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Leena Holopainen

Development in Reading and Reading Related Skills

A Follow-up Study from Pre-school to the Fourth Grade

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JYVÄSKYLÄN YLIOPISTO

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ABSTRACT

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A random sample of Finnish children (N = 92) was followed from pre-school to the fourth grade to examine the developmental paths in children's reading acquisition, and the cognitive and linguistic skills associated with reading acquisition problems. Word and pseudo-word reading accuracy and fluency, and cognitive and linguistic skills were assessed individually twice at pre-school and in the first grade, and once in the second and fourth grade. With 47 of these children, computer-based assessment was executed once a month during the first grade to examine the role played by beginning and end analogies in reading. Home and pre-school print exposure, strategies for reading instruction in classrooms and in special education were ascertained by questionnaires. The results indicated the reciprocity between learning to read and phonological awareness at the end of pre-school. Reading in the first grade was based on single phoneme/letter analogies instead of the use of larger unit analogies found with English-speaking children. Pre-school measures used to assess phonological awareness were not able to predict delay in reading achievement at the second grade. Letter knowledge, pseudo-word repetition skill, short-term memory, and naming speed measures were good predictors for the duration of instruction required for reading acquisition by the end of the second grade. Some skills that represent a more general domain than language may be important in the automatization of reading skills. On the other hand, phonological awareness, pseudo-word repetition, and naming speed at the first grade predicted reading accuracy at the fourth grade, and pre-school naming speed and phonological awareness at the first grade predicted reading speed at the fourth grade. At the individual level, there was considerable heterogeneity in the cognitive and linguistic skills leading to different kinds of reading problems. The results indicated that the assessments and interventions for children with potential problems in reading acquisition should be carried out even before pre-school age, and should be expanded to include a wider battery of functions to enhance reading readiness and to hasten reading acquisition.
Keywords: dyslexia, language development, reading acquisition, reading problems, reading instruction, special education.

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LIST OF PUBLICATIONS

Study 1
Holopainen, L., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2000). Two Alternative Ways to Model the Relation Between Reading Accuracy and Phonological Awareness at Preschool Age. Scientific Studies of Reading, 4, pp. 77–100.

Study 2
Holopainen, L., Ahonen, T., & Lyytinen, H. (2001). Predicting Delay in Reading Achievement in a Highly Transparent Language. Journal of Learning Disabilities, 34, pp. 401–413.

Study 3
Holopainen, L., Ahonen, T., & Lyytinen, H. (2002). The Role of Reading by Analogy in First-grade Finnish Readers. Scandinavian Journal of Educational Research, 46, pp. 83–98.

Study 4
Holopainen, L., Ahonen, T., & Lyytinen, H. (submitted). Development of Reading and Linguistic Abilities: Results From a Finnish Longitudinal Study.

CONTENTS

1 INTRODUCTION

1.1 Reading acquisition: A context for reading problems

It is always a challenge for a child, parents and teachers to face the fact that learning to read may transpire to be difficult and laborious. In modern society, reading difficulty is especially handicapping because our lives have become more and more dependent on the information obtained from printed and electronic sources, and the adequate and rapid mastery of reading skills assumes an increasingly prominent position in education. As an important prerequisite for subsequent achievement, failure to acquire reading competence adversely affects other fundamental cognitive skills (Zeffiro, and Eden, 2000). Sometimes the inevitable difficulties in reading acquisition can be predicted early, e.g. because the child displays specific language impairment before school age, or may be at familial risk for dyslexia, but often the problem is not faced until the child attends school. In the current four-year follow-up study, the main foci are the reading acquisition processes, the search for paths leading to reading failure, and the characterization of reading problems at group and individual levels from an orthographic-specific view, the Finnish language. This view has evolved from the discussion concerning whether deficits in reading skill are universal, irrespective of the specific language (Grigorenko, 2001; Lundberg, Olofsson, and Wall, 1980; Wimmer, 1993; Wimmer, and Landerl, 1997). Languages differ in several characteristics, but the main interest here is the effect of orthographic regularity. In a regular orthography, the relationship between graphemes and phonemes is highly consistent as e.g. in Finnish, Greek, and German. In contrast, in an irregular orthography, this relationship is inconsistent, whereby orthography represents phonology indirectly, as e.g. in English, Dutch and French (Elbro, Bostrøm and Petersen, 1998; Venezky, 1970; Wimmer, 1993).

The simple view for communication is, that there is a requirement for humans to communicate by listening and speaking, and that the use of acoustic and articulatory speech signals entails phonological processing (Leong, and

Joshi, 1994). Learning to talk is generally viewed as requiring less direct instruction than learning to read. Theories stating that learning to read and learning to talk both employ the same mechanism are based on the assumption that biological endowment first supports the acquisition of spoken and later, written language, wherein the child makes considerable progress on the basis of a minimal effort (Crain, 1991). An alternative viewpoint holds that learning written language is less natural than learning spoken language. In these theories, it is especially important to know the different levels at which verbal messages are represented by writing systems and the way in which these systems constrain the mapping of the spoken language. In linguistic communication, where every sender is a receiver and every receiver a sender, the processes of production and perception must be linked. Liberman, and Mattingly (1989) have called this link a requirement for biologically-based parity. This means that the necessary link between production and perception is provided immediately by the genetically-determined phonetic module which consequently ensures that the specific phonetic motor structure in the mind of the speaker is reproduced in the mind of the listener. Although parity in speech is partly biologically determined, it does not follow that speech is not learned, or that it need not be taught. For the learning of speech, there are two main sufficient conditions: membership of the human race, and exposure to a mother tongue in an emotionally successful environment (Liberman, 1997). In reading, this parity has been established by agreement. An outcome is that learning to read and write is largely a matter of mastering the arbitrary terms of specified visual shapes, and this naturally requires instruction. In a large number of studies, e.g. in the area of neuropsychology, psychology and linguistics, the interest has been to detect the relations between speech and reading, to understand the precise nature of phonological processing and the underlying speech perception and production mechanisms, and their consequences for early literacy (Byrne, Fielding-Barnsley, Ashley, and Larsen, 1997).

Skilled readers exhibit two striking characteristics. One is the ease and speed with which they are able to read. The other is the amount and texture of information and response, which they generate in reading (Adams, 1990). Understanding how normal reading is acquired may be critical to understanding the difficulties in it. Snowling, Goulandris, and Stackhouse (1993) have postulated that the most appropriate framework within which to investigate developmental disorders of reading is within the context of theories that deal with the development of normal literacy skills. Moreover, theories about how reading is acquired often influence decisions about what curriculum materials is used in reading instruction and in special education.

Theories about how reading is acquired can be viewed from different models. It has been widely held in the English orthography that word recognition involves at least two relatively independent mechanisms that form the dual-process framework. The first mechanism is described as the phonological, indirect or non-lexical route, which involves the use of phonological information. This process is used in the sounding out of unfamiliar words by blending grapheme-phoneme correspondences in order to identify the word. The reader uses knowledge of grapheme-phoneme correspondences to translate the printed word to an internal phonological representation and this may ultimately be used to retrieve the meaning of the word. In our script, this process operates in a left-to-right manner ad is also called sequential decoding. The second mechanism, which is described as the visual or direct, lexical route, uses "direct" mapping from the visual word form onto word meaning, thus establishing the word's specific orthographic patterns (Stuart, and Coltheart, 1988). It has also been shown that in skilled reading, these two routes can be used simultaneously, because most of the English words have phonological and non-phonological factors that influence the pronunciation of the words (Henderson, 1982; Seidenberg, and McClelland, 1989; Van Orden, Pennington, and Stone, 1990).

Another, but very similar way of describing the development of word recognition skills is by using stage models of literacy development (Frith, 1985; Mars, Friedman, Welch, and Desberg, 1980). In an initial logographic stage, children recognize words based on any salient visual and contextual features. In the phonological, alphabetic stage of reading development, children acquire knowledge of letter-sound relationships that can be used to derive pronunciation for printed words. The final stage is fluent orthographic reading. In the stage models of reading processes formulated by Seymour, and McGregor (1984), and later by Høien, and Lundberg (1988), the development of word recognition skills is described in four distinct stages: pseudo-reading, logographic reading, alphabetic-phonemic reading and orthographic-morphemic reading. Through reading experience, the word recognition processes become less and less dependent on contextual support, and the process culminates in an automatic, fast and accurate system, where possible top-down influences originate from local sources within the word itself or the sentence currently being read. Ehri (1987) has proposed a theory of reading development where as a result of reading practice, children improve their decoding skills. In turn, this leads to an increase in accuracy and speed and phonological representations of letter 'chunks' become directly associated with their orthographic form without a need to sound them out letter by letter.

Several studies done on the English language have recognized the importance of analogy in learning to read. Analogy in reading refers to the use of the spelling-sound pattern of one word, for example, 'light', as a basis for decoding a new word, for example, 'fight' (Goswami, and Bryant, 1990). This similarity in spelling allows the inference that the pronunciation of the two words can also be analogous. The systematic relationship between letters and sounds forms the basis for the analogous prediction. It has been proposed (Marsh, Desberg, and Cooper, 1977; Marsh, Friedman, Welch, and Desberg, 1980) that readers in the late stages of reading development could best use analogical processes. However, Baron (1977) and Goswami (1986) have shown that five-year-old English-speaking children are already able to spontaneously use analogies that are based on a rime unit at the beginning stages of reading. This use of analogy in reading has been given an alternative interpretation in several studies e.g. by Bowey, Vaughan, and Hansen (1998), and Nation, Allen, and Hulme (2001).

They argue that young children do not genuinely make orthographic analogies but rather phonological priming with limited orthographic knowledge explains the transfer in their reading (Nation et al. 2001). In Finnish, the use of analogy has been studied with neither younger nor older readers. It has been demonstrated in cross-language studies that the more regular the writing system, the more strongly the beginning reader relies on phonological processing (Sebastian-Gallés, and Vacchiano, 1995; Sprenger-Charolles, Siegel, and Bonnet, 1998). It has also been suggested that the regularity of the orthography could have an indirect effect on reading development via the teaching of reading (Wimmer, and Goswami, 1994). The highly orthographic regularity of the Finnish language provides an ideal opportunity to apply a synthetic method by using phonemes and letters to the teaching of beginning reading. The above factors raise doubts as to whether Finnish beginning readers link elements of written language at the level of larger inter-syllabic units than phonemes and letter.

The core problem concerning reading difficulties is located in the word recognition aspect of reading (Stanovich, 1986), and consequently the assessment of reading acquisition must strongly focus on the basic processes involved in word recognition (Høien, and Lundberg, 1988). Problems with vocabulary, syntax, or comprehension, which are also frequently found among reading disabled children and adults are regarded as originating from the more basic word recognition problems (Shankweiler, and Crain, 1986). Furthermore, with children exposed to the orthographically quite regular German language, Wimmer, Mayringer, and Landerl (1998) and with Finnish adults, Leinonen, Leppänen, Aro, Ahonen and Lyytinen (2001), have shown rather high reading accuracy of pseudo-words, but slow reading speed. Additionally, different reading profiles for reading accuracy and reading speed have also been found with English speaking children (Lovett, 1984). Reading ability in English-language studies has, however, been predominantly defined on the basis of reading accuracy. However, for the assessment of reading at least in orthographically regular languages, it might also be reasonable to use reading speed.

Reading in the present study is defined as fluent mastery of a strategy according to which the child knows and uses correspondences between individual graphemes and phonemes and is also able to fluently decode pseudo-words. The latter ability is often used for assessing the accuracy of the phonological representations or phonological decoding skill (Siegel, and Ryan, 1989). This definition emphasizes the phonological, alphabetic stage of reading. The relevant operational measure is the reading accuracy and reading speed of phonetically familiar non-words. In most previous Finnish studies the reading speed of pseudo-words has not been measured. Another difference from previous Finnish studies on reading acquisition is that here the interest has only been in reading problems, not in spelling and reading problems together. The third difference compared to most previous Finnish studies is that the focus is on reading development and not on the quality of reading errors (as e.g. in Ruoppila, Röman, and Västi, 1968).

1.2 Reading problems

There are numerous complexities associated with the study of reading disabilities. The first is their definition. Grigorenko (2001) has recently summarized the difficulties associated with the definition of dyslexia, and has raised an essential question as to whether dyslexia is a qualitative or a quantitative disruption. In fact, spanning the 100 -year history of known dyslexia-like problems, the condition of specific reading failure has been referred to in various ways. These include congenital word blindness first described by Hinshelwood in 1895 and Morgan in 1896, developmental alexia in 1906, strephosymbolia by Orton in 1937, specific reading disability, specific developmental dyslexia, dyslexia, backward reading, and poor reading (cited in Hynd and Cohen 1983; Orton 1937; Pirozzolo, 1979). Most definitions reflect an expectation about the existence of a qualitatively separable entity from normal reading development. The latter two terms, backward and poor reading, appear to link the problem with the normal variation in reading ability. A central tenet in several definitions of developmental dyslexia holds that there is a sub-population of children who fail to learn to read in spite of conventional instruction and adequate intelligence.

Another question which investigators have puzzled over is the apparent heterogeneity of children with dyslexia. This observation has led to the subtype hypothesis. The main idea is that dyslexia may represent different subtypes that vary in phenotypic characteristics, neurobiological correlates, and response to interventions (Bakker, 1990; Fletcher, Morris, Lyon, Stuebing, Shaywitz, Shankweiler, Katz, and Shaywitz, 1997; Seymour, and MacGregor, 1984). Terms such as dyslexic readers, slow starters, poor readers, garden-variety poor readers or long-term poor readers have been used while describing children who meet the criteria for reading disability. Developmental dyslexia is inferred on the basis of an individual's relative inability to read single words. Orthographic and/or phonological difficulties have often been used to define two distinct types of dyslexia. Problems in orthographic processing (manifested e.g. in irregular word spelling) have been associated with surface dyslexia, and problems in phonological processing, e.g. making phonological adjustments, have been linked to phonological dyslexia (Manis, Seidenberg, Doi, McBride-Chang, and Petersen, 1995; Stanovich, Siegel, and Gottardo, 1997). Slow starters have been defined as children who are poor readers at the beginning of schooling, but who acquire fluent and accurate reading skills relatively quickly (Badian, 1988; Cox, 1987; Mc Gee, Williams, and Silva, 1988). On the other hand, the term poor reader refers to individuals who have problems in reading, spelling, phonological processing, memory and language, but IQ does not set limits on a child's ability to learn to read (Siegel, 1992). Closely related is the concept of garden-variety poor readers, whose cognitive performance profiles resemble the performance of younger children, who are at the same stage of reading acquisition as younger readers, and may also have phonological problems, but in a less severe form than dyslexic children. Some of these cognitive deficits may also be linked to problems with reading comprehension (Stanovich, 1988). Finally, long-term poor readers have been found to display a paucity of literacy experience at home and limited vocabulary, and lower maternal reading ability, mostly associated with low parental SES (Badian, 1988 and 1993; Cox, 1987; Mc Gee, Williams, and Silva, 1988). In the present study, the term "delayed reader" has been used at the group level to refer to accuracy and /or fluency problems in reading. At the individual sub-typing level, terms describing the core problem of cognitive and linguistic skills (e.g. naming deficit reader, poor reader) were used. The term "reading problems" is used in the text as a general term to refer to any kind of problems in reading.

Those who successfully master reading skills and those who do not, differ on a wide range of reading-related processes (Grigorenko, 2001). Previously, research into reading problems focused for several years on the role of visual-processing difficulties, but during the last twenty years, the focus has increasingly changed to verbal difficulties, and specifically, to phonological processes. The role played by visual and higher-order cognitive skills in reading has not been overlooked, but evidence of the involvement of different phonological processes (perceiving, storing, accessing, and manipulating phonological information) associated with reading has been convincing (Goswami, and Bryant, 1990; Liberman, Liberman, Mattingly, and Shankweiler, 1980; Lundberg, and Höien, 1990; Olofsson, and Niedersøe, 1999; Stanovich, 1988; Torgesen, Wagner, and Rashotte, 1994). Recent research has also shed light on the biological, neuro-anatomical mechanisms that affect reading (Galaburda, and Livingstone, 1993; Leppänen, Pihko, Eklund, and Lyytinen, 1999; Näätänen et al., 1997; Pennington et al. 1999), and the genetic origin of reading problems (Grigorenko, 2001; Pennington, 1999).

At pre-school age, most children are competent in the production and comprehension of language although this competence does not automatically lead to success in reading acquisition. In order to read, children have to learn a new code connecting graphemic and phonetic units. In addition to language skills, this requires letter knowledge. Scanlon, and Vellutino (1996) found in their longitudinal study that a child's ability to name letters and numbers was the factor most strongly related to first-grade reading (accounting for 35.2 % of the variance). Scarborough (1990) reported from a longitudinal study that children who were at familial risk for reading problems were less familiar with letters of the alphabet at the age of five than their peers. On the other hand, there is good evidence to show that training letter names on its own does not provide children with any appreciable reading advantage (Adams, 1990).

