were reading for fun more often than poor readers and had had more shared reading experiences before school entry.

Overall, the mixture analyses of the present study support the previous findings of heterogeneous reading development and also show that, in a highly transparent writing system, substantial heterogeneity is already present after only two years at school. The description of the early skill development among JLD children gave support for the present understanding that fluent word recognition is predicted by letter knowledge, phonological awareness and rapid naming and that reading comprehension skills are associated with vocabulary. The effect of familial risk on reading skills was also evident.

4 GENERAL DISCUSSION

The present thesis focused on reading development and development of two of its key predictors, letter knowledge and phonological awareness. The development of reading skills has been widely studied over the past few decades but the present work represent additions to the literature in that it draws on longitudinal data covering a wide area of child skill development and learning environment from a very early age and also includes a group of children with familial risk for dyslexia. In addition, in the data analysis, an attempt was made to address the following large issues; First, the development of a complex skill such as reading is a dynamic interactive process that is affected by both the characteristics we have inherited and those we face in our environment. Second, the traditional statistical research tools focusing on group averages and variances do not always provide best fit with the developmental research questions and phenomena. Thus, a wide range of measures of children's skills, environments and the index of familial risk for dyslexia were included in Studies I-III and special effort was invested to isolate the best fitting analysis strategies for the research questions. This led to the combined use of person-oriented and variable-oriented methods.

Overall, the findings of the thesis were in line with the previous research in that the best predictors of difficulties in reading were familial risk for dyslexia, phonological awareness, letter knowledge and rapid serial naming. The association between home literacy environment and skill development was also in line with previous findings (e.g. Sénéchal & LeFevre, 2002): letter name teaching had an effect on letter name learning, shared reading had an effect on vocabulary and a subgroup of good readers were found to have had more shared reading experiences at an early age and also to read more themselves than a subgroup of poor readers. Familial risk for dyslexia was related to slower skill development but not to less supportive environment. The associations between home literacy environment factors, child's reading interest and skills were found to be moderated by familial risk for dyslexia whereby in the at-risk group, the associations were stronger. The analyses underlined the intertwined interactions between several skill areas and to some extent between skills and

environmental factors. Thus, it is difficult to draw clear inferences with regard to causal relations. The analyses of individual heterogeneity in development revealed that, even though at the group level literacy skills are closely related and stable, individuals may have several different developmental routes, e.g., in reading development, decoding and reading comprehension showed discrepant development in some individuals whereas in others, they developed in concert.

4.1 The Intertwined Development of Language and Literacy Skills

While the analyses of the present thesis demonstrated the strong stability and close relationships of various language and literacy skills, it also showed that developmental differentiation between individuals occurs over time. In Study I the development of phonological awareness was examined together with the development of vocabulary, letter knowledge and beginning reading. Phonological awareness skills both predicted and were predicted by vocabulary and letter knowledge. Vocabulary also predicted letter knowledge but the effect was partly mediated by phonological awareness. Study II showed that phonological sensitivity, phonological memory and RAN were the best predictors of deficient letter knowledge development. The effect of vocabulary skills on letter knowledge was mediated by the above measures. In Study III, phonological awareness, letter knowledge, RAN and vocabulary were most clearly associated with difficulties in reading; RAN particularly with slow reading and expressive vocabulary more with reading comprehension difficulties. These findings were in line with previous findings of the best predictors of reading (e.g. Adams 1990; Byrne, 1998; Elbro, Borstrøm, & Petersen, 1998; Gallagher, Frith, & Snowling, 2000; Holopainen, Ahonen, & Lyytinen, 2001; Lonigan, Burgess, & Anthony, 2000; Pennington & Lefly, 2001; Scarborough, 2001; Snow et al., 1998; Vellutino, Fletcher, Snowling, & Scanlon, 2004; Wimmer, Mayringer, & Landerl, 1998, 2000; Wimmer & Mayringer, 2002).

The language and literacy measures showed high stability over time, the two measures were closely related and, when monitored before school age, the differences between groups of children who became proficient readers and those with reading difficulties appeared to widen over time. Even though the group level correlations were high, there was, however, also strong evidence for individual heterogeneity. In Study II, the development of letter knowledge, and in Study III, the development of reading, were shown to be heterogeneous and development took rapid leaps for many individuals. The rapid developmental leaps in reading development and letter name learning are probably particularly typical for the highly regular Finnish language. Its lack of rules of exceptions, irregularities and inconsistencies reduces the amount of letter-sound connections that children must learn to 23 and after learning these, the

child is able to decode any text. Individual heterogeneity was not identified to the same extent in phonological awareness development in Study I. This may be due to the nature of the phonological awareness development at the particular period in time (4.5 -6.5 years of age) when most of the children could not yet read and were not exposed to formal reading instruction. Leaps and individual heterogeneity in phonological awareness development may be seen in measures of phonemic awareness which capitalize on orthographic knowledge at later age. The close relationships among various language and literacy skills at the group level but simultaneously coupled with individual heterogeneity are in line with previous empirical findings, (e.g. Catts et al., 2003; Leach et al., 2003; Lyytinen et al., 2006; Morris et al., 2006; Nation, et al., 2004; Shankweiler et al., 1999), with current accounts on reading development (e.g. Pennington, 2006; Scarborough, 2001) and with developmental accounts in general (Allport, 1937; Bergman, Magnusson, & El-Khouri, 2003; Gottlieb, 1991, 1998, 2003; Pennington, 2006; Nesselroade, 2001; Sameroff & MacKenzie, 2003).

The findings of heterogeneous subtypes in Studies II and III indicated that the group level models may be misleading. In cases where group averages consist of the scores of subgroups of individuals, the conclusions based on total group averages may become muddled (e.g. Bergman & El-Khouri, 2001). In such cases the best prediction is impossible to achieve without first untangling the heterogeneity issue. For example, in Study II herein, there were indications of subpopulations in the distributions of letter knowledge from early on and the analysis of the individual trajectories revealed that indeed there were three subtypes to be identified. Of these subtypes, only one presented high vulnerability to beginning reading difficulties. The other two differed from each other in that one showed a "precocious" development with very high letter knowledge already at age 4.5 and the other showed a more slow development, reaching the level of the precocious just before school entry. The separation of these three subtypes showed that reliable identification of individual children with high risk for reading difficulties based on their letter knowledge is difficult very early on because of the rather fast learning curve of a group of children – despite the correlations showing high stability at the group level. Another example was shown in Study III where we showed that the reading development subtypes of reading comprehension and word recognition can be identified and that these subtypes show different early skill development paths. These findings support the notion that different early skills predict different reading skills and that the use of large reading composites do not describe adequately the development of reading skills for a rather substantial proportion of individuals. Again, even though the correlation between reading comprehension and word identification was very high, there were many individual for whom these two skills did not go hand in hand. For remedial purposes, this information is crucial and research findings that do not take into account this separation cannot provide easily-applicable information to the field of educators and clinical practitioners.