The phonological basis of skilled reading and the phonological deficits seen in disabled reading, have both prompted researchers to posit a core phonological process that accounts for a variety of commonly seen correlates of reading performance (Brady, 1991; Liberman, and Shankweiler, 1979). The first phonological candidate associated with reading skill is phonological awareness, which includes such terms as sensitivity, reflection or conscious awareness of speech sounds, that in turn may include allophones, phonemes, onsets and rimes, syllables, sound-clusters or words (Bradley, and Bryant, 1985; Goswami, and Bryant, 1990). One way of gaining insight into the nature of phonological awareness is by examining the assessment of phonological awareness itself. To measure phonological processes, participants are usually asked to make judgements concerning speech sound units that vary in terms of size and level of abstraction (e.g. phoneme segmentation, phoneme deletion). In the present study, the main focus in phonological awareness is on phoneme awareness. This is measured by phoneme identification (saying /r/ when given the word '*rapu*'), phoneme blending (saying '*iso*' when given the sounds /i/-/s/-/o/), phoneme deletion (saying /*apu*/ when given the word '*rapu*', or saying '*sana*' when asked to say '*sauna*' without the /u/ sound), and phoneme substitution (e.g. saying '*veli*' when asked to say '*vesi*' by changing the /s/ sound to the /l/ sound). Phonological awareness in children emerges as an initial sensitivity to the phonological structure of words that, in turn, is required to understand the way that oral language is represented in written form (Torgesen, 1998). A deficit in phonemic awareness may also be a mediating link between the inaccurate perception of speech, preventing the adequate formation of awareness, and reading acquisition.

The second phonological process involved in reading is establishing fully specified phonemic representations of words. This refers to the ability of making precise and stable phonological forms of new items, usually assessed by vocal repetition of pseudo-words (Gathercole, 1995; Stone, and Brady, 1995). The deficits underlying weak performance can include poor perception of rapid temporal changes in speech, which may prevent the formation of accurate representations of phonemes, and thus, accurate phonemic awareness (Gathercole, 1995; Stone, and Brady, 1995; Tallal, 1980). Also, other deficits in segmenting the flow of speech and organizing the output of speech may play a role in explaining difficulties in pseudo-word repetition and poor reading skills (Snowling, 1981; Snowling, Goulandris, Bowlby, and Howell, 1986).

The third problem with encoding of the speech stimuli may involve verbal short-term memory. Inefficient or inaccurate formation of phonological representations might limit the resources available for recall, or might result in a less durable memory trace. The component of working-memory called the 'phonological loop' plays a crucial role in learning novel phonological forms of new words (Baddeley, Gathercole, and Papagno, 1998; Scarborough, 1998).

Problems reported with productive naming tasks could also be one form of difficulty in establishing specified phonemic representations of words found with poor readers. Current debate among researchers has concerned explanations of rapid naming deficits. The first view is that this impairment is part of a pervasive problem at the level of underlying phonological representations (e.g. Snowling, Goulandris, and Stackhouse, 1994; Torgesen, Wagner, Rashotte, Burgess, and Hecht, 1997). Another account views the deficits in rapid naming as the consequence of an impairment of timing mechanisms affecting the fluency of reading (Bowers, and Wolf, 1993; Korhonen, 1995). Wolf, and Bowers (1999) have demonstrated sub-groups of children whose reading was limited by naming speed only, by phonological awareness only, or what they termed a double deficit characteristic in children with deficits in both naming speed and phonological awareness. Children who were poor in naming speed were poor in reading speed and comprehension. They were also quite poor in word reading accuracy but not in their accuracy of reading pseudo-words. Children with phonological deficits were poor in word- and non-word reading accuracy as well as in reading comprehension. Children with combined phonological and naming-speed deficits had more severe reading difficulties than children with either deficit alone.

One of the fundamental precepts of dyslexia is that dyslexic children learn to read differently from children whose reading difficulty derives from low intellect. Comparisons between the reading progress of children who have low intelligence and reading problems, and children with specific reading disability, have shown that the reading progress is not very different (Stanovich, 1994). The second question in this area centres on whether reading acquisition is related to intellect in a continuous fashion. Share, McGee, and Silva (1989) have found that although there is a correlation between reading and intellect for the general population, the relationship between intellect and reading ability is not linear for individual children. The IQs of some children would predict garden-variety poor reading, but still they attain reading skills at significantly advanced rates. Finally, the ability of IQ-achievement discrepancy formulas to appropriately identify children with reading problems has been challenged (Siegel, 1989; Stanovich, and Siegel, 1994; Vellutino, Scanlon, and Lyon, 2000). This challenge is based on several factors. First, reading skills and IQ are interdependent constructs in a way that language abilities make substantial contributions to both of them. Second, reading difficulties may slow down the rate of intellectual growth and thereby obscure the discrepancy between reading skill and IQ (Shapiro, 1998).

One tenet in the research of reading problems is that these problems and the related disorders are fundamentally linked to differences in brain structure and function. With structural (Magnetic Resonance Imaging [MRI]) and functional brain imaging techniques (Event-related potentials [ERPs], Positron Emission Tomography [PET], and Magnetoencephalography [MEG]), investigators can explore the neural mechanisms underlying reading in children. Studies of both structural and functional brain differences between normal readers and those who have problems in reading have accumulated evidence suggesting that persons with reading problems are different from normal readers (e.g. Hari, and Kiesilä, 1996; Morgan, and Hynd, 1998). It appears that a reader with problems does not show extreme characteristics on a normal distribution but instead demonstrates features that are either suppressed or not at all present in normal readers (see reviews by Grigorenko, 2001; Habib, 2000; and Zeffiro, and Eden, 2000). In a recent study by Paulesu *et al.* (2001), the cultural and biological aspects were investigated in the same study. The cerebral blood flow was measured by PET scans during single word reading performance of Italian (more regular orthography), and English and French (irregular orthography) adults with dyslexia. A similar reduction in activity in a left hemisphere region was observed in adults with dyslexia from all three countries. What is more, Italian adults with dyslexia performed better on reading tasks due to differences between the orthographies. Paulesu et al. (2001), concluded that ”there is a universal neurocognitive basis for dyslexia and differences in reading performance among dyslexics of different countries are due to different orthographies”, p. 261.

In understanding the etiology of reading problems, their heredity has been investigated for almost 50 years. Genetic explanations have relied mostly on evidence from twin studies (e.g. Cardon, Smith, Fulker, Kimberling, Pennington, and DeFries, 1994), but more recently they have also drawn upon studies of “dyslexic” families (Elbro, Borstrøm, and Petersen, 1998; Lyytinen *et al.*, 2001; Scarborough, 1990), and molecular-genetic studies (e.g. Grigorenko, Wood, Meyer, Hart, Speed, Shuster, and Pauls, 1997). Twin studies have focused either on reading achievement or on reading-related processes. Modern twin studies have been based on the assumption that reading disability is not a categorical disorder, but an extreme position on the continuum of reading ability. The results have supported a substantial genetic influence on reading deficits at the group level, and suggested some hereditary components of reading related skills (Gilger, Pennington, Harbeck, DeFries, Kotzin, Green, and Smith, 1998; Nopola-Hemmi, Myllyluoma, Haltia, Taipale, Ollikainen, Ahonen, Voutilainen, Kere, and Widen, 2001; Wadsworth, Olson, Pennington, and DeFries, 2000).

Even if reading problems are linked to a major gene, there is considerable room for interplay between the environmental and genetic factors that affect individuals, and so the variation we observe in a population will be continuous, no matter how precise the measurement instruments aimed at the diagnosis of reading problems become (Grigorenko, 2001). Commonly cited major environmental risks for failing to reach optimal reading development are: (1) low socioeconomic level, (2) problematic educational factors, and (3) a deficient home literacy environment. The household income and parent’s educational and occupational status are conventional indices of the socioeconomic status (SES) of the family. Low SES is often associated with a broad array of environmental circumstances that may place the child at risk for reading problems (Scarborough, 1998). Socioeconomic level holds in several related factors (e.g. parental education, child education), which makes it difficult to assess its effects separately. Also the relationship between reading and SES has shown to be complex. In particular, the degree of risk associated with the SES of an individual child’s family is considerable lower than the degree of risk associated with the SES level of a group of pupils attending the same some school (Share, Jorm, Mclean, and Matthews, 1984; White, 1982). Educational factors include both educational opportunities and characteristics of the school environment (educational settings, classroom instruction, remediation). The characteristics of several home literacy environments (parental reading habits, stimulating verbal interactions, availability of reading materials) contribute towards reading achievement and have been found to be predictors of an individual child’s risk for reading difficulties (Scarborough, 1998). However, as Grigorenko (2001) has pointed out, the environmental factors put the child at risk in mastering reading, but they are not causal factors solely determining reading failure. Moreover, the effect of the home literacy environment on reading achievement among elementary school children has been shown to be relatively small and inconsistent (Rowe, 1991). Plomin (1994), and later Rutter (1997), have presented three mechanisms that may affect a child's exposure to different environments via genetic factors. First, the passive gene-environment, which involves the influence of the parents' genes on their child's experience through the environment offered to the child. Second, the evocative gene-environment correlation refers to a situation in which the child's inherited characteristics serve to elicit particular responses from other people and thus influence the child's own responses and experiences. Third, the active-environment influence indicates a process in which the child will select and create his/her experiences and environments in correlation with his/her own genetic propensities. Finally, Eckert, Lombardino, and Leonard (2001) have demonstrated a linear association between cerebral organization (planar asymmetry) and phonological skill within socio-economic groups. Their data provided evidence that both environmental and biological factors are independent determinants of a child's ability to process linguistic information.

Although much research has been conducted with regard to the manifestation of reading problems, the environmental factors and the definition of reading achievement and reading related components vary from study to study and consequently limit the interpretation of the findings. Figure 1 is an attempt to theoretically illustrate the pathway regarding how the different biological and environmental elements and etiological factors crucial to this study may be involved in reading acquisition and in reading problems.

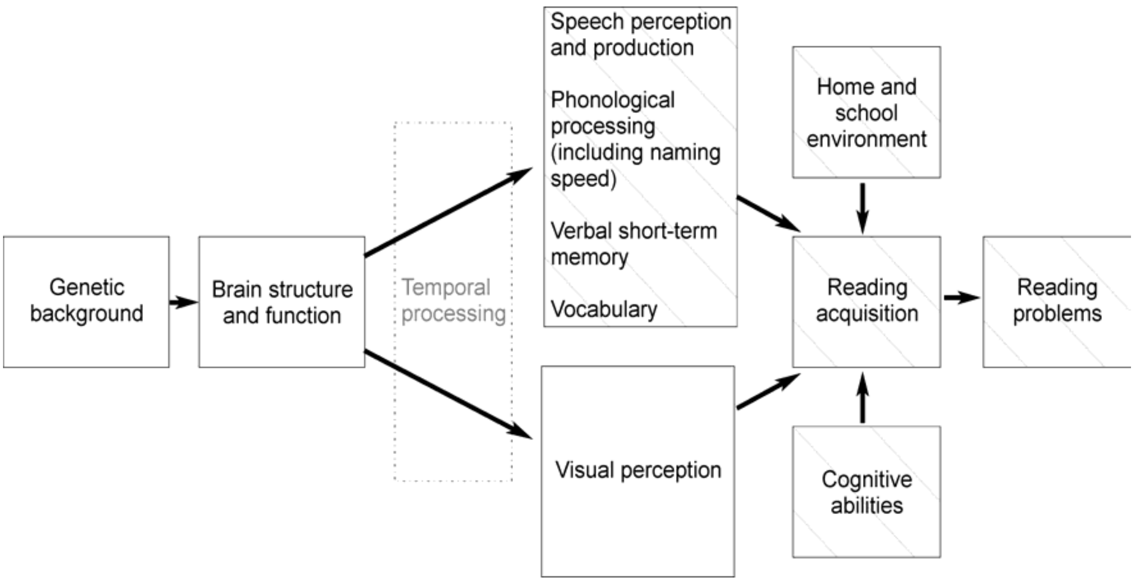

FIGURE 1 Theoretical model of etiological mechanisms for reading problems. Mechanisms assessed in this study are marked with skewed lines.

Understanding the unexpected problems that are related to reading problems is an important goal for practical as well as theoretical purposes. It holds considerable significance for dyslexic individuals, parents and teachers of dyslexics. An understanding of the underlying causes of reading problems is also an important first step towards devising appropriate remedial programmes. Another practical consequence of a proper understanding of the causes of reading problems is that it should facilitate early detection of potential difficulties. This facilitates screening of those difficulties at an early stage and thus prevents the emergence of reading and spelling problems (Catts, 1989; Rack, 1994).

1.3 Finnish research on reading

It is of special interest here to examine reading acquisition in the Finnish language. In the history of Finnish reading research, there are only a few studies that focus on questions close to this dissertation topic, such as reading achievement, predictors for reading problems, or the development of reading related skills in the early school years. Studies by Korkeamäki (1996), Lehtonen (1993), Matilainen (1985), and Ojanen (1985) targeted the area of reading acquisition, and those by Ahvenainen (1980), Mäki (1954), and Salminen (1979) dealt with the area of reading problems. If reading problems are viewed as developmental problems in reading acquisition, which require several hierarchical processes of cognitive systems and operations, then longitudinal research is required in order to find the developmental paths. However, the majority of the previous studies have been carried out at one point in time (e.g. one term, one year), and as such they can provide only a snapshot of the skill studied, but cannot throw light on how it changes over time. Moreover, if the spectrum of cognitive and behavioural problems covered by the concept of reading problems is as broad as reflected in existing studies the best way to create the structure is to link different methodologies and interpretations. Studies mentioned above have their roots in general or special education with very few cross-disciplinary studies. A few quite recent exceptions to this rule must be mentioned. The study by Korhonen (1995) was a longitudinal study from a neuropsychological perspective where the persistence of problems in rapid naming in subjects with reading difficulties was assessed. In the study by Aro, Aro, Ahonen, Räsänen, Hietala, and Lyytinen (1999), educational and neuropsychological aspects have been integrated, as will be described later.

During the last ten years, four cross-disciplinary research groups have been formed to search for answers to the questions concerning reading acquisition and reading problems: one at the university of Jyväskylä, two at Helsinki University of Technology, and one at the University of Turku. The Jyväskylä Longitudinal study of Dyslexia (JLD; Lyytinen, Ahonen, and Räsänen, 1994; Lyytinen, Leinonen, Nikula, Aro, and Leiwo, 1995; Lyytinen, 1997), attempts to identify early precursors and developmental paths associated with dyslexia. Approximately 200 children, half with and half without familial risk for dyslexia have been intensively assessed during their development from birth. Today, all of these children have reached the age of five years. In the JLD, children have, in addition to parent(s) with diagnosed dyslexia, at least one of his/her close relative with reported reading problems. A number of signs indicating differences were already observed during the first six months of life in the experimental studies with the JLD -infants. The earliest differences between familial risk group children and control children were found at 6 months in brain event related potential responses to speech sounds and in head-turn responses conditioned to reflect categorical perception of speech stimuli (Lyytinen et al., 2001; Lyytinen, Leppänen, Richardson, and Guttorm, in press). Later differences emerged between children-at-risk and control groups in tasks of language production such as the maximum sentence length at 2 years and the pronunciation of diphthongs and long words at the age of 2½ years. At age 3½ years, the most explicit differences between the groups included Boston Naming, Emerging Phonological Awareness and Inflectional Morphology. In addition, at the age of 5 years, Digit Span, vocabulary and letter naming, for example, show reliably higher scores among non-risk children, even after controlling for non-verbal IQ. The practical conclusion so far is that if a child is at familial risk for dyslexia and with the history of late talking age, she/he may be at higher risk for delays in language acquisition than a child without the familial risk, and therefore requires more careful assessment and intervention (Lyytinen, P., Poikkeus, Laakso, Eklund, and Lyytinen, H., 2001).

Two groups of researchers in the Low Temperature Laboratory at the Helsinki University of Technology have studied differences between adults with and without dyslexia. One group has identified brain locations in the temporal and posterior auditory and speech-related areas that show atypical activation among adults with dyslexia on reading-related tasks (e.g. Helenius, Tarkiainen, Cornelissen, Hansen, and Salmelin, 1999; Salmelin, Service, Kiesilä, Uutela, and Salonen, 1996). The other group has shown that not only do adults with dyslexia differ from normal readers on tasks requiring temporal perception of sound (Hari, and Kiesilä, 1996; Helenius, Uutela, and Hari, 1999), but also on comparable visual tasks (Hari, Renvall, and Tanskanen, 2001; Hari, Sääskilahti, Helenius, and Uutela, 1999). They have linked their findings to a possible magnocellular impairment.

Researchers in the Centre for Learning Research at the University of Turku have examined the cognitive and motivational correlates and predictors of learning disorders including dyslexia (Dufva, Niemi, and Voeten, 2001; Kinnunen, Vauras, and Niemi, 1998; Lehtinen, Vauras, Salonen, and Olkinuora, 1995; Lepola, Salonen, and Vauras, 2000; Poskiparta, Niemi, Lepola, Ahtola, and Laine, submitted). They have also evaluated the effects of intervention on early reading (Poskiparta, Niemi, and Vauras, 1999; Poskiparta, Vauras, and Niemi, 1998). In addition, they have carried out important research in understanding the resistance to treatment associated with dyslexia (Niemi, Kinnunen, Poskiparta, and Vauras, 1999).

Learning to read Finnish is especially interesting because the grapheme-phoneme correspondence is more consistent than in most alphabetic languages. In Finnish, all letters including vowels are sounded irrespective of their placement in a word. Each letter always indicates only one phoneme and this regularity is explicit in both directions with only one exception (ng), whereas the pronunciation of English sounds vary dependent on orthographic environment.