4.2 Learning Environment and Child's Reading Interest in Relation to Skill Development

Several factors describing the children's learning environment were included in the three studies. In Studies I and II the focus was on skill development prior to school age involving factors of home literacy environment (HLE) and parental report on child's reading interest. Shared reading was found to be associated with vocabulary development and vocabulary mediated its effect on phonological awareness. Letter name learning, on the other hand, was associated with letter name teaching at home. The more indirect HLE measures, such as the amount of parent's own reading activities or the amount of books at home, were not directly associated with skill development. These findings are similar to those presented previously (e.g. Sénéchal & LeFevre, 2002) and fit nicely with the view that the development of print knowledge and vocabulary are more environmentally mediated than for instance phonological awareness (e.g. Byrne, Delaland, Fielding-Barnsley, et al., 2002).

Study III included the environmental factors of school classroom membership and children's print exposure before and after school entry. The effect of being a member of a specific classroom on children's reading skills was small but significant, varying between 4 and 10 %, depending on reading skill and time of assessment. This rather small effect was not surprising considering the Finnish schooling system. Nearly all children are enrolled in public schools with a national curriculum and participate in similar reading instruction which emphasizes systematic use of phonics with a strong focus on letter sound relations. Although the classroom effect was rather weak, it was statistically significant. Factors behind these classroom differences were not the focus here and they may range from teaching to other characteristics of the classrooms. We also examined the effects of print exposure and found that poor readers had had less shared reading experiences with parents at a very early age than good readers and that the good readers also engaged in more solitary reading than poor readers, already before school entry. The amount of reading experience has also previously been found to be higher among children with better reading skills (e.g., Leach et al., 2003; Leppänen, Aunola, & Nurmi, 2005; Scarborough, Dobrich, & Hager, 1991; Sénéchal & Lefevre, 2002).

4.3 Familial Risk for Dyslexia and Gene-Environment Interplay in Relation to Skill Development

The direct effects of familial risk of dyslexia on children's skill development and learning environment and its moderator effects on the associations between skills and learning environments were one focus of the present thesis. As expected (e.g. Gilger et al., 1991; Pennington et al., 1991; Scarborough et al.,

1991; Snow et al., 1998; Snowling et al., 2003), the findings of each study showed that, as a group, the at-risk children performed more poorly than the control children on most of the language and literacy skills assessed, starting with very early vocabulary development. At-risk children were also over-represented in the delayed letter knowledge group in Study II and in the slow reader's subgroup in Study III.

The associations between the language and literacy skills were, however, found to be similar in the at-risk and control groups. In Study I the associations between phonological awareness, letter knowledge, vocabulary and beginning reading were highly similar for the controls and at-risks. In Study III poor reading level and in particular slow decoding was more common among at-risks than the controls. However, those control children who were having difficulties in decoding did show similar early characteristics of language and literacy development that the at-risk children with difficulties. In contrast, in Study II, predicting delayed letter knowledge development, the best early skill predictors differed between controls and at-risks. For the control group, after controlling for performance IQ and home literacy environment factors, the best skill predictors of delayed letter knowledge were phonological memory and rapid serial naming. For the at-risk group, on the other hand, the best and only significant early skill predictor was phonological awareness. The risk for difficulties in reading development at 1st grade in the case of delayed letter knowledge development before school age was, however, the same for the at-risks and controls. The latter finding fits nicely with the wide body of evidence concerning associations between phonological awareness and dyslexia (Byrne, 1998; Elbro et al., 1998; Gallagher et al., 2000; Pennington & Lefly, 2001; Snowling et al., 2003).

Based on the findings of Studies I-III, what can we say about gene-environment correlations and interaction? That is, are individuals who are at genetic risk more sensitive to specific environmental risks (gene-environment interaction, GxE)? Or are individuals who are at genetic risk more likely to be exposed to environmental risk through passive, evocative or active G-E correlation, r_{GE}? (e.g. Plomin & Rutter, 1998). The answers to these questions, based on the data at hand and on the knowledge of the complex genetic basis of reading difficulties, can of course be only suggestive. The high risk status of the at-risk children multiplies the risk for dyslexia but does not mean 100% incidence of dyslexia.

Our findings indicated that the at-risk status did moderate somewhat the associations between environmental support, child's interest in reading and child's skills. Since the correlations between environmental factors and skills and between interest and skills were found to be higher in Study I among at-risk children than among controls, the high level of environmental support does seem to co-occur with high level of skills (and low level of support co-occurs with low level skill) among at-risks more than among controls. We may interpret these finding as an indication of individuals at-risk being more sensitive to the environmental risks and support. That is, when their genetic vulnerability coincides with environmental stressors, these children are more

likely to experience difficulties in the outcome skills (diathesis-stressor model or GxE). In the control group, on the other hand, any extra environmental support may not be necessary. In short, small-scale deprivation of support does not hinder them in terms of learning various language and literacy skills. The exploration of GxE would require genetically sensitive design with measures of environment included and the possibility to examine interaction effects of presence vs. absence of genetic liability.

The processes of r_{GE}, however, complicate the interpretations in a design such as ours. In families where the parents and their children share both large amount of genes and everyday experiences, the effect of environmental factors can not be attributed solely to environment. The mechanisms of passive, evocative and active r_{GE} may enhance the correlations between environmental support and children's skills more in the at-risk group than in the control group. In a parent-child dyad with both having dyslexia, for instance, the parent may be offering a less supportive environment to the child due to his/her own difficulties which matches with the child's genetic makeup (passive r_{GE}), or the child's behavior may instigate less support (evocative or active r_{GE}) than in the case where the child's risk had not been actualized. In such cases, the effect of environmental factors may appear exaggerated due to their mixture with genetic components. On the other hand, in a parent-child dyad where the parent has dyslexia but where dyslexia risk has not actualized for the child, the child's innate abilities and interest in reading may trigger the parent to address this interest and ability despite their own difficulties. In such cases the non-passive r_{GE} mechanisms are likely to operate. It should be noted that the picture is further complicated by the fact that besides the severity of the genetic load that the parents have with respect to reading difficulties, their attitudes toward reading, parenting etc. also vary. Moreover, the genetic and environmental variation provided by the non-affected parent in the family comes into play.

In two recent papers reporting passive r_{GE} that were based on more genetically informative studies of adoption families, the existence of passive r_{GE} was supported but it was also shown that environmental influence on children's skills exists which cannot be attributed to shared genes between parents and their children (Gilger, Ho, Whipple, & Spitz, 2001; Petrill, Deater-Deckard, Schatschneider, & Davis, 2005). When we consider our findings from the r_{GE} perspective, the evidence for passive r_{GE} was not very convincing. That is, children with familial risk for dyslexia were not found to have different environmental support from the controls apart from the fact that parents with dyslexia were reading less and had more negative attitudes towards reading than parents without reading difficulties The differences in parental attitudes, however, were not strongly associated with the amount of shared reading with a child. In families with reading disabilities, children were reported to have a similar amount of reading experiences and to be as interested in reading activities as children in control families, as expected (Elbro et al., 1998; Gallagher et al., 2000; Laakso et al., 1999; Scarborough et al., 1991; Snowling, 2000). In Study III, the subgroup of poor readers, whether belonging to the at-

risk or control group, were both found to be read with and to engage in solitary reading less than the subgroups of good readers.

There were some indications in the findings of the present thesis where evocative and active correlations may operate. In Study I, child's vocabulary skill was found to predict the amount of shared reading and parental perception of child's interest in reading later on, and the amount of shared reading was also found to correlate with child's reading interest. It may be that the children with difficulties in early language skills show less interest in reading activities than children without such difficulties which is then reflected in the amount of shared reading activities. Co-occurrence of parental dyslexia and child actualized risk (indexed by difficulties in vocabulary) appear to have an effect on daily reading activities. Persuading an unwilling toddler to engage in reading activities is not easy, even for a motivated adult.

Although the causal mechanisms behind the associations between children's skill development and parental practices or children's literacy interest (whether inherited or environmentally learned) remain unresolved, the higher correlations among the HLE factors in the at-risk group point toward accumulation of risks for at least a portion of at-risk children. In contrast, for some children in the at-risk group, an accumulation of benefits and a very supportive home literacy environment seem to hold true. In the latter families, parents appear to be active readers themselves and are more likely to spend a lot of time in shared book reading with their children, visit the library frequently, obtain books and magazines for the children and find their child to be particularly interested in reading.

4.5 Limitations and Suggestions for Future Research

Familial Risk and Genes

As stated above, the lack of knowledge in the genetic makeup of reading difficulties hinders the exploration of diathesis-stressor models or G-E interplay in the present data. This applies not only to the current data-base, but is currently engaging many researchers worldwide. The difficulty lies, as Petrill (2005) describes, in that "*Because reading is quantitatively distributed, multidimensional construct, it is highly unlikely that there is a single gene that "causes" reading disability. Instead, reading is influenced by several genes that are neither necessary nor sufficient for reading disability to occur.* " It may be possible in the next decades to reveal the secrets of the genetic background of dyslexia but this goal requires a lot of work also in the description of the dyslexic phenotype (Wagner, 2005). In the present database, the future challenges concern the examination of DNA samples and phenotype comparisons of children and their parents.

On Measuring the Environment

The measurement of the home literacy environment (HLE) has typically been based on parental questionnaires e.g. on the amount of shared reading activities with their children, number of books at home and library visits. This is also the case in the present study. The use of self-reports and questionnaires has been criticized because (a) estimating the frequencies of behaviors and interpreting the meanings of the researchers' questions may be difficult for respondents, (b) there may be social desirability bias and (c) response choices limit the answers' distribution to a predetermined scale with a limited number of choices. (e.g., Scarborough & Dobrich 1994; Lonigan 1994; Sénéchal, LeFevre, Thomas & Daley 1998). In the present studies we used several measurement phases and typically several items for each concept to increase reliability of the measures. Very close to normal distributions were found for the HLE measures even before they were summed which further convinced us that the measures are not all that unreliable. The analyses of Studies I and II were limited to the questionnaire-based HLE estimation but in Study III, classroom membership effect was also controlled for. Although the effect of classroom membership was not the main focus of the study, the nature of that effect deserves further examination in future studies. Also, the effects of day care and special education are potentially important environmental sources of individual variation that were not included into the present studies.

Overall, the measurement of environmental influences is challenging. In addition to the above mentioned critique for questionnaire-based data, the amount of error variance arising from the fact that different people experience their environments differently (GxE and r_{GE}), coupled with the emotions and past experiences attached to interaction situations between a parent and child, makes the construction of the measuring rod very difficult. This difficulty in measurement makes the environmental measures weak and unavoidably affects the estimations of their effect on language and literacy skills. It should be borne in mind that, even though the effects of individual factors are small, the effects of environmental risks may accumulate and the combined effects of various environmental risk or protective factors may be larger than those reported in the literature for each type of environmental factor. In addition, the effects of environment may not show the largest effects on the skill level measured at one point in time but rather the support given by environment is the basis of the child's ability to sustain motivation to learn, to consider her-/himself as a capable learner etc. These types of support help the child to sustain the practice that will support skill development. In the long-term follow-up of children with early learning difficulties, it would be possible to investigate the effects of the accumulation of environmental risks and support on the life span scale.

Methodological Evaluation

The three studies comprising the present thesis aimed to include several interactive levels of an organism and on the other hand, to avoid blind use of group level statistics in the analyses. These aims led to the combining of more traditional variable oriented methods with three different types of longitudinal subgrouping analyses; In Study I Latent growth curve analysis of PA (with an attempt to identify PA subtypes, which was not, however, successful) combined with SEM; In Study II the use of trajectory analysis of letter knowledge development combined with logistic regression; and in Study III a 2-level mixture analysis combined with subtype comparisons in the subtype mean level.

In Study I the focus was in the growth patterns (e.g. linearity, stability, and individual variability) of children's phonological awareness development and latent growth curve (LGC) modeling (a structural equation modeling, SEM, approach) was employed. LGC is seen as an effective tool for analyzing change because it places individual growth trajectories at the center of focus (Curran & Muthen, 1999; Francis, Fletcher, Stuebing, Davidson, & Thompson, 1991; Li, Duncan, & Acock, 2000; McArdle & Epstein, 1987; Meredith & Tisak, 1990; Willett, Ayoub, & Robinson, 1991; Willett & Sayer, 1994). With LGC we were also able to investigate whether the so-called Matthew effect (i.e. "the rich get richer and poor get poorer", Stanovich, 1996) can be found in phonological awareness development. The advantages of the SEM approach are its possibilities for flexible, theory-based model building with several latent factors (taking into account measurement error), examination of direct and indirect effects and estimation of all associations between factors in the model simultaneously. In this study the person-oriented analysis strategy was employed only in the examination of whether subgroups of children can be identified in phonological awareness development by using mixture modeling. Subgroups were not identified and the emphasis of this study was on examination of associations between the longitudinal assessments of language and literacy skills. In this study, the heterogeneity in other than phonological awareness development was not examined. In the analyses by Lyytinen et al 2006 of the JLD data, subgroups of early language and literacy development were identified when it was specifically searched for in several domains of language and literacy skill development. It is possible that this heterogeneity weakens the predictive associations of Study I. The use of LGC had its advantages but it also constrained the use of phonological awareness measures to be identical at each age phase, 4.5, 5.5, and 6.5 years. The validity of the use of identical measures across age phases may be challenged if qualitative changes are expected in PA development between ages 4.5 and 6.5 years.