Moreover, when reading English the reader must process a long sequence of letters before he can even initiate the accurate articulation of the written word, which, in turn, may reflect the role of processes required in learning to read. Consistency in Finnish also includes the semantically highly distinctive length of sounds. This is clearly marked as single versus repeated (i.e. double) letters (e.g. mato (worm) vs. matto (carpet), tuli (fire) vs. tuuli (wind). This phonological characteristic demands accuracy in reading and especially in spelling at the word and phoneme levels. Finnish words usually consist of a relatively large number of syllables and monosyllabic words are rare, which sets an extra load on the decoding process (Karlsson, 1983).

Furthermore, the method of classroom instruction may partially explain possible differences in reading acquisition between orthographies (Valtin, 1994). It has been demonstrated (Valtin, 1994; Wimmer, and Goswami, 1994) that in a language with regular grapheme-phoneme-correspondences, it is a rational choice to use an alphabetic strategy, where emphasis is placed on phonics in reading, thus reinforcing grapheme-phoneme correspondences. It must be mentioned here that the school entry in Finland occurs in the year during which the child reaches the age of seven, whereas children in most countries start school earlier. It has been shown (Adams, 1990; Gombert, 1992; Muter, Snowling, and Taylor, 1994) that phonological awareness shows a clear developmental progression between the ages of 4 and 6 years (moving from rhyme detection to phoneme manipulation). This allows the assumption of more advanced stages of phonological awareness for Finnish children than e.g. English speaking children at the beginning of formal reading instruction.

In Finnish schools, as with the children in the present study, the above instruction method includes letter recognition, listening and sounding out phonemes and syllables, and even practising sounding out phonemes in front of a mirror. This simultaneously strengthens children's decoding skills and phonological awareness. Studies by Julkunen (1984) and Ojanen (1985) demonstrated that after two school years, most children are good decoders. In the cross-national reading survey by the International Association for the Evaluation of Education Achievement in 1990-1993, Finnish 9- and 14 year olds were among the best readers (Linnakylä, 1995), as well as in OECD Programme for International Student Assessment (PISA) in 2000 - Finnish 15 year-old students performed the best in reading literacy assessment out of all the OECD countries participating in the study (Välijärvi, Linnakylä, Kupari, Reinikainen, Malin, and Puhakka, 2000). Share, and Stanovich (1995) have stressed the importance of fully attaining alphabetic reading skills because inherent problems not only limit early reading but also interfere with subsequent development of other word reading strategies (e.g. orthographic) that form the basis of fluent reading and reading comprehension. Additional evidence supporting the use of the alphabetic strategy in reading, especially in Finnish, where reading and spelling are instructed at the same time, is that Muter (1998) has shown that spelling seems to be even more explicitly phonologically driven than reading, and that the need for phonological support remains later in spelling development than in reading development. However, it is clear that children must also be taught to glean the meaning from text, but it is still an unresolved question as to what would be the most appropriate time and method of integrating phonics and context-based skills to decipher meaningful text (Torgesen, Wagner, and Rashotte, 1997). In summary, it is still an open question as to whether and to what extent the degree of transparency between graphemes and phonemes in a language might facilitate or hinder a beginning reader's efforts to attain automatic decoding (Näslund, Schneider, and van den Broek, 1997).

Another topic that has been addressed, especially by teachers and also by some researchers in Finland, is the approach to instructional methods for remediation of reading disabilities and the role of other skills in reading. The very first notable studies on the history of reading and writing problems in Finland have been carried out by Niilo Mäki in the years 1950 and 1954, wherein he described the term "word-blindness" with respect to such children, and studied the manifestation of dyslexia caused by brain injuries. The study by Salminen in 1979 has played an important role in developing the assessment of early language acquisition in relation to reading and writing skills. Children's sensory-motor readiness (auditory-visual integration, phonemic, melodic, optic, and kinaesthetic differentiation) for learning to read and write was assessed in pre-school whereby children with poor readiness were trained for three months and assessed again in the first school year. These results suggested that sensory-motor readiness measured in pre-school predicted the child' s success in learning to read and write, but poor sensory-motor abilities could be improved by training. Another perspective on reading and writing problems was in the study by Ahvenainen (1980), where the quantitative and qualitative features of remedial reading and writing instruction, and the effect of remedial reading and writing instruction (once a week in a small group) on second and third grade pupils were examined along with other research problems. An interesting finding was that over twenty years ago, before the specific interest in the linguistic (especially phonological) problems related to reading difficulties, one third of all remedial reading and writing instruction was tied to the practice of basic linguistic skills, and two-thirds of the instruction in reading and writing operated visually or visuo-motorically. The effect of this remedial instruction was most clearly seen in the second grade as a positive influence on mechanical reading and writing skills.

During the last ten years, the focus has changed more and more to the early prediction and intervention of reading problems. Korkman, and Peltomaa (1993) showed in their study with language impaired pre-school boys (at the age of 6) who were deemed to be at risk of reading problems that these children benefited from early intervention focused on both phonological awareness and direct training on reading. In a study by Aro et al. (1999), the relation between phonological abilities and reading acquisition with children whose school entry had been postponed because of their underdeveloped social skills and immature group work abilities was followed during the first grade (age of 7). Children received phonological training (sentence level exercises, word segmentation exercises and rhyming exercises) twice a week for 5 months. In addition, children participated in visuo-motor and meta-cognitive training. The results showed that the predictive value of phonological manipulation skills was not very high because many of these skills showed improvement only shortly before the children started to master reading and beyond. In addition, in a study by Poskiparta et al. in 1999, half of the participants (first graders, aged 7 years) received normal special education instruction at school, and the remainder received phonological awareness training 47 times for twenty minutes at a time. The participants belonged to the lowest quartile in phonological awareness of 240 children assessed. In the analysis, participants were divided into two groups based on their cognitive level (low vs. nearly average). The results showed that those children who had a low cognitive level (low level of verbal intelligence, working memory, counting skills and knowledge of alphabet) but received training in linguistic awareness, made considerable progress in decoding and spelling. In summary, these results show that early detection and intervention, especially with those children who have deficient language or cognitive development, should also be taken seriously in association with the development of special education at schools.

Although reading acquisition and developmental dyslexia have been enthusiastically investigated throughout the world, surprisingly few Finnish studies in special education have been focused on the development of reading, its associations to reading related skills, and on inability to master reading. As children with reading and spelling problems comprise the largest group of students receiving special education services in Finnish schools (Ihatsu, Ruoho, and Happonen, 1996), especially longitudinal research in particular is required in the area of special education. On the other hand, the variety of findings on complex etiological, cognitive and behavioural sources suggest that in the search to understand the nature of developmental dyslexia and the means of remediation, the contribution of cross-disciplinary and cross-linguistic research should be addressed.

1.4 Research purposes, problems and hypotheses

This dissertation has three main aims: firstly, to examine normal reading acquisition and the role of reading instruction based mainly on synthetic phonics in the acquisition process. Secondly, to detect early predictors of, and pathways leading towards reading failure. Thirdly, to characterize reading and reading related problems at group and individual levels in order to later develop special instruction for different types of delayed readers. In addition, while orthographies vary in their phonological transparency and, likewise, methods of reading instruction vary among different orthographies, the general focus is to compare the results from this study to the findings from reading studies in other languages, where the letter-sound correspondences are more complicated than in Finnish. The research problems, hypotheses and statistical analyses in each study are presented in Table 1. The details of statistical analyses are presented in chapter 2.3.

TABLE 1 Research problems, hypothesis and statistical analysis of separate studies.

Research problems of the study	Hypothesis	Statistical analysis
	Study 1	
What are the associations between non-verbal skills, verbal skills (especially phonological awareness) and reading at school entry before formal instruction begins?	Phonological awareness is a prerequisite for learning to read. Learning to read fosters the development of phonological awareness.	Structural equation modelling.
	Study 2	
Which preschool measures predict the differences in the age at which children achieve accurate and fluent reading skill?	Predictive power of phonological awareness for reading accuracy varies with the reading instruction time. Naming speed at pre-school age plays a central role in predicting later reading fluency.	Logistic regression analysis.
	Study 3	
Do Finnish beginning readers decode syllables more accurately in clue-syllable situations (= using analogy) than without the clue-syllables?	No benefit of clue-syllables is expected.	Multivariate analysis of variance.
Does the reading accuracy or reading speed change due to the cued recognition units (beginning, end) compared to control syllables?	No change is expected in reading accuracy or reading speed.	
Does the size of the syllable structure affect the accuracy or speed of reading in a cued situation compared to a control situation?	The size of the syllable structure does not have an effect on the accuracy or speed.	
	Study 4	
What is the relation of cognitive and linguistic skills to inaccuracy and dysfluency in reading at the fourth grade, and at both group and individual levels?	Several different skills and different developmental paths of the participants are associated with the heterogeneous appearance of inaccuracy and dys-fluency in reading.	Multivariate and univariate analysis of variance, Multiple regression analysis.

2 METHOD

2.1 Participants

In the first phase, 71 girls and 89 boys (N = 160) from 13 pre-school groups in nine day-care centres in Jyväskylä, Finland, took part in the study after they had been seven months in pre-school groups. The chronological mean age of the children was 6.9 years (SD 0.3 years). Parental SES and parental education were representative of the distribution in the Finnish urban population of this age group [mean age of the mothers was 36.6 years and of the fathers 38.8 years] (Statistical Yearbook of Finland, 1996). In the second phase, after children's attendance at the pre-school for 9 months, 92 children (38 girls and 52 boys) were randomly selected for the follow-up study. At age 7.5 in 1998, 37 girls and 51 boys (96.3 % of the original sample), at age 8.5 in 1999, 35 girls and 49 boys (92.6 % of the original sample), and at the age of 10.5 in 2001, 32 girls and 41 boys (82.5 % of the original sample) were able to participate in these follow-up phases.

2.2 Procedure and measures

The follow-up started in March 1997, after 7 months at pre-school. The next assessments were at the end of pre-school in May 1997 after 5 months in the first grade in January 1998, at the end of the first school year in May 1998, after the second school year in May 1999, and in the fourth grade in January 2001. Assessment was carried out individually. Each assessment lasted approximately two hours including breaks, as and when required by the child. As far as was possible, the same examiner tested the same child in each phase. Tests were presented in the same fixed order to all children. Table 2 summarizes the school phases of data collection, and the measures used in the four separate studies of this dissertation. The full description (procedure and scoring) of the measures can be found in the relevant study noted in the Table 2.

TABLE 2 Assessment phases, and areas measured in separate studies of the dissertation.

Phases				***Assessment areas***[1]	***Studies***			
Pre-school	1. grade	2. grade	4. grade		1	2	3	4
				Language skills				
x		x	x	Vocabulary	x	x		x
x	x	x	x	Auditory reasoning	x	x		
x	x	x	x	Pseudo-word repetition	x	x		x
x	x	x	x	Oral-motor coordination	x	x		
x	x	x	x	Naming	x	x		x
x	x	x	x	Short-term memory	x	x		x
x	x			Phonological awareness	x	x		x
		x	x	Phonological processing		x		x
				Cognitive abilities				
x		x	x	Non-verbal intelligence	x	x		x
x	x	x	x	Visual analogical reasoning	x	x		x
				Reading skills				
x				Letter knowledge	x	x	x	x
	x			Letter identification		x		x
x				Word reading	x		x	
x				Syllable reading	x	x	x	x
	x			Pseudo-word reading 1		x		x
		x	x	Pseudo-word reading 2		x		x
			x	Reading comprehension				x
				Background factors				
x	x	x	x	Parental socio-economic status and print expose at home	x	x	x	x
x				Print expose at pre-school	x			
	x	x		Reading instruction		x	x	
	x		x	Special instruction		x		x
			x	Special instruction in detail				x

[1]*Measures*: Vocabulary (PPVT-R; Dunn, & Dunn, 1981), Auditory reasoning (ITPA, Kuusinen, & Blåfield, 1974), Pseudo-word repetition, Oral-motor coordination and Phonological processing (NEPSY, Korkman, Kirk, & Kemp, 1997), Naming (RAN, Denckla, & Rudel, 1974), Short-term memory (WISC-R, Wechsler, 1974), Phonological awareness, Letter knowledge, and Word reading (Diagnostiset testit 1, Poskiparta, Niemi, & Lepola, 1994), Non-verbal intelligence (Raven`s Coloured Matrices, 1962), Visual analogical reasoning (K-ABC, Kaufman, & Kaufman, 1983), Letter identification and Pseudo-word reading 1 (European Commission, COST Action 8, National data for reading at the first grade, Niilo Mäki Institute, 1997), Syllable reading and Pseudo-word reading 2 (Niilo Mäki Institute, Neuropsychological and achievement tests: Local normative data for Niilo Mäki Institute Test Battery, 1994), Reading comprehension (ALLU, Lindeman, 1998), Socio-economic status and print exposure at home (Questionnaire, modified for this study from Lyytinen, Laakso, & Poikkeus, 1998), Print expose at school, reading instruction, Special instruction and Special instruction in detail (Questionnaires, formulated for this study).

2.3 Statistical analyses

In order to test the theoretical hypotheses of relationships among reading related measures, especially phonological awareness, reading and letter knowledge in Study 1 (N = 92), two structural equation path models were constructed. These theoretical constructs were estimated and tested using structural equation modelling (LInear Structural RELationships program, Jöreskog, and Sörbom, 1996). The measurement model specifies how latent variables are indicated by the observed variables, and describes the reliabilities and validities of the observed variables. The structural equation model for its part specifies the relationships among the latent variables, describes the effects, and assigns the explained and unexplained variance. The use of this method was warranted because then the associations between observed variables and latent variables in the measured model and the associations between the factors in structural equation modelling drawn from theory could be estimated in one statistical model. This reduces the margin for errors in the statistical management of the data.

In analysing the data in Study 2 (N = 89), binomial logistic regression analyses (using stepwise method with backward condition, where the least significant predictor was dropped), was used in order to test the significance of the individual independent variables on reading performance. This form of regression analysis was used in this study because the dependent variable was dichotomous (two reading groups). Multiple linear regression analysis would not have handled non-linear relationships, whereas the log-linear method did. In this form of regression analysis, the odd ratios for each of the independent variables were able to use an estimation of the probability of occurrence of the studied event. Moreover, multi-linear logistic regression analysis was not used because in this study, it was especially interesting to ascertain the differences between all groups in order to show the differences in times required for reading instruction.

In Study 3 (N = 47), the research questions were focused on two different concerns: analogous situations (beginning, end, control), and five syllable structures (CV, CVV, CVC, CVCC, CVVC), and the equality of their means in two reading situations (pre-test, test). Because there were several correlating dependent variables, multivariate analysis of variance (MANOVA, Pillai´s Trace) for repeated measures was appropriate.

In Study 4 (N = 73), longitudinal data of four years' follow up were gathered in order to examine the development of reading and reading related skills. Two methods of data analysis were selected. Firstly, a multivariate analysis of variance for repeated measures (MANOVA) was deployed to examine the mean differences of seven measures (Raven, PPVT, Digit Span, Phonological Awareness, Pseudo-word Repetition, Matrix Analogies and Naming Speed), measured at four time points (preschool, first grade, second grade, fourth grade), between two reading groups (delayed readers vs. normal readers). The significant results of the MANOVA were further analyzed by using univariate analysis of variance (ANOVA). Secondly, the results were complemented with multiple regression analysis, using a Forward method, in order to determine the independent variance of specified dependent variables, when reading accuracy and reading speed were used as two separate continuous variables.

3 MAIN RESULTS OF SEPARATE STUDIES

3.1 Study 1: Two alternative ways to model the relation between reading accuracy and phonological awareness at preschool age

In the first study the structural equation models were built to examine the connections between children's reading abilities and particularly, their phonological skills at the end of the pre-school. The main results of the first study showed that the model (Figure 2), which emphasized sensitivity to the phonological structure of the word as the prerequisite for learning to read, fitted the data very well, as shown by the goodness-of-fit measures in the structural equation model (page 91 in original article). The other model (Figure 3), which was likewise theoretically and statistically quite plausible (seen from details in the results on page 92), implied, by contrast, the reciprocity between learning to read and the emergence of phonemic awareness. The results of this current study suggest that non-verbal and verbal skills related to reading at pre-school age are in many respects the same and have the same relationships in Finnish as in English. However, there also seem to be differences, especially in the relationship between phonetic awareness skills and reading that may be language-specific.