In Studies II and III we focused more directly into identification of individual heterogeneity in skill development before group level analyses. For this purpose we used trajectory analysis (SAS, e.g. Nagin & Tremblay, 2001) in Study II and latent mixture modeling in Study III (M-plus, e.g. Muthén, 2006). Both analysis strategies allow the analysis of developmental data at an

individual level and the search for similarities and differences among individuals. In contrast to more variable-oriented methods (which assume normally distributed variables and linear associations and focus on means and variances of variables), a more detailed picture of the growth process can be obtained with these methods as the analysis is based on longitudinal data. The advantages of Mixture modeling and trajectory analysis over the use of e.g. cut-off criteria, or traditional cluster analysis are that they provide statistical tests for selection of the best solution and can base the sub-grouping on several measurements instead of relying on one measurement occasion. Trajectory analysis identifies similarities among individual growth curves in both level and shape and calculates the number of distinct clusters and the average growth trajectory for each cluster. The model best fitting the data (i.e., comprising an optimal number of clusters and the best fitting average curve for each cluster) is selected on the basis of the Bayesian information criterion (for a more detailed description of the analysis method, see, e.g., Nagin & Tremblay, 2001). Mixture modeling in the M-plus package offers more flexibility for building a model of associations between the variables used for subgroup identification. This allows subgroup identification procedure to be based more closely on the phenomena to hand. Mixture modeling allows e.g. the isolation of measurement error, use of multilevel models and assumption of different variances in each subgroup to be identified. It should be noted that estimations of models such as those in Study III are still computationally heavy and very time-consuming.

These three sub-studies provide some examples of the use of person-oriented methods in combination with variable-oriented methods. Other good examples and more rigorous recent discussion on the matter can be found for example in the special issue of Merrill-Palmer Quarterly (2006, 52(3)) or in relation mixture models in Muthén (2006). The analysis strategies selected in Studies I-III were based on the formulation of the research questions and our knowledge on suitable methods. The person-oriented subtyping techniques offered the possibility to account for the heterogeneity in the data and therefore improve the predictive models. The use of wide variation of language and literacy skills and environmental measures allowed a wide description of children's development in the environmental context. Such a strategy does not, however, answer questions concerning the processes at a more detailed level, such as those concerning the detailed causal mechanisms of letter knowledge and phoneme awareness. Such a question would require a detailed item-level examination in a longitudinal experimental design. A combination of such detailed level examination of the development of language and literacy skills and a person-oriented data-analysis might produce interesting possibilities in revealing the processes of language and literacy development.

4.6 Some Concluding Remarks

When this work was begun a few years ago I had just changed my major from the Department of Sociology to the Department of Psychology and was puzzled by two issues: first, the fact that, at that time, questions concerning groups of people in Sociology were examined mainly with qualitative methods and questions concerning individuals in Psychology with group based quantitative methods and second, the roles of individuals' genetic makeup and the context in which they live (as these were rather differently handled in the two scientific fields). These two themes have shadowed me over the last few years as I have worked with the studies included in this thesis. During these years I became acquainted with work that is conducted all over the world to find answers and solutions to these problems. The nature-nurture question has puzzled researchers for centuries and the recent revelations in genetics have provided new information on e.g. gene functioning in interaction with the environment. Learning about the G-E interplay and the complexities of genetic research has increased my interest in learning more of the better ways to model data on individuals. The traditional statistical tools we use are not well-suited to this task and new approaches are required. Such new possibilities are currently under development and, in my opinion, they provide great promise to psychometrics in future.

TIIVISTELMÄ

Tässä tutkimuksessa tarkasteltiin lukemisen ja kahden sen vahvimman varhaisen ennustajan – kirjainten nimeämisen taidon ja fonologisen tietoisuuden- kehittymistä. Aineiston analysoinnissa pyrittiin aiempia tutkimuksia kokonaisvaltaisempaan otteeseen, jossa otettiin huomioon yhtä aikaa useiden lapsen kielen kehityksen osa-alueiden kehittyminen, oppimisympäristön piirteitä, lapsen kirjakiinnostus sekä suvussa esiintyvään lukivaikeuteen liittyvä tavallista korkeampi lukivaikeusriski. Perinteisen muuttuja-orientoituneen otteen lisäksi analyyseissä sovellettiin yksilö-orientoituneita menetelmiä.

Aineistona oli Lapsen Kielen Kehitys (LKK) – projektissa kerätty pitkittäisaineisto, jossa seurattiin 214 lapsen kehitystä syntymästä kolmannen kouluvuoden loppuun saakka. Näistä lapsista noin puolella oli kohonnut lukivaikeusriski koska toisella tai molemmilla heidän vanhemmistaan oli lukivaikeus. Tässä väitöskirjassa käytettiin 1–8-vuotiaiden testituloksia fonologisen tietoisuuden, kirjainten nimeämisen, sanavaraston, nopean sarjallisen nimeämisen, morfologisen tietoisuuden, muistin ja älykkyyden osalta. Ympäristön ja lapsen kirjakiinnostuksen mittarit oli kerätty vanhempien kyselyillä.

Ensimmäinen osatutkimus keskittyi alle kouluikäisten (4.5–6.5-vuotiaiden) lasten fonologisen tietoisuuden kehittymiseen. Fonologisen tietoisuuden kehitystä tarkasteltiin yhdessä kirjainten nimien oppimisen, sanavaraston kehittymisen, varhaisen lukutaidon, kotiympäristön piirteiden ja lapsen osoittaman kirjakiinnostuksen kanssa. Analyysimenetelmänä oli rakenneyhtälömallinnus (latentti kasvukäyräanalyysi). Tutkimuksessa oltiin kiinnostuneita seuraavista kysymyksistä: 1) Miten fonologinen tietoisuus kehittyy vuorovaikutuksessa muiden taitojen kanssa (sanavarasto, kirjainten nimeäminen ja varhainen lukutaito)? 2) Miten kotiympäristön piirteet ja lapsen kirjakiinnostus ovat yhteydessä lapsen fonologisen tietoisuuden sekä muiden taitojen kehittymiseen? 3) Vaikuttaako lukivaikeusriski taitojen kehittymiseen, kotiympäristöön, lapsen kirjakiinnostukseen tai näiden välisiin yhteyksiin? Tulokset viittasivat siihen, että fonologisen tietoisuuden kehittyy tutkitulla aikavälillä vuorovaikutuksessa sekä sanavaraston että kirjainten nimien kehityksen kanssa. Varhaista lukutaitoa ennustivat suoraan sekä kirjainten nimien osaaminen että fonologinen tietoisuus. Kotiympäristön eri piirteistä lapsen ja vanhemman yhteisen lukemisen määrä ennustivat hyvää sanavarastoa myöhemmällä iällä. Lukivaikeusriski oli yhteydessä alhaisempaan taitojen tasoon mutta ei juurikaan kotiympäristön piirteisiin tai lapsen kirjakiinnostukseen. Ainoastaan vanhempien oma lukuharrastuneisuus oli vähäisempää riskiryhmässä kuin kontrolleilla. Taitojen yhteydet kotiympäristön piirteiden ja lapsen kirjakiinnostuksen kanssa olivat kuitenkin korkeammat riskiryhmässä kuin kontrolleilla. Riskiryhmässä esimerkiksi havaittiin 3.5-vuotiaiden sanavaraston ennustavan myöhempää kirjakiinnostusta mutta vastaavaa yhteyttä ei löydetty kontolliryhmässä. Myös kotiympäristön piirteet ja lapsen kirjakiinnostus korreloivat keskenään vahvemmin riskeillä kuin kontrolleilla. Tutkimuksen tulokset korostavat eri taitojen vuorovaikutuk-

sellista kehittymistä sekä viittaavat kotiympäristön tekijöiden kumuloitumiseen ja merkitykseen erityisesti riskiryhmässä.