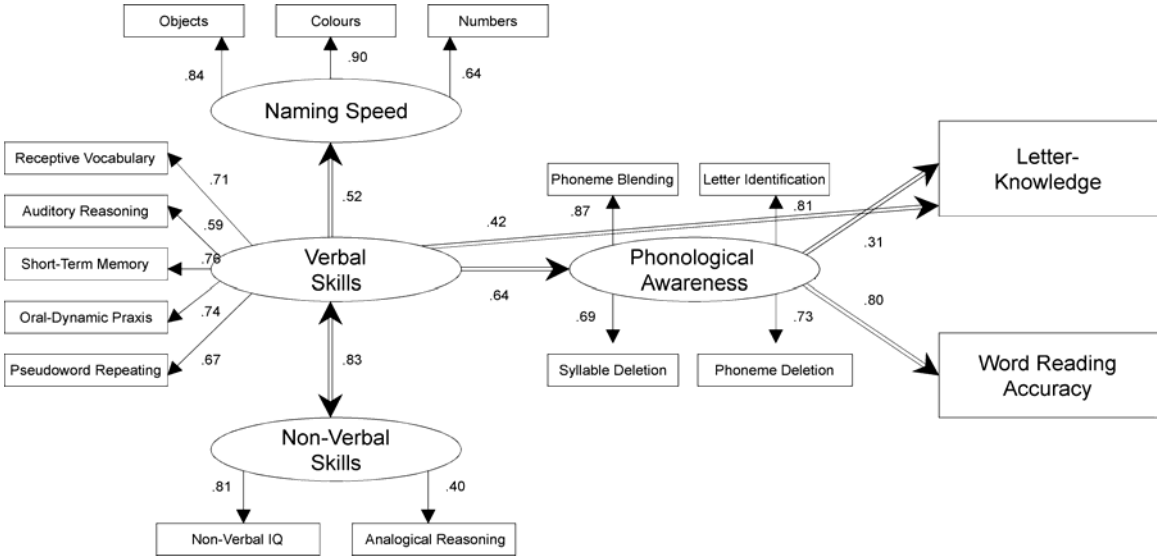

FIGURE 2 The estimated LISREL –model I of the factors formed from non-verbal and verbal skills, phonological awareness, letter-knowledge and word reading accuracy.

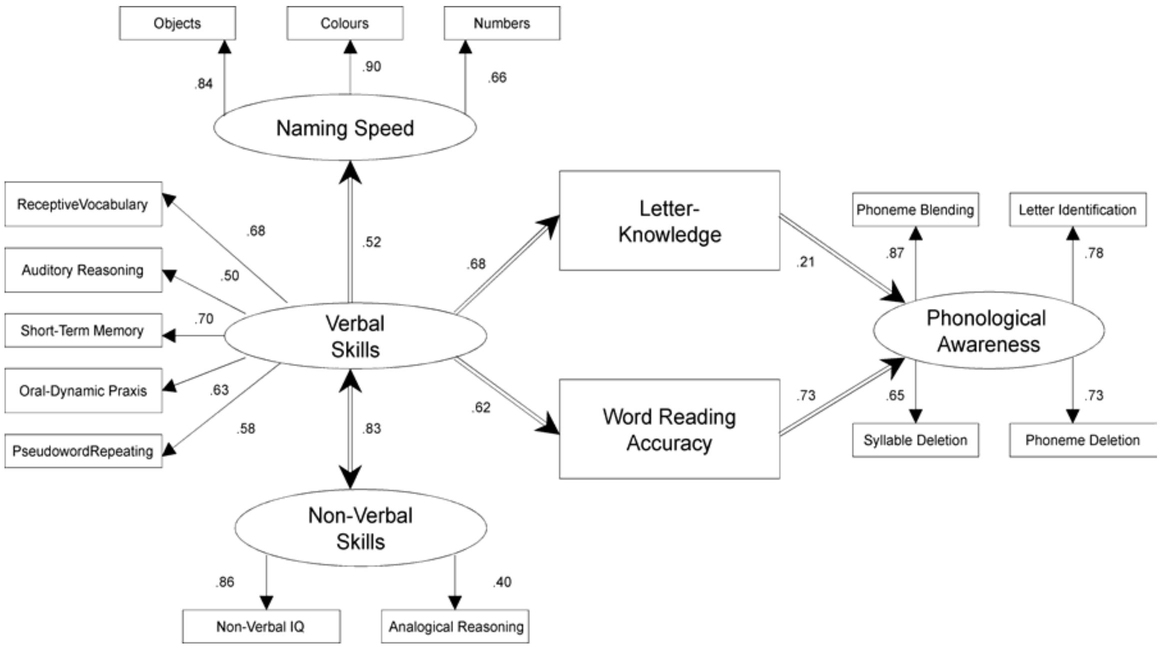

FIGURE 3 The estimated LISREL –model II of the factors formed from non-verbal and verbal skills, word reading accuracy, letter-knowledge and phonological awareness.

3.2 Study 2: Predicting delay in reading achievement in a highly transparent language

In the second study, verbal and non-verbal skills measured at the end of the pre-school were used as predictors for the time of instruction required to accurately decode pseudo-words. At the end of the second grade, participants were divided into four reading groups depending on the duration of instruction required in order to reach 90 % accuracy in their reading of pseudo-words. These reading groups were: Precocious Decoders (N=18), who read at school entry, Early Decoders (N=27), who learned to read within the first four months at grade 1, Ordinary Decoders (N=25), who learned to read within 9 months, and Late Decoders (N=19), who failed to reach the criterion until 18 months at grade 2, or who did not read after two years of synthetic phonics reading instruction. In summary, pseudo-word repetition skill and analogical reasoning best differentiated Late Decoders from Ordinary Decoders, and letter knowledge best differentiated Late Decoders from Precocious and Early decoders. After phonological awareness and letter knowledge were excluded from the analysis, short-term memory best differentiated Late Decoders from Precocious Decoders, and analogical reasoning Late Decoders from Early Decoders. Phonological awareness seemed to play a significant role only in differentiating readers or almost readers from each other (Precocious Decoders and Early Decoders from each other and from Ordinary Decoders). In Table 3, all significant ($p < .05$) pre-school variables predicting the reading group differences are presented from three analyses; firstly, all variables were included, secondly, all measures with the exception of the phonological awareness measures were used in the analysis, and thirdly, all measures with the exception of phonological awareness and letter knowledge measures were incorporated into the analysis. The results are shown in detail on pages 14–17 of the original article.

TABLE 3 Significant pre-school predictors differentiating the groups formed according to the time required to achieve reading accuracy (Precocious decoder = before reading instruction, Early decoders = after four months of instruction, Ordinary decoders = after nine months of instruction, Late decoders = after two years of instruction).

Groups	**Predictors**		
	All variables in analysis	*Phonological awareness excluded*	*Phonological awareness and letter knowledge excluded*
Precocious decoders vs. Early decoders	Phonological awareness ($p < .01$)	Pseudo-word repetition ($p < .05$) Letter knowledge ($p < .05$)	Short-term memory ($p < .05$)
Precocious decoders vs. Ordinary decoders	Phonological awareness ($p < .01$)	Letter knowledge ($p < .05$)	Naming speed ($p < .01$)
Precocious decoders vs. Late decoders	Letter knowledge ($p < .05$)	Letter knowledge ($p < .05$) Analogical reasoning ($p < .05$)	Short-term memory ($p < .05$) Analogical reasoning ($p < .05$)
Early decoders vs. Ordinary decoders	Phonological awareness ($p < .05$)	Naming speed ($p < .05$) Oral-motor coordination ($p < .05$)	Naming speed ($p < .05$) Oral-motor coordination ($p < .05$)
Early decoders vs. Late decoders	Letter knowledge ($p < .01$)	Letter knowledge ($p < .05$)	Analogical reasoning ($p < .05$)
Ordinary decoders vs. Late decoders	Pseudo-word repetition ($p < .05$)	Analogical reasoning ($p < .05$)	Analogical reasoning ($p < 05$)

3.3 Study 3: The role of reading by analogy in first-grade Finnish readers

Computer-based assessment of the use of beginning and end analogies based on clue-syllables of five different syllable structures was developed to examine the role of analogy in beginning reading. In the pre-test situation, all syllables of each syllable structure were shown singly, printed in capital fonts and at random on a 15” computer screen. The child was asked to read the syllable as soon as he/she saw it. In the test situation, the clue-syllable was read aloud to the child. She/he was then told that this clue-syllable would remain on the top of the screen and that this may help the child to read the other syllables (= same beginning, same end and control syllables). The child was also told that the new syllable would appear in the middle of the screen. The child was told to read aloud the new syllable, as soon as he knew what it was. This procedure was repeated after each new clue-syllable. Beginning, end and control syllables were presented in randomised order. The reading accuracy and reading speed were measured.

The most clear-cut and hypothesised result throughout the syllable structures was that the two shared conditions, beginning and end, did not significantly differ in accuracy or in reading speed from each other. This implies that in a transparent orthography such as Finnish, the single letters/phonemes than are larger segments, and reading is based on single phoneme/letter correspondences. The significantly more accurate reading of the clued condition (beginning and end situations together) in CVV (C = consonant, V = vowel)- and CVCC- structures than in control syllables compared to a pre-test showed that some transfer might take place in reading. In fluent reading, readers are, however, likely to use several levels of analogy processing and also have the capacity to use larger segments in reading within regular writing systems. However, beginning-end- analogies do not appear to be of relevance. The specific results concerning the reading accuracy and reading speed of different syllable structures are presented on pages 12–15 of the original article.

3.4 Study 4: Development of reading and linguistic abilities: Results from a Finnish longitudinal study

In the fourth study the reading accuracy and reading speed skills were examined by means of a four-year follow up. The aim was to find out the relation between the development of cognitive and linguistic skills and problems in reading and, specifically to inaccuracy and dysfluency in reading at the fourth grade, at both group and individual levels. Firstly, children with (N = 14) and without (N = 58) delays in achieving accurate and/or fluent reading skill by the end of the fourth grade were compared. The comparison of reading skills was based on pseudo-word reading accuracy and reading speed measures. The delayed readers had a z- score below -1.5 on reading accuracy (N = 8), on reading speed (N = 5), or on both the accuracy and speed composites (N = 1). Multivariate analysis of variance showed a significantly lower level of phonological awareness, RAN, and digit span measures among the delayed readers in comparison to their normally reading peers. Particularly, this was the case for digit span in relation to the whole developmental path (seen in Table 4). A significant group difference in the development of naming speed skills and visual reasoning was shown as a function of school grade. Secondly, multiple regression analysis was used to evaluate the power with which the various measurements assessed in different ages separately predicted reading accuracy and reading speed in the fourth grade. The cognitive measure from the fourth grade was entered in the first block of the model to control for the general cognitive skill. Other measures were entered in the next blocks using a Forward method and reading accuracy and reading speed were analyzed separately. The results revealed that rapid naming skills, phonological awareness and pseudo-word repetition assessed at the first grade accounted for independent variance in later reading accuracy scores even when pre-school measures were entered first in the regression analysis. Rapid naming measured at pre-school and phonological awareness at the first grade accounted independent variance in reading speed scores when pre-school measures were entered first in the regression analysis. At the individual level, three different types of reader (single deficit, double deficit, and poor reader) were described. These are also depicted in Figures 2–4 in the original article. The reading performances of these children varied from very slow reading without reading accuracy problems to problems in reading accuracy, reading speed and reading comprehension. It is important to highlight this level of heterogeneity in the delayed readers group, especially when remedial and instructional actions are planned. The results of this study inevitability stress the significance of an individual curriculum for children with reading disabilities. All results are given in detail on pages 8–20 of the original paper.

TABLE 4 Means, standard deviations (in brackets), significance of mean differences, and *F*-values for main reading group (normal readers (NR, N = 58) and delayed readers (DR, N = 14) effects (MANOVA) for variables measured in pre-school, first grade, second grade, and fourth grade.

	Pre-school			**First grade**			**Second grade**			**Fourth grade**			
Test	NR	DR	***p*** [c]	**NR**	**DR**	***p***	**NR**	**DR**	***p***	**NR**	**DR**	***p***	[d] ***F*** **(1,71)**
Raven	21.93	18.86	**	-	-		28.45	24.50	**	31.79	28.64	*	7.29
	(4.18)	(3.32)					(4.35)	(4.55)		(2.86)	(4.36)		p = .002
Letter	16.86	13.57	*	-	-		-	-		-	-		
Knowledge	(3.34)	(5.32)											
Phonol.	14.62	7.29	**	37.07	31.43	*	29.24	26.79	*	32.79	30.43	*	11.97
aw. [b]	(10.96)	(6.75)		(5.26)	(7.76)		(4.23)	(3.77)		(2.86)	(4.38)		p = .001
Naming speed	191.75	207.38	*	145.45	173.43		134.03	148.71	*	115.36	133.79	*	14.83
(sec)	(46.04)	(37.89)		(21.55)	(36.08)		(20.20)	(23.45)		(15.78)	(23.87)		p = .000
PPVT (121)	80.54	76.64		-	-		91.74	90.93		99.09	98.29		0.55
	(11.95)	(12.98)					(10.05)	(8.06)		(7.14)	(3.60)		ns
Digit Span	7.09	5.29	**	-	-		9.09	7.57	**	9.95	7.93	**	14.53
	(1.80)	(1.64)					(2.03)	(1.70)		(2.04)	(1.90)		p = .000
PW- repeti-	9.44	9.00		8.57	7.57		11.79	10.93		11.89	10.99		2.86
tion(16)	(2.73)	(2.25)		(2.69)	(2.62)		(1.94)	(2.50)		(1.49)	(2.22)		p = .04
Anal. Reason (16)	10.19	10.21		11.33	10.71		15.24	12.50	*	17.86	15.07	*	4.56
	(2.60)	(2.39)		(2.65)	(2.84)		(3.82)	(3.61)		(2.10)	(3.85)		p = .04

[a] = Pseudo-word reading, pre-school maximum is 42, first grade 18, and second and fourth grade 20. [b] = Pre-school, and first grade maximum is 40, second and fourth grade 36. [c] = ANOVA results: * $p < .05$, ** $p < .01$, *** $p < .001$. [d] = MANOVA results: the main reading group effect for independent variables measured at four time points

4 GENERAL DISCUSSION

4.1 Discussion on reading acquisition

In this work, the relation between reading acquisition and linguistic and cognitive skills were modeled, predictors for delayed reading acquisition were sought, the benefit of using larger linguistic units in reading was examined, and variables with a long-term predictive power for different reading problems were traced at the level of both the group and the individual. This study encompasses three disciplines, developmental and cognitive psychology, and special education. The inspection of orthographic regularity also throws it in the path of the linguistic world. The decision to carry out this study within these scientific frameworks was very natural after working for many years as a special teacher, and for the latter five years as a researcher in the Niilo Mäki Institute where the research on learning disabilities is founded on the bases and methodologies of neuropsychology, developmental psychology, psycholinguistics, psychophysiology, special education and cognitive psychology. To begin this discussion, the validity of theories on which this study was based, and the definition and measures of reading are discussed.

In examining the reading acquisition of children at the age of six and seven years, reading ability was defined as a skill where the child knows and uses correspondences between graphemes and phonemes, and is able to decode the words grapheme by grapheme. This is also the definition of the phonological, alphabetic stage of reading development proffered by Frith (1985), and Seymour, and McGregor (1984). This ability was measured by word-list and pseudo-word list reading accuracy because the ability to fluently decode pseudo-words is often used to assess phonological decoding skill (Siegel, and Ryan, 1989). The word list reading test (Poskiparta et al., 1994) also consisted of very familiar Finnish words (e.g. 'auto' [car], 'äiti' [mother], 'isä' [father]), which might have been recognized by those children who were at the logographic stage of reading (Frith, 1985) at pre-school age. It was a surprise that already by the end of pre-school, a very high correlation (r = .93, $p < .01$) between reading non-words and words among those who could read, was shown, as seen in Study 1. Obviously, the logographic phase is not typical for Finnish children at pre-school age, but could perhaps be observed with younger children. With German-speaking children, similar findings have been reported (Valtin, 1994; Wimmer, 1993)

In Finnish, the grapheme-phoneme correspondences are so strong that it is difficult to assess the phonological and orthographical decoding separately. This difficulty was also shown in Study 3 where the use of an analogical model was offered to beginning readers to provoke faster or more accurate reading of each test syllable. The phoneme-by-phoneme decoding was so fast without assistance from clue-syllables that no benefit of the use of a larger segment was observed, even in the reading speed of clued syllables. The theories of initial reading acquisition in English characterised by the existence of the logographic stage of reading and the use of orthographic analogies could not be detected with children in this study at the ages of six to seven years.

In this study, the number of accurate readers before entering school (24.8 %) was roughly the same as has been found in other Finnish studies (Julkunen, 1984, 21%, Poskiparta et al., 1994, 17 %). In addition to the strategy for reading, the speed of the learning process in reading acquisition was astonishing; namely, after only a few months 30% from non-readers moved up to the reader's group, and after the first school year 77 % of children were very accurate readers, even of pseudo-words. The use of a thorough phonics method probably had a positive effect on these percentages.

The reading acquisition process is discussed next from the educational perspective, especially for those children experiencing problems. Classroom teachers could very soon point out those who could not follow the reading instruction. It was clear that the developmental stage of linguistic and cognitive skills of these children did not match the instruction given. Part-time special education in small groups was given (as shown in the questionnaires addressed to special teachers), but the basic problem was that special instruction in reading and spelling was usually offered only once a week in a group of approximately four children, which was not enough to support reading acquisition. Although instruction in reading and writing at the first grade is given daily in the classroom, children with problems in reading acquisition were not able to take advantage of it. At the same time the classroom teachers did not have enough knowledge (as shown by the answers to the questionnaires addressed to classroom teachers) of how to streamline their reading instruction in order to address the different readers. In such situations motivational and emotional problems cannot be avoided, as shown recently in Finnish studies by Aunola, Nurmi, Niemi, Lerkkanen, and Rasku-Puttonen (in press), and Lepola, Salonen, and Vauras (2000).