Toisessa osatutkimuksessa tarkasteltiin kirjainten nimien oppimista 4.5–6.5-vuotiailla lapsilla ja pyrittiin etsimään varhaisia heikon kehityksen ennustajia lapsen taitojen ja ympäristötekijöiden joukosta. Myös lukivaikeusriski otettiin huomioon. Analyysissä käytettiin kehityspolkuanalyysiä (trajectory analysis), jonka avulla etsittiin erilaisia yksilöllisen kehityksen alaryhmiä. Kolme alaryhmää löydettiin; 1) ”Varhaisen kehityksen alaryhmä”, jossa osattiin lähes kaikki kirjaimet jo 4.5-vuotiaana, 2) ”Lineaarisen kehityksen alaryhmä”, jossa osattiin vain muutamia kirjaimia 4,5-vuotiaina, mutta varhaisen kehityksen alaryhmän taso saavutettiin 6.5-vuotiaaseen mennessä, sekä 3) ”Hitaan kehityksen alaryhmä”, jossa kirjainten nimien kehittyminen oli hidasta koko tarkasteltuna ajanjaksona. Hitaan kehityksen alaryhmään kuuluvat lapset olivat pääasiassa LKK riskiryhmän lapsia ja varhaisen kehityksen alaryhmän lapsen LKK kontrolleja. Hitaan kehityksen alaryhmään kuulumista selittivät 3.5-vuotiaana mitatut fonologinen muisti, nopea sarjallinen nimeäminen ja fonologinen tietoisuus sekä kirjainten opettamisen määrä kotona ja äidin koulutustaso. Hitaan kehityksen alaryhmään kuuluminen ennusti pulmia lukemaan oppimisessa ensimmäisellä luokalla sekä LKK riski- että kontrolliryhmässä. Tutkimuksen tulokset korostivat että kirjainten nimien oppimiseen vaikuttavat paitsi ympäristöaltistus kirjainten nimille niin myös lapsen varhaiset kognitiiviset taidot, erityisesti fonologiseen prosessointiin liittyvät taidot. Tulokset osoittivat myös että kirjainten nimien oppimisessa on erilaisia yksilöllisiä kehityspolkuja ja vaikkakin aikapisteiden väliset korrelaatiot ovat korkeita, yksilökohtainen ennustaminen on hankalaa johtuen nopeista oppimispyrähdyksistä. Tästä johtuen myös lukemaan oppimisen ennustaminen kirjainten nimien taitojen avulla ei ole tarkasti mahdollista kovin varhaisista vaiheista käsin.

Kolmannessa osatutkimuksessa tarkasteltiin lukemisen kehitystä 1. ja 2. luokan aikana. Lähtökohtana oli yksinkertainen näkemys lukutaidosta (*Simple view of reading*), jonka mukaan lukutaito koostuu teknisestä lukutaidosta ja luetun ymmärtämisen taidosta. Tämän näkemyksen pohjalta voidaan olettaa löytyvän alaryhmiä, joilla lukemisen osataidot ovat joko samalla tasolla tai poikkeavat toisistaan (esimerkiksi lapsella on pulmia molemmissa tai vain toisessa lukemisen taidossa). Näitä alaryhmiä etsittiin aineistossa, jossa oli tutkittu neljässä aikapisteessä yhteensä 1750 lasta (LKK seurantatutkimuksen osallistuneet noin 200 lasta sekä heidän luokkatoverinsa). Aiemmista vastaavantyyppisistä tutkimuksista poiketen pystyimme tarkastelemaan luokkaan kuulumisen efektiä suuressa otoksessa sekä käyttämään edistyneintä analyysitekniikkaa alaryhmien tunnistamisessa (mixture mallinnus). Alaryhmien tunnistamisen lisäksi tutkimuksessa kuvataan LKK seuruuaineiston sisällä eri lukemisen alaryhmien varhaista kehitystä (1-8 -vuotiaana) erilaisilla kielen ja kognition mittareilla sekä lasten käyttämää aikaa lukemisen parissa (yhdessä vanhempien kanssa sekä yksin). Viisi lukemisen taitojen alaryhmää löydettiin: 1) ”Heikot lukijat”, joilla oli pulmia sekä teknisessä lukemisessa että luetun ymmärtämisessä, 2) ”Hitaat lukijat”, joilla oli pulmia teknisessä lukemisessa, mutta jotka saavuttivat

keskimääräisen tason luetun ymmärtämisessä toisen luokan loppuun mennessä, 3) ”Heikot ymmärtäjät”, joilla oli lähes keskimääräinen teknisen lukutaidon taso, mutta jotka eivät kehittyneet muiden tapaan luetun ymmärtämisessä, 4) ”Keskimääräiset lukijat ”, joilla molemmat lukemisen osataidot olivat keskimääräistä tasoa, sekä 5) ”Hyvät lukijat”, joilla molemmat lukemisen osataidot olivat keskimääräistä korkeampaa tasoa. Luokkaan kuulumisen vaikutus oli suhteellisen pientä, taitojen tasosta luokkaefekti selitti 4–10 prosenttia, riippuen taidosta ja mittausajankohdasta. Lukivaikeusriski näkyi siten että LKK riskiryhmään kuuluvat lapset suoriutuivat lukemisen tehtävistä keskimäärin heikommin kuin luokkatoverinsa tai LKK kontrollit. LKK riskiryhmän lapselle oli tyypillisempää kuin muille lapsille kuulua hitaiden lukijoiden alaryhmään. Kun tarkasteltiin LKK lasten joukossa varhaista kielellistä ja kognitiivista kehitystä havaittiin seuraavaa: Lukemisen alaryhmät erosivat toisistaan lukuisissa varhaisissa taidoissa ja erot kasvoivat suuremmiksi ajan myötä. Erityisen selkeitä eroja havaittiin fonologisessa tietoisuudessa, kirjainten nimien osaamisessa, sanavarastossa ja nopeassa sarjallisessa nimeämisessä. Heikkojen lukijoiden alaryhmä suoriutui kaikissa tehtävissä heikoimmin. Hitaiden lukijoiden alaryhmä ei kuitenkaan poikennut heikoista lukijoista nopeassa sarjallisessa nimeämisessä. Heikoilla ymmärtäjillä pulmia oli erityisesti sanavarastossa. Hyvien lukijoiden havaittiin käyttäneen eniten aikaa ja heikkojen lukijoiden vähiten kirjojen lukemiseen (yhdessä vanhemman kanssa ennen kouluikää ja yksin kouluikäisenä). Mielenkiintoista on, että oletetut alaryhmät kyettiin löytämään jo ensimmäisten kahden kouluvuoden jälkeen, mikä johtunee lukutaidon nopeasta kehittymisestä Suomessa. LKK seuruuaineiston pohjalta tehty varhaisen kehityksen kuvaus sopii hyvin tämänhetkiseen ymmärrykseen teknisen lukemisen ja luetun ymmärtämisen taustataidoista.