Finally, the validity of reading assessment is discussed. There have been three problems in assessing reading in this study. Firstly, in Finland there are no standardized word- and pseudo-word reading tests for the individual assessment of reading accuracy and reading speed with children or adults. In

1998, a standardized ALLU- test battery (Lindeman, 1998) for group assessment of reading and reading comprehension was published (the comprehension test was used in study IV), but it includes neither word list nor pseudo-word list reading measures. In this study, reading was assessed by three separate reading tests that have local normative data (measures are shown in Table 2), but the use of three different non-standardized reading tests, of course, reduces the reliability of the assessment. Secondly, reading acquisition for Finnish children seems to be an "on-off" process with about a quarter of children reading quite accurately at pre-school and the rest hardly at all. It must be noted, however, that even non-readers have relatively good letter knowledge (shown in Study 1). Within a year, most children learn to read very accurately and this inverts the figure. This bisection of reading ability at the beginning sets high demands for the reading tests and also for the statistical analysis of the data. Closely associated with this aspect is the third discussion point concerning assessment; namely that even those who form the group of "poor readers" at the fourth grade, can correctly read more than half of the difficult pseudo-words. Moreover, there are readers who can decode quite accurately, but their reading speed is very slow (as could be seen in Study 4). This also seems to be typical of German-speaking dyslexic readers (Wimmer, 1993), and should be taken into account in the assessment of reading Finnish.

4.2 Discussion on mechanisms in reading problems

The definition of reading problems is discussed first. In this study, the problems in reading were seen as developmental, heterogeneous, and partly orthographically specific wherein the core features of the deficit might alter over time. Reading problems were indexed by pseudo-word reading accuracy or reading speed, and those who obtained a low score in either or both were identified as delayed readers. The participants were a random sample of children from ordinary pre-school groups entering ordinary primary school classes and their non-verbal IQ was in the normal range (> 80). The results of individual cases were shown to illustrate the subtypes of different reading problems, and the profiles of related skills (such as naming fluency, visual analogical reasoning, verbal short term memory) representing known conceptual categories, such as poor readers or naming deficit readers.

Most of the findings concerning the role of reading related skills were in line with the results from a number of studies in other orthographies, which indicates that these studies hold general interest, independent of the language context within which the participants are reading. At the same time, the view raised by Paulesu et al. (2001) was supported to the effect that although there is probably a universal neuro-cognitive basis for dyslexia, orthographic regularity might affect the speed of the reading acquisition, and the reading performance. Firstly, the role of phonological awareness in reading problems is discussed.

There is a common agreement that a causal link between reading problems and phonological processing deficits exist. The results from Study 1 showed that phonological awareness is strongly, and at least in some part reciprocally, related to early reading ability at the end of pre-school. Thus, it must be noted that all readers used letter-names in the phoneme identification task and also when they described their use of strategy in blending tasks. This suggests that orthographic images of the sounds and words were used to perform used phonological tasks, which may be a problem of assessment method used or an orthographic specific feature. In Study 2, pre-school measures (cognitive and linguistic, also phonological awareness measures) were used as predictors of the time of instruction required for accurate decoding of pseudo-words. After two years, participants were divided into four reading groups depending on the duration of instruction they had required to reach 90 % accuracy in their reading of pseudo-words. As was shown in Table 3, these pre-school phonological awareness measures played a significant role in discriminating precocious readers from early readers and ordinary readers, and early readers from ordinary readers, but not those readers who were delayed in their reading acquisition by the end of second grade. But it was interesting to find out in Study 4, that phonological awareness measured at the end of the first grade predicted both reading accuracy and reading speed at the fourth grade. This challenges the value of phonological awareness measures in a highly regular Finnish orthography as early predictors of reading problems. But it also provides a challenge for developing phonological awareness measures, where the dilemma to use letters and early reading skills in the phonological awareness tasks could be avoided. The measures of phonological awareness were similar to those used in other orthographies (identification, deletion, and blending of phonemes, and the deletion of syllables) that have been thought to measure the two dimensions of phonological awareness, - analysis (segmentation) and synthesis (blending) (Bradley, and Bryant, 1983; Wagner, and Torgesen, 1987). Based on the results of the present study it is concluded that the relation between phonological awareness and reading is somewhat different than to many other languages. It is problematic to say, however, whether these different results genuine divergences or rather differences in conceptual premises, measurement properties of the tests used, the reading instruction methods, or a combination of these factors.

Moreover, 49 % of the children could name all common letters at the end of pre-school, and 88 % of children could name more than half of the common letters. As Treiman (1992), Stahl, and Murray (1994) and Muter (1994) have stated, letter-knowledge can help children understand that print represents sounds, which is the basic step for the discovery of the alphabetic principle. Another interesting finding linked to phonological awareness was that in Study 1 all pre-schoolers (readers and non-readers) used letter-names instead of letter-sounds in the phoneme identification task. This could indicate that in a language such as Finnish, the skill to explicitly differentiate between letter-names and phonemes is not a pre-requisite for learning to read at least in cases when this ability has been acquired without formal instruction. Moreover, the mean in the phoneme identification (answered with *phonemes*) and phoneme blending tasks almost reached ceiling after five months of reading instruction. It can be concluded that phonemic awareness can be quickly elevated from zero to a high level via systematic reading instruction in a regular orthography. What remains to be mastered later on is the fluency of assembly, which, for the most part, is very poor among those who have difficulties in reading acquisition.

Secondly, verbal repetition and the distinctness of phonological representations measured by repetition of single pseudo-words will be discussed. Here in Studies 2 and 4, as in several previous studies (Catts, 1986; Snowling, 1981; Taylor, Lean, and Schwartz, 1989), non-word repetition has been especially shown to discriminate good readers from poor readers (ordinary decoders from late decoders). The deficits underlying weak performance may include poor perception of speech, which may prevent the formation and storage of accurate representations of phonemes and thus, accurate phonemic awareness (Gathercole, 1995; Stone, and Brady, 1995; Tallal, 1980). Also, difficulties in organizing the production of speech may play a role in explaining difficulties in pseudo-word repetition and poor reading skills (Snowling, 1981, 1986). Snowling (2001) has stated that the difficulty in processing non-words may partly be due to deficiencies in motor programming to articulate the unfamiliar item (as a non-word). In this study, the production of speech was also measured by assessing the children's association processes when working from auditory concepts and in producing a suitable continuation to a sentence initiated by the tester (ITPA, auditory reasoning, Kuusinen, and Blåfield, 1974), and further, by oral-motor coordination, where the child was asked to repeat sound sequences and tongue twisters (Oral Dynamic Praxis- test, Korkman, Kirk, and Kemp, 1997). Also rapid naming (discussed later) may be part of this lack of phonological specifications. The first two of these measures did neither explain nor predict reading problems. This may be due to the fact that production of speech as such was not a correlate of delayed reading as was perception and manipulation of speech sounds. Alternatively, the tests used were not measuring the essential features of production problems.

Thus, naming speed may be one pre-requisite in the establishment of specific phonemic representations of words as shown by its contribution to the prediction of later reading speed. The two explanations for rapid naming deficits have been presented earlier. In this study, naming speed was connected to beginning reading accuracy only indirectly through the non-verbal and verbal factors (in Study 1). However, naming speed at pre-school age seems to especially predict the level of reading fluency, and naming speed at the first grade reading accuracy at the first grade. This was shown in Study 4 and supports the view of Wolf (1986). In Study 2, where naming speed at pre-school differentiated those who were already reading before school entry from those who learned to read very early in the first school year, and these early readers from ordinary readers, the automatic perception of good quality orthographic codes and their rapid connection to phonological representations (as suggested by Scanlon, and Vellutino, 1996) was probably explaining the role of naming.

The next topic for discussion is the role of short-term memory (or verbal working memory) and general cognitive abilities in reading problems. The finding that the level of pre-school working memory was a significant discriminator between precocious and early learners was interesting. This indicates that good memory skills are important for very early learning of the orthographic code. On the other hand, this finding could shed light on the pupil's interest and attentive orientation to verbal materials. It has been suggested (Scarborough, 1998) that verbal working memory weaknesses can arise if spoken material is poorly phonologically encoded for storage. This weakness may limit the resources available for recall or result in a less durable memory trace. In turn, it may hamper the development of reading, as could also be seen from the significant difference between normal and delayed readers' scores in short-term memory assessments throughout the follow-up in multivariate analysis of variance in Study 4.

According to Baddeley et al. (1998), the phonological loop, a central component of working memory, plays a crucial role in learning the novel phonological forms of new words. Especially in the early and middle childhood years, children's short-term memory performance is strongly related to their vocabulary knowledge (Scarborough, 1998). The mean age of children at the beginning of the present study was 6.9 years. There was, however, no significant difference in the amount of vocabulary assessed by the PPVT from pre-school to the fourth grade between normal and delayed readers, and no significant link between vocabulary and short-term memory development could be found among delayed readers. It is apparent that intelligence and normal reading development are positively and significantly associated (Aaron, 1985, Anderson, 1992). In the present study, non-verbal intelligence was assessed by the Raven's Colored Matrices in order to monitor the development of non-verbal abilities. In addition, analogical reasoning skills were measured in order to ascertain if they played some role in the use of analogical segments in reading. No such role was detected, and no benefit of the use of analogies was shown. It is still very interesting that an association, which has seldom been examined, was observed between visual analogical reasoning and the automatization of reading skill. In Studies 2 and 4 analogical reasoning was found to be an important predictor (independently from Raven) of reading difficulties. The analogical reasoning obviously involved some features of a more general domain other than language, which may be important in the automatization of decoding skills in our orthography. If the follow-up had been longer, perhaps a significant difference between normal and delayed readers would also have emerged in vocabulary due to the bi-directional relationship between reading and cognitive development as described by Stanovich (1986) as the "Matthew effect".

In the present study, the commonly cited major environmental factors relating to reading problems (socioeconomic level, print exposure at pre-school and primary school, and print exposure at home before the age of seven years) were assessed by questionnaires. In Study 1, the socioeconomic level of parents, print exposure at home and pre-school were entered into the structural equation models to examine their connections with children's reading abilities. None of these factors improved the goodness-of-fit measures, and they were not accepted in the final models. Similarly, in Study 2, the same factors and the print exposure at school were taken as predictors for reading acquisition but they did not have any predictive power. However, parental SES showed significant correlations with the linguistic skills measured at pre-school, e.g. with vocabulary (r = .30, $p < .01$), and with phonological awareness (r = .29, $p < .01$), and the correlation between home print exposure and vocabulary was also significant (r = .39, $p < .01$). Even at the fourth grade, the parental SES correlated (r = .29, $p < .05$) with vocabulary. This might indicate that the parental and home environment effects are to some extend tapped by the linguistic measures before the reading acquisition was measured and which subsequently could explain the loss of their power in statistical analysis. The non-existence of print exposure at pre-school and primary school in the models can be explained by the fact that teachers were describing the actions of the whole group, including about 20 children with better and worse cognitive and linguistic skills. Although there would have been a lot of e.g. language interaction and shared reading at pre-school groups, the opportunity for learning has been shown to be most optimal when the child and adult share the same focus of attention (Harris, 1992). In a group, there are probably children (and probably just the ones with risk for reading problems) who do not have interest in pre-school literacy activities and do not share the attention with the adult who is telling stories or teaching letter-names.

4.3. Conclusions

The studies included in this dissertation form a coherent "narrative" concerning reading acquisition and associated problems among almost one hundred randomly selected Finnish children. All of them attended pre-school one year before entering school. When this study began in 1997, there was no uniform curriculum for pre-schools to plan and carry out their education. Hence the pre-schools had their own plans of action. After the year 2002, every municipality in Finland has to provide pre-school education free of cost to all six-year-old children based on the National Curriculum for Pre-school Education, formulated in the year 2000 (National Board of Education). The free-admission pre-school also provides opportunity for early identification of those children who have problems in the development of school-related skills, such as social interaction, cognitive and linguistic skills, and task orientation. In pre-schools and primary schools the awareness concerning reading disabilities by additional training and education should be raised. Also, parents' general knowledge, on the one hand, in supplying a successful environment for the child's development, and on the other hand, in emotionally supporting, helping, and motivating the child facing a reading problem can be raised. It will be possible to utilize the findings of this study. However, further development of proper measures for assessing Finnish word-level reading at different ages is essential.

While it has become clear from different studies that the indications of reading problems could be detected earlier than is usual at present, such a goal also emphasizes the need to develop the language and reading instruction provided in pre-schools, classrooms and in special education. It is important to convert the children's natural interests in stories and meaning-laden texts to instructional advantage in order to focus the attention towards actual reading instruction. The use of instruction, where emphasis is placed on phonics in reading reinforcing grapheme-phoneme correspondences seems to be an effective strategy for teaching reading, but classroom teachers should adjust their rate and content of teaching with respect to readers at different developmental stages. More research is required to develop different "programs" for different readers in classrooms. Most children with reading problems, however, require much more support than ordinary reading instruction can offer. The results of present study showed that the most important predictors for late decoding acquisition were letter knowledge, pseudo-word repetition, analogical reasoning and short-term memory. When trying to apply these results into the practice of special education the first interpretation might be that problems in reading can already be predicted before school age. Another interpretation is an attempt to look at the processes underlying these predictors: the ability of making precise and stable phonological forms of new items, perception of rapid temporal changes in speech, segmenting the flow of speech and organizing the output of speech, formation of phonological representations, and more general domain skills as seen by e.g. analogical reasoning, and – while concentrating instruction on reading, attempts should also be made to allocate instructional time to the mastery of these other processes, which might also be quite difficult. Future research must also be directed especially at "treatment resistant readers" (Niemi et al., 1999; Torgesen, Wagner, Rashotte, Rose, Lindamood, Conway, and Garvan, in press) - those children who do not respond well to the current interventionprograms.

TIIVISTELMÄ

Lapselle lukutaidon oppiminen ja opettajalle sen opettaminen ovat haasteellisia tehtäviä. Se, kuinka hyvä ja käyttökelpoinen väline lukutaidosta kehittyy, vaikuttaa suuresti myös muuhun oppimiseen ja osallistumiseen tietoyhteiskunnassamme aktiivisesti toimivana jäsenenä. Tässä erityispedagogiikan väitöskirjatutkimuksessa mielenkiinto on lasten lukutaidon oppimisen lisäksi lukemisvaikeuksiin liittyvien tekijöiden ja lukemisvaikeuksien erilaisten kehityksellisten ilmenemismuotojen tarkastelussa. Tutkimustieto tältä alueelta on kertynyt pääasiassa muista kielistä, joten tutkimustuloksia tarkasteltiin erityisesti suomen kielen näkökulmasta.

Tutkimusjoukon muodosti tutkimuksen ensimmäisessä vaiheessa 160 Jyväskylän kaupungin eri osissa asuvaa lasta (71 tyttöä ja 89 poikaa), jotka olivat syntyneet vuonna 1990 (keski-ikä 6,9 vuotta, keskihajonta 0,3 vuotta) ja puhuivat ensimmäisenä kielenään suomea. Lapsilla ei ollut diagnosoitua kehitys-, kuulo- tai näkövammaa. Lapset kävivät esiopetuksessa, joka oli järjestetty yhdeksän päiväkodin 13:n kokopäivä- tai puolipäiväryhmän yhteyteen. Pitkittäistutkimukseen näistä valittiin satunnaisesti 92 lasta (38 tyttöä ja 52 poikaa).

Ensimmäinen tutkimusvaihe oli maaliskuussa vuonna 1997, jolloin lapset olivat olleet esikoulussa seitsemän kuukautta. Pitkittäistutkimuksen tutkimusvaiheita oli viisi: esikouluvuoden lopulla, ensimmäisen kouluvuoden tammikuussa ja toukokuussa, toisen kouluvuoden toukokuussa ja neljännen kouluvuoden tammikuussa vuonna 2001. Tutkimukset toteutettiin yksilötutkimuksena lasten päiväkodeissa ja kouluilla siten, että väitöskirjan tekijä toimi vastuullisena tutkijana apunaan psykologian ja erityispedagogiikan loppuvaiheen opiskelijoita.

Lukemisvaikeuksissa on kyse moni-ilmeisestä ongelmasta, jonka selvittäminen vaatii useiden muuttujien kehityksellisten polkujen tarkastelua. Lukemaan oppimisen ongelmien ajatellaan kietoutuvan vahvasti erilaisiin kielellisiin ongelmiin – äänteiden havainnointiin, erotteluun ja käsittelyyn puhevirrassa –, jotka puolestaan lukemaan opettelussa voivat kulminoitua kirjain-äännevastaavuudenoppimisenpulmiksi. Tässä tutkimuksessa puhutun kielen prosessointikykyä arvioitiin seuraamalla fonologisen tietoisuuden, epäsanojen toistamisen ja suun motoristen taitojen kehittymistä. Nopean nimeämisen taitojen ajatellaan lukemisessa liittyvän ortografisten ja fonologisten koodien oikea-aikaiseen yhdistymiseen, jota pidetään tärkeänä lukutaidon automatisoitumisen saavuttamisessa. Lukemisvaikeuteen liittyvät nimeämisen pulmat voivat myös heijastella tarkkojen äännehavaintojen syntymistä tai liittyä yleisempään temporaalisten prosessien hitauteen. Tässä väitöskirjatutkimuksessa nimeämisnopeuden arvioinnissa käytettiin sarjallisen nimeämisen tehtäviä. Lyhytkestoisen kielellisen muistin pulmat voivat rajoittaa niitä resursseja, joita tarvitaan lukemisprosessin aikana, ja heikentää myös pysyvämpien muistijälkien syntymistä. Se saattaa vaikeuttaa sanavaraston kehittymistä. Lukemisvaikeus saattaa myös vaikuttaa kykyyn hankkia ja käsitellä tietoa. Tässä tutkimuksessa ei-kielellisten

kognitiivisten kykyjen kehittymistä arvioitiin kahden erilaisen visuaalista päättelykykyä mittaavan tehtävän avulla.

Lapsen kasvu- ja oppimisympäristö vaikuttaa monin tavoin siihen, miten lukutaito kehittyy. Lukutaitoon vaikuttavia ympäristötekijöitä kartoitettiin kyselylomakkeilla, joissa vanhemmilta kysyttiin lapsen kielellisestä ja kirjallisesta kotiympäristöstä, lastentarhanopettajilta ja luokanopettajilta kysyttiin kielellisistä leikeistä ja lukemaan ja kirjoittamaan opettamisesta ja erityisopettajilta tiedusteltiin erityisopetuksen sisältöjä.

Merkityksettömien sanojen lukemisen ajatellaan mittaavan sellaista fonologisen dekoodaamisen taitoa, jossa sanan merkityssisältö ei ohjaa lukemista. Tässä tutkimuksessa lukutaitoa arvioitiin paitsi merkityksettömien sanojen oikeinlukemisella myös niiden lukemisnopeudella, koska lukemisvaikeudet voivat ilmetä myös lukemisen hitautena. Toisella ja neljännellä luokalla arvioitiin lisäksi luetun ymmärtämisen taitoja.

Tämä tutkimus osoitti, että koulun alkuvaiheessa 49,4 % lapsista tunsi kaikki suomalaiset kirjaimet nimeltä. Kaiken kaikkiaan kirjaintietoisuus oli hyvä, sillä 88 % lapsista osasi nimetä yli puolet suomalaisista kirjaimista. Esikouluvuoden jälkeen 16 % lapsista osasi lukea täysin oikein (ja 24,8 % lähes oikein) myös merkityksettömiä sanoja. Lukemaan opettamisessa kaikki opettajat käyttivät menetelmää, jossa edettiin kielen pienemmistä yksiköistä, kirjaimista ja äänteistä, suurempiin yksiköihin, tavuihin ja sanoihin (KÄTS-menetelmä tai sen muunnokset). Lukutaidon oppiminen eteni nopeasti, sillä ensimmäisen kouluvuoden tammikuussa 40 % ja ensimmäisen kouluvuoden lopulla 77 % lapsista osasi lukea myös merkityksettömiä sanoja täysin oikein. Sekä lapset, jotka olivat oppineet lukemaan ennen kouluikää, että ne, jotka olivat oppineet lukemaan koulussa, käyttivät yhdenmukaisesti lukemisessaan kirjain-äännevastaavuutta hyväkseen eivätkä hyötyneet lukemisen nopeuden tai oikeellisuuden suhteen kolmannessa osatutkimuksessa tarjotusta mahdollisuudesta käyttää apunaan suurempia kokonaisuuksia (alku- tai loppuanalogioita).

Ensimmäisellä luokalla kirjainten ja äänteiden oppimisen ja niiden yhdistämisen vaikeudet tulivat osalla lapsista näkyviin varsin pian. Ensimmäisen kouluvuoden lopulla oikeinlukemisen pulmia oli 10,6 %:lla lapsista, ja 5,8 %:lla ne jatkuivat neljännelle luokalle asti. Lisäksi osa lapsista oppi lukemaan tarkasti, mutta ongelmana oli lukemisen hitaus, mikä selvästi haittasi toimivaa lukutaitoa neljännellä luokalla 3,7 %:lla tutkimusjoukon lapsista. Vain yhdellä tutkimusjoukon lapsista sekä lukemisen virheellisyys että hitaus olivat merkittävästi lukemisen esteenä vielä neljännellä luokalla. Lukutaidoltaan heikot neljäsluokkalaiset olivat saaneet lukemisen ja kirjoittamisen erityisopetusta pienryhmissä alkuopetuksen aikana. Erityisopetus olisi kuitenkin voinut olla paremmin kohdennettua, intensiivisempää ja pitkäkestoisempaa, ja yksilöllisesti eriytetty luokkaopetus olisi tukenut lukutaidon oppimista.

Lukemisvirheet tai hidas lukeminen voivat vaikeuttaa myös luetun ymmärtämistä. Lukemisvaikeuslasten lukemisen ymmärtämistä arvioitiin toisella ja neljännellä luokalla siten, että testattava sai käyttää kertomustekstin lukemiseen niin paljon aikaa kuin oli tarpeen, minkä jälkeen ymmärtämistä arvioitiin monivalintatehtävillä. Lukutarkkuudeltaan heikoista lapsista (N = 8) kolmella ja lukusujuvuudeltaan heikoista lapsista (N = 6) kahdella sekä lapsella, jolla sekä lukusujuvuus että tarkkuus olivat puutteellisia, oli heikko tekstin ymmärtämisen taso vielä neljännellä luokalla.

Lukemaan oppimisen pulmien taustatekijöitä tutkimalla haluttiin selvittää, voidaanko lukemaan oppimisen vaikeuksia ennustaa – pelkästään lukutaitoa tai kirjainten tuntemista arvioimalla näyttää olevan vaikea tietää, ketkä tarvitsevat erityistä tukea oppimiseensa. Fonologisen tietoisuuden ja lukutaidon suhdetta tarkasteltiin eri tavoin useassa ikävaiheessa. Esikouluvuoden lopun arviointitiedoista rakennetut rakenneyhtälömallit osoittivat, että lukutaito, kirjainten tunteminen ja fonologinen tietoisuus ovat vastavuoroisessa suhteessa.

Toisessa osatutkimuksessa esikouluvuoden lopulla mitatuista taidoista ennustettiin, miten lukutaito kehittyy ensimmäisen ja toisen luokan aikana. Havaittiin, että fonologisen tietoisuuden ja kirjainten tuntemisen perusteella voidaan ennustaa tavanomaisesti tapahtuvaa lukutaidon oppimista, mutta ei juurikaan viivästynyttä lukutaitoa, jota puolestaan ennustavat epäsanojen toistamisen ja visuaalisen järkeilyn taidot. Nopean nimeämisen taidot ennustivat parhaiten lukusujuvuuden kehittymistä.

Neljännessä osatutkimuksessa huomattiin, että lapsilla, joiden lukutaidon kehitys oli viivästynyt, visuaalinen järkeily ja nopea nimeäminen kulkivat merkitsevästi heikommalla tasolla ja profiililtaan huonompaan suuntaan tavanomaisesti lukutaidon oppineiden kehitykseen verrattuna. Regressiomalliin otettiin mukaan kaikkien ikävaiheiden kielelliset muuttujat ja kontrolloitiin ei-kielelliset kognitiiviset kyvyt. Sen mukaan neljäsluokkalaisten lukutarkkuutta ennustivat parhaiten ensimmäisen kouluvuoden lopulla mitatut fonologisen tietoisuuden taidot sekä nopean nimeämisen ja epäsanojen toistamisen taidot. Lukunopeutta ennustivat parhaiten ensimmäisen luokan fonologisen tietoisuuden taidot ja esikouluvuoden lopulla mitatut nopean nimeämisen taidot. Lisäksi yksilöllisessä tarkastelussa havaittiin, että erilaiset taustatekijät olivat vaikuttamassa hyvinkin erityyppisten lukemisvaikeuksien syntyyn.

Lukutaidon oppimisen selittäjinä lapsen omat kielelliset ja kognitiiviset taidot näyttivät olevan tilastollisesti merkitsevämpiä kuin kodin tai esikoulun kirjallinen virikkeistö, mikä ei kuitenkaan tarkoita sitä, että lapsen koti- tai kouluympäristö olisi merkityksetön lukutaidon oppimisen kannalta. Kyselylomakkeiden kautta tapahtuva tiedonkeruu ei ilmeisesti ollut riittävän yksilökohtainen, vaan lisäksi olisi tarvittu vanhempien haastatteluja ja opetuksen havainnointia.

Lopuksi, huomionarvoista tutkimuksessa on se, että lukutaidon oppiminen näyttää tapahtuvan useimmilla lapsilla nopeasti ja taidosta kehittyy tarkka ja sujuva ensimmäisen kouluvuoden aikana. Toisaalta jo esiopetusiässä – ja mahdollisesti paljon varhaisemmin – saatujen arviointitietojen avulla voidaan ennustaa mahdollisia lukemaan oppimisen vaikeuksia. Oppimisvaikeuksien varhainen tunnistaminen ja kuntouttaminen asettavat jatkossa entistä suuremman tutkimus- ja koulutushaasteen sekä erityisopetuksen alalla työskenteleville ihmisille että erityispedagogiselle tutkimukselle.

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Study 1

Two alternative Ways to Model the Relation Between Reading Accuracy and Phonological Awareness at Preschool Age

by

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In this study, 91 Finnish-speaking preschoolers (ranging in age from 6.4 to 7.4 years) were tested by using 2 structural equation models. None of the participants had entered school at the time of the study because the age of school entry in Finland is 7 years. The structural equation models were built particularly to examine the connections between children's reading abilities and their phonological skills. The main results of this study show that, in a very transparent language such as Finnish, the model that emphasized sensitivity to the phonological structure of the word as the prerequisite for learning to read fit our data well. The other model, which was likewise theoretically and statistically quite accessible, implied, by contrast, the reciprocity between learning to read and the emergence of phonemic awareness. The results of this study suggest that skills related to reading at preschool age are in many respects the same and have the same relations in a transparent language such as Finnish as they do in English. However, there also seem to be differences, especially in the relations between phonemic awareness skills and reading that may be language specific and require further investigation.

At preschool age, most children are competent to produce and comprehend language, but this competence does not automatically lead to successful reading acquisition. In this study where Finnish, a highly transparent language, was used, word-reading abil-

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ity was defined as mastery of a strategy according to which the child knows and uses the correspondences between individual graphemes and phonemes and is able to decode the words grapheme by grapheme. This strategy is described as an alphabetic strategy in Frith's (1985) theory of reading acquisition and in a model of reading and spelling processes proposed by Seymour and McGregor (1984).

In this section, we provide a short review of the empirical literature on the importance of letter knowledge in reading. Scanlon and Vellutino (1996) found in their longitudinal study that a child's ability to name letters and numbers was the factor most strongly related to first-grade reading (accounting for 35.2% of the variance) and that phonological-processing skills (measured by segmentation task in their study) accounted for 18.5% of the variance in first-grade reading performance. Scarborough (1990) reported in a longitudinal study with children at familial risk of dyslexia that at the age of 5 years, these children were less familiar with letters of the alphabet than were their peers. Also, Muter (1994) showed that letter knowledge proved a powerful contributor ($\beta = 0.40, p < .01$) to reading during the first year at infant school. On the other hand, there is good evidence to show that training letter names on its own does not provide children with any appreciable reading advantage (Adams, 1990).

The last 20 years of reading research have produced a broad variety of converging evidence demonstrating a strong relation between children's ability to assemble sounds into words and their progress in learning to read; thus, there can be little doubt that phonological awareness plays an important role in reading (Goswami & Bryant, 1992). Wagner, Torgesen, and Rashotte (1994) and Goswami and Bryant (1990) suggested that, according to considerable evidence, there are at least three alternative ways to look at the relation between reading and the awareness of sounds. The first possibility is that the development of phonological-processing abilities facilitates the acquisition of beginning reading. Second, children learn how to divide words into their constituent sounds because they are taught to do so when they learn to read so that learning to read would be a prerequisite for phoneme awareness. Third, learning to read and phoneme awareness are reciprocally related. These three alternative approaches have been studied in at least two ways: training and predicting studies, where path analysis, regression analysis, or structural equation models have been used (Elbro, Borstrom, & Petersen, 1998; Torgesen & Wagner, 1998). In the following passages, we discuss the evidence supporting these three views.

According to the first of these views, phonological awareness is one of the most important factors in predicting later reading ability (Badian, 1994; Bradley & Bryant, 1983, 1985; Torgesen, Wagner, & Rashotte, 1994). Muter (1994) showed that, although all measures of phonological awareness will predict reading and spelling success, some tasks are better predictors than others. Adams (1990) mentioned that phoneme segmentation and manipulation, which are more difficult, are stronger predictors of reading development than those phonological awareness skills acquired earlier, such as nursery rhyme knowledge, syllable segmentation, and sound blending. Furthermore, Muter, Hulme, Snowling, and Taylor (1997) showed that segmentation skills predict reading best. In fact, in their study, the linear combination of segmentation and letter knowledge and the product of these two variables accounted for 64% of the variance in first-year reading. This result was replicated in a study conducted by Muter and Snowling in 1998. The training studies demonstrated that specific training in phonological awareness has a positive impact on success in early reading (Ball & Blachman, 1991; Bradley & Bryant, 1985; Lundberg, Frost, & Petersen, 1988; Schneider, Küspert, Roth, Visè, & Marx, 1997). Although a few training studies have shown that training in phonological awareness by itself can positively influence reading acquisition, most of these studies showed that combining phonological awareness training with letter–sound correspondences is the most effective means of accelerating the rate of growth in reading abilities (Torgesen & Wagner, 1998).

The second alternative way of looking at the relation between reading and phonological awareness is to regard learning to read as the cause of phoneme awareness. Ehri (1989) suggested that phonological awareness is shaped and bound up with the learner's knowledge of the spelling system. When phonological awareness skills have been assessed in people who have not acquired any reading or spelling skill (e.g., nonreading preschoolers and illiterate adults) and readers of nonalphabetic orthographies, those have been found to be poor (Lundberg & Höien, 1990; Mann, 1986; Read, Zhang, Nie, & Ding, 1986). In short, the level of phonological awareness is much better among people who have been taught how an alphabetic orthography maps the phonemic structure of speech (Alegria, Piagnot, & Morais, 1982). That words are composed of individual phonemes does not become apparent to most language users until these units are explicitly highlighted through instruction and practice in an alphabetic orthography. Moreover, the results of the study by Alegria et al. suggested that the development of phonological awareness is contingent on the way people are taught to read and supported the hypothesis of a causal relation between reading instruction and the awareness of phonemes. Bertelson, Morais, Alegria, and Content (1985) and Morais, Cary, Alegria, and Bertelson (1979) concluded that the development of reading itself might play a crucial role in the organization of the phonological representation at the phonemic level because phonemic awareness may largely be a consequence of learning to read. Putting it all together, if children can read word lists accurately before they are fully able to segment words into phonemes, it is difficult to argue that this manipulation is a reading prerequisite (Murray, 1998).

However, children do not usually attain full development of explicit phonological awareness until reading instruction begins (Torgesen et al., 1994). That brings us to the third point of view, according to which the relation between reading acquisition and phonological awareness is thought to be reciprocal. Acquiring phonological awareness involves learning two different things about phonemes. First, words can be segmented into smaller parts than syllables, and second, children have to learn the distinctive features of individual phonemes and how to manipulate them. It is not necessary to be consciously aware of the phonological structure of words to speak or to understand them in spoken language, but to understand the written alphabetic language children must become aware that words are actually composed of segments at the phonemic level (Morais, 1991; Torgesen & Wagner, 1998). This discussion also raises some further questions: When does fully explicit phonological awareness develop in different orthographies, and what is the phonological awareness level needed to read accurately?

Although phonological awareness and its relation to reading have been shown to be valid in languages other than English, the role of phonological awareness at the beginning of reading acquisition is probably different in different languages. In the language studied here—Finnish—the grapheme–phoneme correspondence is almost perfect. Standard Finnish has 13 consonants and 8 vowels, all of which have their own phonemic equivalents. All vowels and consonants can occur as either short or long sounds, and the difference between short and long sounds is used to distinguish among different words.[1] In addition, Finnish has 6 foreign letters, which are used only in some loan words (Karlsson, 1983; Kyöstiö, 1980; Lieko, 1992) and do not have their own phonemic equivalents. Finnish is an agglutinative language. Words generally consist of a relatively large number of syllables, and the number of monosyllabic words is very limited (about 50). An average Finnish word contains more semantic information than an average English word[2] because of the agglutinative nature of Finnish (Kyöstiö, 1980). Syllabification is in most cases determined by the rule that there is a syllable boundary before each combination of consonant and vowel,[3] and the main stress always lies on the first syllable of the word. It can be claimed that, if the beginning reader knows the Finnish alphabet and the phonological equivalents of the graphemes, he or she can decode a new word just by assembling the letter-related sounds in sequence, letter by letter, to combine the equivalent phonemes to each other to form the word they represent. In English, however, the reader must process a long sequence of letters before he or she can even initiate the accurate articulation of the written word. Ehri (1992) pointed out that, even in English, if the beginning reader knows only letter names, not the letter sounds, he or she can use the phonetic information in the letter name to create a connection, if he or she has sufficient phonetic segmentation skills to detect the presence of separate sounds in letter names and in the pronunciation of words.

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[1]Examples: *tule* (come), *tulee* (comes), *tullee* (will probably come); *ei tuule* (is not windy), *ei tuulle* (is probably not windy), *tuulee* (is windy), *tuullee* (is probably windy).