Kaiken kaikkiaan tämän väitöskirjan tulokset siis tukivat käsitystä että varhaisista taidoista kirjainten nimeäminen, fonologinen tietoisuus ja nopea sarjallinen nimeäminen ovat parhaita teknisen lukemisen taidon ennustajia. Varhaiset taidot näyttävät kehittyvän kiinteässä yhteydessä toisiinsa varhaisesta iästä lähtien. Ympäristön vaikutus taitojen kehitykseen oli tässä tutkimuksessa melko pientä eikä kausaalisuuden suunnasta voida olla varmoja. Ympäristön mitoista yhteinen lukeminen vanhempien kanssa oli kuitenkin yhteydessä sanavarastoon, kirjainten nimien opettaminen kirjainten nimien osaamiseen ja koululuokkaan kuuluminen ja lukemisen harrastuneisuus lukutaitoon. Peritty lukivaikeusriski oli yhteydessä heikkoihin taitoihin, mutta ei ympäristön tuen määrään. Lukivaikeusriski näyttää kuitenkin moderoivan ympäristön piirteiden välisiä yhteyksiä. Väitöskirjan yhteenvedossa keskustellaan lisäksi lyhyesti geenien ja ympäristön vuorovaikutuksesta, ympäristön mittaamisesta sekä muuttuja- ja yksilösuuntautuneista tutkimusotteista.

REFERENCES

Allport, G.W. (1937). *Personality: A psychological interpretation.* New York: Holt, Rinehart, & Winston.

Adams, M. J. (1990). *Beginning to Read: Thinking and Learning about Print.* Cambridge, MA: The MIT Press.

Bergman, L.R. (2001). A person approach in research on adolescence: some methodological challenges. *Journal of Adolescent Research, 1,* 28-53.

Bergman, L. R. & El-Khouri, B. M. (2001). Developmental processes and the modern typological perspective. *European Psychologist, 3,* 177-186.

Bergman, L. R., Magnusson, D., & El-Khouri, B. M. (2003). *Studying individual development: A person-oriented approach.* In D. Magnusson (Series Ed.), Paths through life (Vol. 4). Mahwah, NJ: Lawrence Erlbaum

Bishop, D. V. M., & Snowling, M. J. (2004). Developmental dyslexia and specific language impairment: Same or different? *Psychological Bulletin, 130*, 858-886.

Bowey, J.A. (2001). Nonword repetition and children's receptive vocabulary: A longitudinal study. *Applied Psycholinguistics, 22,* 441-469.

Burgess, S.R. (1997). The role of shared reading in the development of phonological awareness: A longitudinal study of middle to upper class children. *Early Child Development and Care, 127*, 191-199.

Burgess, S. R. (2002). The influence of speech perception, oral language ability, the home literacy environment, and pre-reading knowledge on the growth of phonological sensitivity: A one-year longitudinal investigation. *Reading and Writing, 15*(7), 709-737.

Bus, A. G., van IJzendoorn, M. H., & Pellegrini, A. D. (1995). Joint book reading makes for success in learning to read: A meta-analysis on intergenerational transmission of literacy. *Review of Educational Research, 65*(1), 1-21.

Byrne, B. (1998). *The Foundation of Literacy: The Children's Acquisition of the Alphabetic Principle*. Hove, UK: Psychology Press.

Byrne, B., Delaland, C., Fielding-Barnsley, R., Quain, P., Samuelsson, S., Hoien, T., et al. (2002). Longitudinal twin study of early reading development in three countries: Preliminary results. *Annals of Dyslexia, 52,* 49 – 73.

Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology, 96*, 31-42.

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.

Castles, A., Datta, H., Gayan, J., & Olson, R.K. (1999). Varieties of Developmental Reading Disorder: Genetic and Environmental Influences, Journal of Experimental Child Psychology, 72, pp. 73-94

Catts, H. W., Adlof, S. M., Hogan, T. P., & Weismer, S. E. (2005). Are specific language impairment and dyslexia distinct disorders? *Journal of Speech, Language, and Hearing Research, 48*, 1378-1396.

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

Catts, H. W., Hogan, T. P., & Fey, M. E. (2003). Subgrouping poor readers on the basis of individual differences in reading-related abilities. *Journal of Learning Disabilities, 36*, 151-164.

Crain-Thoreson, C., & Dale, P. S. (1992). Do early talkers become early readers? linguistic precocity, preschool language, and emergent literacy. *Developmental Psychology, 28*(3), 421-429.

Curran, P. J., & Muthen, B. O. (1999). The application of latent curve analysis to testing developmental theories in intervention research. *American Journal of Community Psychology*, *27,* 567-595.

de Jong, P.F. & Olson, R.K. (2004). Early predictors of letter knowledge. *Journal of Experimental Child Psychology, 88,* 254-273.

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

Dunham, P., Dunham, F., & Curwin, A. (1993). Joint-attentional states and lexical acquisition at 18 months. *Developmental Psychology, 29,* 827-831.

Elbro, C., Borstrom, I., & Petersen, D. K. (1998). Predicting dyslexia from kindergarten: The importance of distinctness of phonological representations of lexical items. *Reading Research Quarterly, 33*(1), 36-60.

Finucci, J. M., Guthrie, J. J., Childs, A. L., Abbey, H., & Childs, B. (1976). The genetics of specific reading disability. *Annual Review of Human Genetics, 40,* 1-23.

Fisher, S. E., Marlow, A. J., Lamb, J., Maestrini, E., Williams, D. F., Richardson, A. J., Weeks, D. E., Stein, J. F., & Monaco, A. P. (1999). A quantitative-trait locus on chromosome 6p influences different aspects of developmental dyslexia. *American Journal of Human Genetics, 64,* 146-156.

Fowler, A. (1991). How early phonological development might set the stage for phoneme sensitivity. In S. Brady, & D. Shankweiler (Eds.), *Phonological Processes in Literacy* (pp. 97-118). Hillsdale, NJ: Erlbaum.

Francis, D. J., Fletcher, J. M., Stuebing, K. K., Davidson, K. C., & Thompson, N. R. (1991). Analysis of change: Modeling individual growth. *Journal of Consulting and Clinical Psychology, 59,* 27-37.

Frijters, J. C., Barron, R. W., & Brunello, M. (2000). Direct and mediated influences of home literacy and literacy interest on prereaders' oral vocabulary and early written language skill. *Journal of Educational Psychology, 92*(3), 466-477.

Gallagher, A., Frith, U., & Snowling, M. J. (2000). Precursors of literacy delay among children at genetic risk of dyslexia. *Journal of Child Psychology & Psychiatry & Allied Disciplines, 41*(2), 202-213.