[2]Examples: *Syötettäviämmehän* (we must probably feed them too)

Syö (Root) te (Derivate) ttä (Passive) v (Functor) i (Number) ä (Case) mme (Possessive) hän (Clitic)

Pulloissannekin (in your bottles too)

Pullo (Root) i (Number) ssa (Case) nne (Possessive) kin (Particle).

[3]Examples (the syllable boundary is indicated by a dash): *jo-kai-nen* (every), *purk-ki* (jar), *Hel-sin-gis-sä-kin* (in Helsinki, too).

In this study, we were also interested in the role of other nonverbal, verbal, and linguistic skills over and above reading acquisition. Phonetic recoding in lexical access refers to the ability to retrieve the name or phonological code corresponding to a written word or a pictured item (Wagner & Torgesen, 1987). Naming speed and the accuracy of articulation have become important tools in analyzing deficits in reading skills (e.g., Fawcett & Nicolson, 1994; Korhonen, 1995a, 1995b; Wolf, 1991). Bowers and Wolf (1993) and Badian (1997) raised the question of relations involving a double deficit, where children with both phonological and naming speed deficiencies will be poorer readers than will children with just one or with neither of these deficiencies. Swan and Goswami (1997) compared the picture- and word-naming performance of children with developmental dyslexia, and "garden-variety" poor readers without dyslexia, with that of controls matched first for reading age and then for chronological age. Their findings indicated that the children with dyslexia, and the garden-variety poor readers, were both poor in naming relative to both chronological- and reading-age-matched controls, which suggests that picture-naming deficiency is not specific to children with dyslexia (defined on the basis of documented specific literacy difficulties).

Phonological, short-term memory has been one of the predictors of reading development (Pennington, Van Orden, Kirson, & Haith, 1991; Rapala & Brady, 1990; Stone & Brady, 1995). According to Baddeley, Gathercole, and Papagno (1998), the phonological loop, a component of working memory or short-term memory, plays a crucial role in learning the novel phonological forms of new words. They concluded that the function of the phonological loop is to help learn new words. The correlations between phonological memory and vocabulary measures across different studies show that in the early and middle childhood years, children's short-term memory performance is strongly related to their vocabulary knowledge. It has also been suggested (Scarborough, 1998) that verbal working memory weaknesses may arise if spoken material is poorly phonologically encoded for storage, and vocabulary acquisition may be impeded if the stored phonological representations of words are inaccurate or ill specified because of deficient encoding of speech. These findings show that (a) all these verbal factors are very strongly linked together and linked to reading, and (b) the nature and the strength of the relations change during reading development.

RESEARCH PURPOSES

The purpose of this study was to examine associations between nonverbal skills, verbal skills, phonological awareness, and reading accuracy in preschool children before formal instruction began. The main focus was to test two different hypothetical models based on theories of phonological awareness and reading. Of particular interest was our language, Finnish—a language that has highly regular orthography and, thus, may not require a similar degree of training in compound phonological skills as is required in English. The first hypothesis was based on theoretical suggestions that sensitivity to the phonological structure of the words is a prerequisite for learning to read. The alternative hypothetical model theorized that learning to read fosters the development of phoneme awareness (Figure 1).

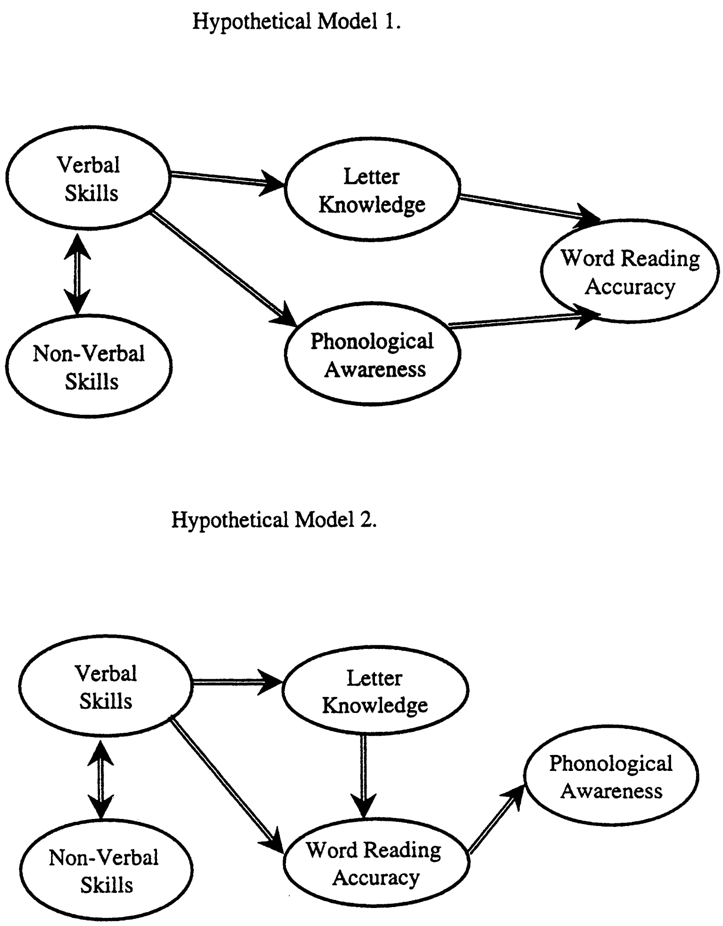

FIGURE 1 Two hypothetical models of reading-related skills.

METHOD

The First Phase

Participants

Children (N=160, 71 girls and 89 boys) from 13 preschool groups in nine day care centers in Jyväskylä, Finland, took part in the study after they had been in preschool groups for 7 months. The chronological mean age of the children was 6.9 years (SD = 0.3 years). Parental socioeconomic status and parental education were representative of the distribution in the Finnish urban population of this age group (age: mothers M = 36.6 years, fathers M = 38.8 years; Statistical Yearbook of Finland, 1996).

Measures

All tests were presented in the same order to all the children, and the measures described here correspond to that order.

Letter knowledge (Dufva, Niemi, & Voeten, in press; Poskiparta, Niemi, & Lepola, 1994) was tested with uppercase and lowercase letters. This was done by showing children a random sequence of 19 Finnish uppercase letters printed on sheets of paper, with 5 letters per paper. Letters were shown one at a time while the other letters were covered. The children were asked to give the name of each letter. The same procedure was repeated with the lowercase letters.

Word list reading. Reading skills were assessed by asking children to read aloud 30 short words "as well as they could." Words were one- or two-syllabic and included the following syllable structures of vowels (V) and consonants (C): V, CV, VC, VV, CVC, CVV, and CVVC (Dufva et al., in press; Poskiparta et al., 1994). All words were written in uppercase letters on a sheet of paper and were shown one at a time. Individual assessments were terminated after three failures. The items used in word list and nonword list reading tests are presented in Appendix A.

Nonword list reading. The nonwords were chosen from the five most common Finnish ABC books used in the first grade on the bases of the frequency of the Finnish syllable structures in the initial syllables. Within that material, the six most common syllable structures, ordered by frequency, were CV, VC, CVV, CVC, CVVC, and CVCC. Seven syllables from each structure group (42 syllables) were chosen and written in uppercase letters on a sheet of paper. Syllables were shown one at a time in order of increasing difficulty while the other nonwords were covered. The children were asked to read the syllable aloud "as well as they could." Assessments were terminated after three failures.

Nonverbal abilities. Raven's (1962) Colored Matrices were used to assess nonverbal IQ. In structural equation models, this measure formed the other part of the *nonverbal* factor.

The Second Phase

Participants

The selection of participants for the second phase was based on the first-phase assessments. Five participants were excluded because they did not speak Finnish as their first language, and 1 girl moved away. The parents of 6 children refused to give their consent for later assessments. The results of the first phase revealed that the correlation between lowercase letter knowledge and uppercase letter knowledge was so high ($r = .87, p < .01$) that the sum of these variables was formed to represent letter knowledge. A very high correlation ($r = .93, p < .01$) was found between reading nonwords and words, and the sum of these variables was formed to represent reading ability. On the basis of these measures, the participants were divided into groups according to their results in letter knowledge and reading: Group 1, girls ($n = 23$) and boys ($n = 37$) who were unable to name letters or read; Group 2, girls ($n = 31$) and boys ($n = 34$) who knew letters but could not read accurately; and Group 3, girls ($n = 12$) and boys ($n = 12$) who knew letters and could read accurately. For the purpose of intensive follow-up study, 92 randomly selected children from these groups (38 girls, 54 boys; 13 from Group 1, 43 from Group 2, and 36 from Group 3) were assessed at the end of preschool by using nine further tasks related to reading.

Measures

Letter knowledge. All participants were tested on their knowledge of letter names with uppercase letters (Dufva et al., in press; Poskiparta et al., 1994). This test was performed by showing children a random sequence of 19 Finnish uppercase letters printed on sheets of paper with 5 letters per sheet. Letters were shown one at a time while the other letters were covered, and the children were asked to give the name of each letter. In the analysis the test results were recoded into three groups (0–10 letters correct, 11–18 letters correct, and all letters correct, respectively). Letter knowledge formed the *letter knowledge* factor in later analysis.

Word list reading. Reading skills were assessed by asking children to read aloud 30 short words as well as they could (Dufva et al., in press; Poskiparta et al., 1994). Words were of one and two syllables and included the following syllable structures: V, CV, VC, VV, CVC, CVV, and CVVC. All words were written in uppercase letters on a sheet of paper and were shown one at a time; the assessment was terminated after three failures. The number of words read correctly (accuracy) was used in the analysis and recoded into three groups (0–5 words correct; 6–28 words correct, and 29–30 words correct). Word list reading formed the *word reading accuracy* factor in later analysis.

Phonological awareness. Phonological awareness was assessed by using one identification task, two phoneme deletion tasks, and one phoneme blending task. Each of these four different tasks had 10 items (Dufva et al., in press; Poskiparta et al., 1994). Before each task, a training set containing 3 items was given. In the *single phoneme identification task,* the child was asked to say aloud the first phoneme of the word. If the child did not know the phoneme, he or she was asked to say the name of the first letter of the word. The results were recoded into four groups (0 correct, 1–3 correct, 4–9 correct, and all correct). Because all children responded with letter names, we refer to this task a letter-identification task later in text.

In the *phoneme deletion task,* the child was asked to delete the initial phoneme and say aloud the remaining part, which formed a new word. In the *syllable deletion task,* the examiner deleted one syllable of the word (in initial, medial, and final positions), and the child was asked to say aloud the remaining part, which formed a new word. The *phoneme-blending task* included two-, three-, and four-letter words, which were presented phoneme by phoneme, and the child was asked to say aloud the resulting word. For later analysis, the measures were recoded into four groups (0 correct, 1–2 correct, 3–5 correct, and 6–10 correct). These phonological awareness tasks formed the *phonological awareness* factor in later analysis. The items used in phonological awareness tests are presented in Appendixes B and C.

Naming tasks. From the Rapid Automatized Naming Task (Denckla & Rudel, 1974), three rapid naming tasks were used in this study. In these tasks, the aim was to name as fast as possible a series of common objects, colored squares, and numbers displayed on a card in five rows, 50 items per card. The time used for completing each task was used as a speed score. These three naming tasks formed the *naming speed* factor. The next five verbal tasks described here formed the *verbal factor* in later analysis.

Receptive vocabulary. The Peabody Picture Vocabulary Test–Revised (PPVT–R, shortened 121-item Finnish version; Dunn & Dunn, 1981) was used to assess the children's receptive vocabulary. The raw scores from the PPVT–R were used in the analyses.

Auditory reasoning. The Auditory Reasoning Test from the Finnish version of The Illinois Test of Psycholinguistic Abilities (Kuusinen & Blåfield, 1974) was selected to assess the children's association processes in working from auditory concepts. Standard procedure was followed. The number of correct answers was the child's score.

Phonological short-term memory. In this study, short-term memory was assessed by a Digit-Span subtest of the Wechsler Intelligence Scale for Children–Revised (Wechsler, 1974) and a pseudoword repetition test (from Developmental Neuropsychological Assessment [NEPSY]; Korkman, Kirk, & Kemp, 1997a, 1997b), in which the child was asked to repeat 16 nonwords, which were presented on audiotape. The number of correct repetitions was the child's score (maximum 16 points). Stable misarticulations and wrong stressing were not counted as errors.

Oromotor coordination. In the Oral Dynamic Praxis test (from NEPSY; Korkman et al., 1997a, 1997b), the child was asked to repeat 14 sound sequences and tongue twisters, such as "pataka/pataka/pataka/" eight times in a sequence presented at a rate of 1 sequence per 1 sec for Items 1 through 8, and 1 sequence per 2 sec for Items 9 through 14. The number of correct sequences was counted for each item (maximum 8 points per item). The total raw score was the sum of all items.

Analogic reasoning. From the Kaufman Assessment Battery for Children (K–ABC; Kaufman & Kaufman, 1983), Matrix Analogies were selected for measuring analogic thinking with pictorial analogies. Standard procedure was followed. In later analysis, the raw scores were used to form the second part of the *nonverbal* factor.

Procedures

This study is the first part of a larger investigation of early reading development beginning at the preschool year and ending at the end of the 2nd year of primary school. This first study focuses on the preschool year, and further reports will concentrate on primary school data.

All children were individually tested in a separate room at their preschools. The first assessment phase took place in March 1997 and the second in May 1997. The first assessment lasted approximately 1 hr, including one break taken if the child needed it. The second phase of testing lasted about 2 hr, including breaks. As was possible, the same examiner tested the child in both situations.

RESULTS

Sample Characteristics and Correlations

The means and standard deviations of the measures are shown in Table 1. All measures listed in this table, except the nonverbal intelligence measure, were assessed during the second phase of this study. The distribution of nonverbal abilities in our sample was similar to the corresponding distributions in the Finnish norming sam-

TABLE 1
Descriptive Statistics of the Sample at the End of Preschool

Measures	*M*	*SD*
Age (years)	6.89	0.30
Nonverbal intelligence (36)[a]	21.31	4.20
Letter knowledge (19)	16.18	4.02
Word list reading (30)	6.63	11.62
Phoneme identification[b] (10)	5.67	4.02
Phoneme identification[c] (10)	.00	.00
Phoneme deletion (10)	1.80	3.3
Syllable deletion (10)	2.98	2.54
Phoneme blending (10)	2.65	3.13
Naming (speed)		
Colors	64.33	18.00
Numbers	65.56	25.00
Objects	72.61	16.40
Receptive vocabulary (121)	80.13	12.80
Auditory reasoning (32)	15.25	7.55
Pseudoword repetition (16)	9.40	2.55
Short-term memory (forward, 9)	3.80	1.31
Short-term memory (backward, 8)	2.85	1.15
Oromotor coordination (112)	66.83	15.80
Analogic reasoning (16)	10.19	2.43

Note. $N = 91$.
[a]Values in parentheses are maxima. [b]Letter names approved. [c]Phonemes in use.

ples of the Raven standard matrices ($M = 20.8$, $SD = 6.5$) On average, children were able to name most of the letters (48.9% named all the letters correctly, and only 8.8% named less than half of the letters); however, only 25% were able to read, and 67.8% were nonreaders. As already mentioned, the readers in this study could read nonwords and words almost equally well ($r = .93, p < .01$). The readers read very accurately; most of their mistakes were omission of letters (i.e., omissions of long vowels, which mark long phoneme duration). The most interesting finding was that phoneme identification on the basis of letter sounds proved to be an unworkable task, even for the readers in our sample; all children responded with letter names rather than with letter sounds when asked the first sound in the word. Note that readers in this study had achieved their skills without formal instruction, which in Finland includes teaching letter sounds and letter names. The polychoric correlation coefficients between reading and reading-related variables are presented in Table 2. Reading was more weakly related to letter identification skill (.49, $p < .001$) than to phoneme deletion skills (.73, $p < .001$), whereas letter naming correlated more strongly to letter identification (.76, $p < .001$) than to phoneme deletion (.41, $p < .001$) and to phoneme blending (.51, $p < .001$).

In Figure 2, the relation between the scores of reading and phonological awareness is described both in terms of plotting individual locations and by fitting exponential curves. Letter name identification represented the highest mean scores found among the phonological awareness tests, reaching the maximum value among the accurate readers. This Finnish data also supported the view that phoneme deletion appeared to be a very difficult task, not only for nonreaders but also for readers. The results of the phoneme blending task were also interesting because there were five nonreaders who could blend the phonemes of the shortest words (e.g., /y/-/ö/->/yö/, /s/-/u/-/u/->/suu/) and two readers who failed to blend the phonemes of the words that have four sounds (e.g., /a/-/i/-/t/-/o/->/aito/). Syllable deletion was the next most difficult task, especially seen in deleting middle syllables, which was difficult even for readers. On the other hand, there were nine nonreaders who mastered the initial-syllable deletion task. This variation can also be seen in the curve describing the relation of the syllable deletion task and reading. The shape of curves, describing the relation of phoneme blending, letter identification, and phoneme deletion to reading is similar, showing a high positive correlation to the development of reading.