Gathercole, S. E., Willis, C. S., Emslie, H., & Baddeley, A. D. (1992). Phonological memory and vocabulary development during the early school years: A longitudinal study. *Developmental Psychology, 28*, 887–898.

Gilger, J.F., Pennington, B.F., Defries, J. C. (1991). Risk for reading disability as a function of parental history in three family studies. *Reading and Writing*, *3*, 205 - 217.

Gottlieb, G. (1991). Experiential canalization of behavioral development: theory. *Developmental Psychology, 27* (1), 4-13.

Gottlieb, G. (1998). Normally occuring environmental and behavioural influences on gene activity: from central dogma to probabilistic epigenesist. *Psychological Review, 105* (4), 792-802.

Gottlieb, G. (2003). On making behavioral genetics truly developmental. *Human Development, 46,* 337-355.

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

Hallgren, B. (1950). Specific dyslexia ("Congenital word blindness"): A clinical and genetic study. *Acta Psychiatrica and Neurologica Scandinavica, 65,* 1-287.

Harlaar, N., Spinath, F.M., Dale, P.S., & Plomin, R. (2005). Genetic influences on early word recognition abilities and disabilities: A study of 7-year-old twins. *Journal of Child Psychology and Psychiatry, 46*, 373-384.

Hoff-Ginsberg, E. (1991). Mother-child conversation in different social classes and communicative settings. *Child Development, 62,* 782-796.

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

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*(4), 179-195.

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.

Leppänen, U., Aunola, K., & Nurmi, J. (2005). Beginning readers' reading performance and reading habits. *Journal of Research in Reading, 28*, 383-399.

Lewis, C. & Gregory, S. (1987). Parents' talk to their infants: The importance of context. *First Language, 7,* 201-216.

Li, F., Duncan, T. E., & Acock, A. (2000). Modeling interaction effects in latent growth curve models. *Structural Equation Modeling, 7,* 497-533.

Lonigan, C. J. (1994). Reading to preschoolers exposed: Is the emperor really naked. *Developmental Review, 14,* 303-323.

Lonigan, C. J., Burgess, S. R., & Anthony, J. L. (2000). Development of emergent literacy and early reading skills in preschool children: Evidence from a latent-variable longitudinal study. *Developmental Psychology, 36,* 596-613.

Lundberg, I. (1991). Reading as an individual and social skill. In I. Lundberg, & T. Hoien (Eds.), *Literacy in a World of Change* (pp. 14-22). Center for Reading Research, Stavanger/UNESCO.

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

Lyytinen H., Aro, M., Eklund, K., Erskine, J., Guttorm, T., Laakso, M.-L., Leppänen, P.H.T., Lyytinen, P., Poikkeus, A.-M., Richardson, U., and Torppa, M. (2004). The development of children at familial risk for dyslexia: birth to early school age. *Annals of Dyslexia, 54,* 184-220.

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, P., Laakso, M. L., & Poikkeus, A. M. (1998). Parental contribution to child's early language and interest in books. *European Journal of Psychology of Education, 13*(3), 297-308.

Lyytinen, H., Ahonen, T., Eklund, K., Guttorm, T. K., Laakso, M.-L., Leinonen, S., Leppänen, P. H. T., Lyytinen, P., Poikkeus, A.-M., Puolakanaho, A., Richardson, U., & Viholainen, H. (2001). Developmental pathways of children with and without familial risk for dyslexia during the first years of life. *Developmental Neuropsychology, 20(2),* 539-558

Lyytinen, H., Aro, M.., Holopainen, L., Leiwo, M.., Lyytinen, P. & Tolvanen, A. (2006) Children's language development and reading acquisition in a highly transparent orthography In R.M. Joshi & P.G. Aaron (Eds.) Handbook of orthography and literacy (pp. 47-62). Lawrence Erlbaum, Mahwah, New Jersey

Magnusson, D. & Törestad, B. (1993). A holistic view of personality: a model revisited. *Annual Review of Psychology, 44*, 427-452.

McArdle, J. J., & Epstein, D. (1987). Latent growth curves within developmental structural equation models. *Child Development, 58,* 110-133.

McCoach, D. B., O'Connell, A. A., Reis, S. M., & Levitt, H. A. (2006). Growing readers: A hierarchical linear model of children's reading growth during the first 2 years of school. *Journal of Educational Psychology, 98*, 14-28.

Mcbride-Chang, C., Wagner, R. K., Muse, A., Chow, B. W., & Shu, H. (2005). The role of morphological awareness in children's vocabulary acquisition in english. *Applied Psycholinguistics, 26*(3), 415-435.

Meredith, W., & Tisak, J. (1990). Latent curve analysis. *Psychometrika, 55,* 107-122.

Metsala, J. L., & Walley, A. C. (1998). Spoken vocabulary growth and the segmental restructuring of lexical representations: Precursors to phonemic sensitivity and early reading ability. In J. L. Metsala, & L. C. Ehri (Eds.), *Word Recognition in Beginning Literacy* (pp. 89-120). Mahwah, NJ: Erlbaum.

Molenaar, P. C. M., Huizenga, H. M., & Nesselroade, J. R. (2003). The relationship between the structure of interindividual and intraindividual variability: A theoretical and empirical vindication of Developmental Systems Theory. In U. M. Staudinger & U. Lindenberger (Eds.),

Understanding human development: Dialoques with lifespan psychology (pp. 339-360). Dordrecht: Kluwer Academic Publishers. Chapter Citation

Morris, R.D., Stuebing, K.K:, Fletcher, J.M., Shaywitz, S.E., Lyon, G.R., Shankweiler, D.P., Katz, L., Francis, D.J., & Shaywitz, B.A. (1998). Subtypes of reading disability: Variability around a phonological core. *Journal of Educational Psychology, 90*(3), 347-373.

Muthén , B. (2004). Latent variable analysis: Growth mixture modeling and related techniques for longitudinal data. In D. Kaplan (ed.), *Handbook of quantitative methodology for the social sciences*. Newbury Park, CA: Sage Publications, pp. 345-368.

Muthén, B. (2006). Latent variable hybrids: Overview of old and new models. Forthcoming in Hancock, G. R., & Samuelsen, K. M. (Eds.). (2007). Advances in latent variable mixture models. Charlotte, NC: Information Age Publishing, Inc.

Muter, V., Hulme, C., Snowling, M. J., & 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.

Nagin, D.S. (1999). Analyzing developmental trajectories: A semi-parametric, group-based approach. *Psychological Methods, 4*, 139-177.

Nagin, D.S. & Tremblay, R. (2001). Analyzing developmental trajectories of distinct but related behaviors: A group-based method. *Psychological Methods, 6*, 18-34.

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., & Norbury, C. F. (2005). Why reading comprehension fails: Insights from developmental disorders. *Topics in Language Disorders, 25*, 21-32.

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.

Nesselroade, J.R. (2001). Intraindividual variability in development within and between individuals. *European Psychologist*, 3, 187-193.

Oakhill, J. V., Cain, K., & Bryant, P. E. (2003). The dissociation of word reading and text comprehension: Evidence from component skills. *Language and Cognitive Processes, 18*, 443-468.

OECD (Organisation for Economic Co-operation and Development) (2004). Learning for tomorrow's world. First results of PISA 2003. http://www.pisa.oecd.org.

Olson, R. K., Datta, H., Gayán, J., & DeFries, J. C. (1999). A behavioral-genetic analysis of reading disabilities and component processes. In R. M. Klein, & P. A. McMullen (Eds.), *Converging methods for understanding reading and dyslexia* (pp. 133-153). Cambridge, MA: MIT Press.

Payne, A. C., Whitehurst, G. J., & Angell, A. L. (1994). The role of home literacy environment in the development of language ability in preschool children from low-income families. *Early Childhood Research Quarterly, 9*(3), 427-440.

Pennington, B. F., Gilger, J.W., Pauls, D., Smith, S.A., Smith, S.D., & DeFries, J.C. (1991). Evidence for major gene transmission of developmental dyslexia. *Journal of the American Medical Association, 266,* 1527-1534.

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. (2006). From single to multiple deficit models of developmental disorders. *Cognition*, 101, 385-413.

Petrill, S.A. (2005). Introduction to this special issue: Genes, environment, and the development of reading skills. *Scientific Studies of Reading, 9*(3), 189-196.

Petrill, S.A., Deater-Deckard, K., Schatschneider, C., & Davis, C. (2005). Measured environmental influences on early reading: Evidence from an adoption study. *Scientific Studies of Reading, 9*(3), 237-259.

Phillips, B. M., & Lonigan, C. J. (2005). Social correlates of emergent literacy. In M. J. Snowling, & C. Hulme (Eds.), *The science of reading: A handbook.* (pp. 173-187). Oxgord, UK: Blackwell.

Plomin, R. (1994). *Genetics and experience. The interplay between nature and nurture.* Thousand Oaks: Sage.

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P.H.T., Poikkeus, A. , Tolvanen, A., Torppa, A., & Lyytinen., H. (in press, 2007).Very early phonological and language skills: Estimating individual risk of reading disability. *Journal of Child Pscyhology and Pscyhiatry.*

Roth, F. P., Speece, D. L., & Cooper, D. H. (2002). A longitudinal analysis of the connection between oral language and early reading. *Journal of Educational Research, 95*, 259-272.

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.

Rutter, M. L., Dunn, J., Plomin, R., Simonoff, E., Pickes, A., Maughan, P., Ormel, J., Meyer, J., & Eaves, R. (1997). Integrating nature and nurture: Implications of person-environment correlations and interactions for developmental psychopathology. *Development and Psychopathology, 9,* 335-364.

Rutter, M. & Silberg, J. (2002), Gene-environment interplay in relation to emotional and behavioral disturbance. *Annual Review of Psychology, 53 (1)*, 463-490.

Rutter, M., Pickles, A., Murray, R., & Eaves, L. (2006). Testing hypotheses on specific environmental causal effects on behavior. *Psychological Bulletin., 127 (3),* 291-324.

Sameroff, A.J. & MacKenzie, M.J. (2003). Research strategies for capturing transactional models of development: the limits of the possible. *Development and Psychology, 15*, 613-640.

Scarborough, H. S. (1990). Very early language deficits in dyslexic children. *Child Development, 61*(6), 1728-1743.

Scarborough, H. S., Dobrich, W., & Hager, M. (1991). Pre-school literacy experience and later reading achievement. *Journal of Reading Disabilities, 24,* 508-511.

Scarborough, H. S., & Dobrich, W. (1994). On the efficacy of reading to preschoolers. *Developmental Review, 14*(3), 245-302.

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 of Early Literacy Research* (pp. 97-110). New York: Guilford Press.

Sénéchal, M., & LeFevre, J. (2002). Parental involvement in the development of children's reading skill: A five-year longitudinal study. *Child Development, 73*(2), 445-460.

Sénéchal, M., LeFevre, J., Thomas, E. M., & Daley, K. E. (1998). Differential effects of home literacy experiences on the development of oral and written language. *Reading Research Quarterly, 33*(1), 96-116.

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

Shankweiler, D., Lundquist, E., Katz, L., Stuebing, K. K., Fletcher, J. M., Brady, S., Fowler, A., Dreyer, L.G., Marchione, K.E., Shaywitz, S.E. & Shaywitz, B.A. (1999). Comprehension and decoding: Patterns of association in children with reading difficulties. *Scientific Studies of Reading, 3*, 69-94.

Snow, C. E., Burns, M. S., & Griffin, P. (Eds.) (1998*). Preventing Reading Difficulties in Young Children*. Washington: National Academy Press.

Snowling, M. J. (2000). *Dyslexia* (2nd Edition). Oxford, UK: Blackwell Publishers.

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

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21,* 360-406.

Stanovich, K. E., & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology*, *86*, 24-53.

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.

Stothard, S. E., & Hulme, C. (1995). A comparison of phonological skills in children with reading comprehension difficulties and children with decoding difficulties. *Journal of Child Psychology and Psychiatry, 36*, 399-408.

Taipale, M., Kaminen, N., Nopola-Hemmi, J., Haltia, T., Myllyluoma, B., Lyytinen, H., et al. (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,USA, 100,* 11553–11558.

Tunmer, W. E., & Hoover, W. A. (1992). Cognitive and linguistic factors in learning to read. In P. B. Gough, L. C. Ehri & R. Treiman (Eds.), *Reading acquisition.* (pp. 175-214) Hillsdale, NJ: Lawrence Erlbaum.

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*(1), 2-40.

von Eye, A. & Bogat, G.A. (2006). Person-oriented and variable-oriented research: Concepts, results, and development. *Merrill-Palmer Quarterly, 52*, 390-420.

Wagner, R.K. (2005). Understanding genetic and environmental influences on the development of reading: Reaching for higher fruit. *Scientific Studies of Reading, 9*(3), 317-326.

Whitehurst, G. J., & Lonigan, C. J. (2001). Child development and emergent literacy. In M.E. Hertzig, & E.A. Farber (Eds.), *Annual Progress in Child Psychiatry and Child Development 1999* (pp. 37-75). Ann Arbor, MI: Sheridan Books.

Willett, J. B., Ayoub, C. C., & Robinson, D. (1991). Using growth modeling to examine systematic differences in growth: An example of change in the functioning of families at risk of maladaptive parenting, child abuse, or neglect. *Journal of Consulting and Clinical Psychology, 59,* 38-47.

Willett, J. B., & Sayer, A. G. (1994). Using covariance structure analysis to detect correlates and predictors of change. *Psychological Bulletin, 116,* 363-381.

Wimmer, H., Mayringer, H., & Landerl, K. (1998). Poor reading: A deficit in skill-automatization or a phonological deficit? *Scientific Studies of Reading, 2*, 321-340.

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.

Wimmer, H., & Mayringer, H., & Landerl, K. (2000). The double-deficit hypothesis and difficulties in learning to read a regular orthography. *Journal of Educational Psychology, 92,* 668-80.