Structural Equation Modeling

To test the hypotheses of relations among reading related measures, two structural equation models were constructed. These models were estimated and tested by using the LISREL 8 program (Jöreskog & Sörbom, 1996a). The input to the LISREL path model was in the form of polychoric correlations produced by PRELIS 1.2

TABLE 2
Correlations Among the Variables Included in the LISREL Structural Equation Model

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1. LK	—															
2. WR	.49	—														
3. SD	.41	.47	—													
4. PD	.41	.73	.53	—												
5. LI	.76	.59	.51	.58	—											
6. PB	.51	.70	.50	.62	.67	—										
7. ITPA	.36	.15	.20	.22	.36	.31	—									
8. WISC	.44	.36	.37	.38	.41	.37	.42	—								
9. PR	.33	.18	.36	.22	.36	.17	.28	.51	—							
10. PPVT	.37	.23	.29	.22	.31	.30	.43	.49	.46	—						
11. RAN1	–.39	–.31	–.10	–.22	–.24	–.31	–.04	–.26	–.16	–.18	—					
12. RAN2	–.31	–.27	–.21	–.26	–.25	–.30	–.18	–.41	–.16	–.34	.54	—				
13. RAN3	–.19	–.19	–.16	–.21	–.17	–.20	–.07	–.29	–.17	–.09	.49	.74	—			
14. IQ	.36	.34	.21	.22	.24	.28	.28	.29	.24	.47	–.08	–.23	–.21	—		
15. AR	.22	.14	.37	.16	.12	.10	.11	.23	.18	.25	–.07	–.13	–.13	.30	—	
16. OP	.38	.27	.48	.40	.37	.38	.39	.57	.48	.39	–.24	–.31	–.29	.14	.28	—

Note. Corresponding levels of significance: .220–.278, $p < .05$; .280–.349, $p < .01$; .350–, $p < .001$. LK = letter knowledge; WR = word list reading; SD = syllable deletion; PD = phoneme deletion; LI = letter identification; PB = phoneme blending; ITPA = auditory reasoning; WISC = Wechsler Intelligence Scale for Children, short-term memory; PR = pseudoword repeating; PPVT = Peabody Picture Vocabulary Test, receptive vocabulary; RAN1 = naming speed, numbers; RAN2 = naming speed, colors; RAN3 = naming speed, objects; IQ = nonverbal intelligence; AR = analogic reasoning; OP = oral-dynamic praxis.

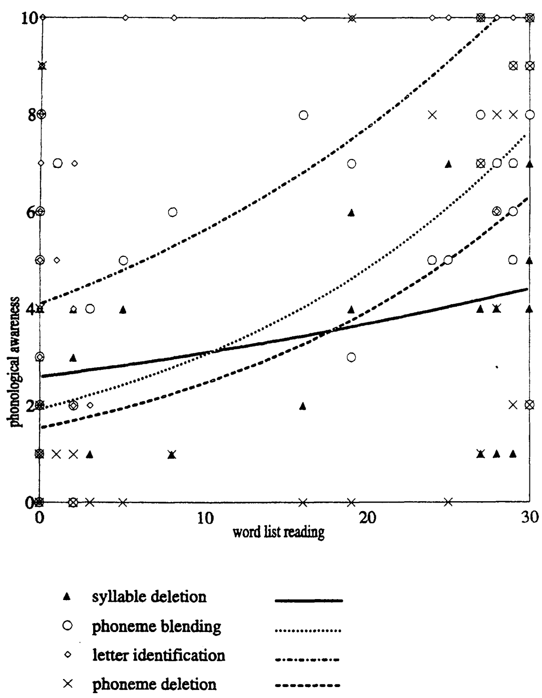

FIGURE 2 The exponential curves fitted to cases (marked by symbols) are described between four phonological awareness and word list reading tests.

(Jöreskog & Sörbom, 1996b), where some of the variables were treated as ordinal. Missing values were treated pairwise.

The method of estimation used was general least squares. To improve the fit of the model to the theoretical models, some modification indexes were released. All connections represented in these models were statistically significant (t test > 2). The fit of the hypothetical models with the observed variables was estimated by using various goodness-of-fit measures: chi square (χ^2), root mean square error of approximation (RMSEA), normed fit index (NFI), and comparative fit index (CFI). In comparing the models, Akaike's information criterion (AIC) was used.

Both models consisted of 16 observed variables: word list reading, letter knowledge, phoneme deletion, syllable deletion, letter identification, phoneme blending, naming tasks (naming speed of objects, colored squares, and numbers), nonverbal intelligence, analogic reasoning, short-term memory, auditory reasoning, receptive vocabulary, oral-dynamic praxis, and pseudoword repetition. These models had six latent variables. Letter knowledge formed the Letter Knowledge factor, and word list reading formed the Word Reading Accuracy factor. The Phonological Awareness factor was constructed from two tasks measuring segmentation and two tasks measuring compound phonological awareness, all correlating strongly. Five linguistic measures (receptive vocabulary, auditory reasoning, pseudoword repeating, short-term memory, and oral-dynamic praxis) were significantly associated with a single factor named Verbal Skills. The fifth factor was formed from two tasks measuring nonverbal skills (nonverbal intelligence and analogic reasoning) and was labeled Nonverbal Skills. Tasks measuring the naming speed of colors, objects, and numbers formed the Naming Speed factor.

Figure 3 illustrates the first estimated structural equation model. In terms of the chi-square test, the statistical fit of the model was good: $\chi^2(96, N = 91) = 78.18, p = .91$. Other indexes of fit also gave good values: RMSEA = 0.12, NFI = .98, CFI = 1.00, and AIC = 158.18. Thus, it can be said that, in this model, the basic theoretical assumptions of the modeling process and the statistical measures of the models are well met. As expected, the Nonverbal factor was strongly correlated (.83) with the Verbal factor, which was presented in both hypothetical models. Following the Hypothetical Model 1, the Verbal factor was connected with the Phonological Awareness factor and to the Letter Knowledge factor, which quite surprisingly

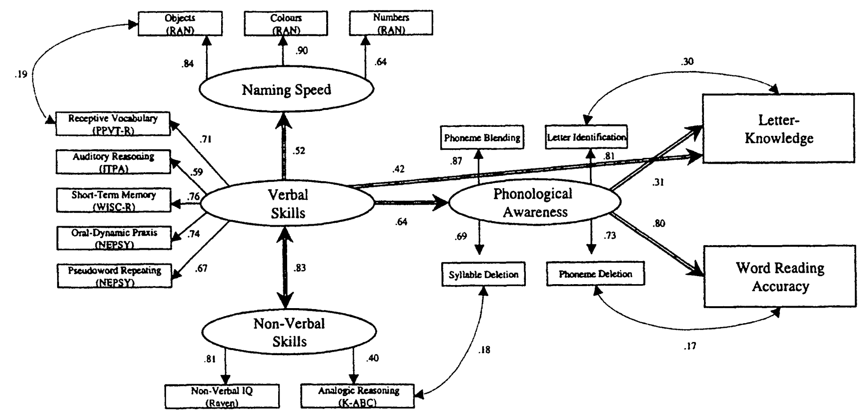

FIGURE 3 The estimated LISREL Model 1 of reading, letter knowledge, phonological awareness, and nonverbal and verbal factors.

was connected to the Word Reading Accuracy factor only through phonological awareness, which did not follow the Hypothetical Model 1. The Verbal factor was also directly related to naming speed, which surprisingly was not directly linked to any other factor in this model. This finding contradicted our theoretical assumptions. However, a residual correlation between receptive vocabulary and naming speed of objects appeared in the model. The Phonological Awareness factor was strongly linked to reading accuracy, but not as strongly (although still significantly) to letter knowledge. The phoneme deletion task and word reading were weakly but significantly connected with each other, as was (very understandably) the letter-identification task and letter knowledge. There was also a weak but significant correlation between syllable deletion and analogic reasoning. None of these residual correlations followed the hypothetical model, but all are very accessible by the theory, as is seen later.

As proposed in different references (Ferguson, 1997; Jöreskog & Sörbom, 1996a), for any given LISREL model there may be alternative models that can describe the data equally as well as the original model. To clarify the relation among reading accuracy, letter knowledge, and phonological awareness, we constructed an alternative model in which we changed the direction of the relation among word-reading accuracy, letter knowledge, and phonological awareness, whereas all other parts of the model were maintained as before (Figure 4). The indexes of fit

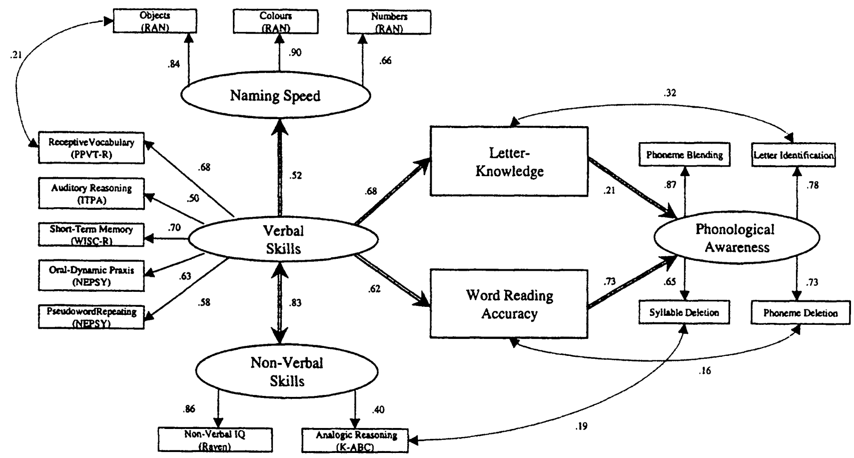

FIGURE 4 The estimated LISREL Model 2 of reading, letter knowledge, phonological awareness, and nonverbal and verbal factors.

for this alternative model were $\chi^2(96, N = 91) = 85.45, p = .77$, RMSEA = 0.19, NFI = .98, CFI = 1.00. It can be seen in Figure 4 that changing the direction of the relation among reading, letter knowledge, and phonological awareness does not change the directions of the relations in other parts of the model; the strength of the predictions also remains almost the same as the four residual correlations. Although both of these models fitted the data well, the AIC (158.18) of the first model was somewhat better than the AIC of the second model (165.45).

DISCUSSION

The aim of this study was to test two hypothetical models of reading and reading-related skills of children, before their formal reading instruction had started, by using the highly regular Finnish orthography. The main results of our study show that the model emphasizing sensitivity to the phonological structure of the words as a prerequisite for learning to read fit our data a little better than the alternative model that showed an opposite direction of these relations, which nevertheless proved to be statistically accessible.

The main interest in this study was to explore the relation between reading acquisition and phonological awareness. The results support the hypothesis that phonological awareness is strongly, and maybe partly reciprocally, related to early reading ability at the end of preschool, at least in languages such as Finnish, where the orthography is highly transparent with a very consistent mapping from spelling to sound. In a study by Stahl and Murray (1994), the ability to isolate phonemes appeared to distinguish children who could read words from the children who were unable to read words from the word lists used in that study. In our study, all preschoolers (readers and nonreaders) used letter names instead of letter sounds in the phoneme identification task. This strong awareness of letter names may explain the intercorrelation between letter knowledge and letter identification. To summarize, this could indicate that in a language such as Finnish, the skill to explicitly differentiate between letter names and phonemes is not a prerequisite for learning to read, at least when learning to read occurs without formal instruction.

The deletion tasks (phoneme and syllable) demand, in addition to phonological abilities, good working memory skills. In a training study by Aro et al. (1999), where six 7.0- to 7.9-year-old nonreaders were followed for 13 months in the interests of the developing their phonological skills and reading acquisition, phoneme deletion skills displayed the largest interindividual variation, which we also found in our study. Our finding of the residual correlation between phoneme deletion and word reading is of considerable interest. When we asked the children the strategy they had used to solve this task, most of them explained that they "looked" at the word (in the air, as if it were written there) and then took the first, last, or middle letter (not the phoneme) away. This suggests at least activation of the orthographic forms of the words and, together with the fact that the nonreaders were quite unable to perform this task, supports the possibility that reading skills might precede phonological awareness in regular orthographies such as Finnish. It is also worthwhile to notice that the skills needed in the syllable deletion task are linked to nonverbal abilities through their residual correlations, in particular to analogic reasoning. This might show how problematic it is to form a phonological task, which would not measure other abilities. The finding that nine nonreaders could solve the initial-syllable deletion task but not the phoneme deletion task could indicate that, in our orthography, explicit awareness of syllables precedes phonemic awareness, which is needed for reading. The fact that in Finnish words the main stress always occurs on the first syllable might help the child to notice it as a separate unit.

In a training study by Poskiparta, Niemi, and Vauras (1999), after the training period, the entire training group had gained the level of reading and spelling where they were able to blend phonemes into words. Phoneme-blending ability seemed, therefore, to be a sign of the children's reading and spelling levels. In another Finnish training study (Aro et al., 1999), phoneme synthesis skills improved simultaneously with the reading skills. In our study, phoneme blending was highly correlated with reading (.70). Also, in this task, activation of orthographic forms of the word could be seen because most of the children performing this task described the strategy they used to solve this task like this: "I just put the letters *R*, *I*, *S*, and *U* together and get the word *RISU*." In our orthography, sound-blending ability seems to be very close, or almost identical, to reading ability. Interestingly, however, there were five nonreaders who were able to blend at least half of the words tested. Obviously, these children were very close to acquiring reading skills.

In our study, almost half (48.9%) of the children at the end of preschool could name all the letters, but only 24.8% could read. It should be noted that the children in this study had not yet received formal reading instruction, but in Finland, about 24% of preschoolers are able to decode written text before they enter school at the age of 7 (Luotonen, 1995). Many other kinds of literacy activities at home, day care centers, and preschools can encourage children to pick up unsystematic hints of the alphabetic and phonemic correspondences. Following Treiman and Zukowski (1996) and Stahl and Murray (1994), letter knowledge can help children understand that print represents sounds, which is the basic step for the discovery of the alphabetic principle. In our models, the connection between letter knowledge and phonological awareness was much weaker than the relation between reading and phonological awareness. As can be seen in both models, naming letters is only partly a phonological ability; hence, it also has a strong connection to other verbal abilities, such as memory, vocabulary, and articulation. It would be reasonable to conclude, therefore, that letter naming is part of a wider linguistic ability that underlies reading ability. This can also be seen in Model 2. In this light, it is easy to understand the importance of letter knowledge in many studies on reading development prior to the detection of phonological awareness.

It has become apparent that, when normal reading development is examined, intelligence and reading ability are positively and significantly associated (Aaron, 1985; Anderson, 1992). In a study conducted by Rupley, Willson, and Nichols (1998), the relations among the variables in reading development were examined by using structural equation modeling. In that study, the cognitive power variable was defined by the K–ABC Mental Processing score for measuring more global intelligence components and by PPVT–R for investigating verbal, crystallized components of intelligence at Grades 3 and 4. A direct path from cognitive power to both word recognition and comprehension emerged, and the strength of the paths increased from Grades 3 and 4 to Grades 5 and 6. This is consistent with the conclusion of Rupley and Willson (1997) that, in young readers, cognitive power operates primarily through decoding.

The verbal skills, for their parts, form a very coherent factor. The theories of short-term memory in vocabulary acquisition (Baddeley et al., 1998; Scarborough, 1998) received support in these models, and at the same time the importance of vocabulary to reading become very clear. Interestingly, in this study where reading accuracy, not reading speed, was measured, naming speed formed a separate factor in addition to phonological awareness and other linguistic skills. Naming speed seems to be connected to beginning reading accuracy only indirectly through the nonverbal and verbal factors. Moreover, the quite weak, but interesting residual, correlation between receptive vocabulary and naming speed of objects shows the verbal role of naming.

Torgesen and Wagner (1998) suggested that phonological awareness includes different levels that usually fully develop only after reading instruction begins. Fully explicit awareness is described as the ability to pronounce, separately, the individual sounds in a word or to delete sounds inside the word. In a Finnish training study by Poskiparta et al. (1999), it was found that the lack of phonological awareness alone at school entry does not cause problems in reading, at least not in a school system such as in Finland, which emphasizes training in phonics. Furthermore, among Finnish schoolchildren, there is a large group of pupils who fail to "break the code" between letter names and letter sounds without specific training and instruction. These results suggest that reading acquisition in Finnish at preschool level shares similarities with less regular languages such as English. However, certain differences that may be specific to orthography and language are also apparent, which require further investigation. As mentioned by Aro et al. (1999); Lyytinen, Leinonen, Nikula, Aro, and Leiwo (1995); and Poskiparta et al. (1999), the reading instruction may complement, relatively quickly, this poorness of phonemic awareness, which is needed for accurate letter-by-letter and phoneme-by-phoneme assembly. What is left to be learned later is the fluency of the assembly, which is for the most part very poor among those who have difficulties in reading acquisition. Thus, it may be that the main bottleneck of reading acquisition is encountered later in Finnish than in English. The follow-up of the children assessed here will monitor the progress of reading skill and its relation to phonemic awareness and other verbal and nonverbal skills. We hope that future findings will shed more light on the rate issues, provide support for either of the models, and address the questions that remain open in this study.

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APPENDIX A
Items of the Nonword and Single Word Reading Tasks

Nonwords			*Words*	
1. II	2. OO	3. EE	1. JOKA	2. SUU
4. AA	5. UU	6. ÄÄ	3. EIKÄ	4. SAA
7. LA	8. MO	9. TI	5. KOSKA	6. OVI
10. ES	11. UP	12. ÄK	7. JOLLA	8. KISSA
13. HOO	14. JUU	15. MEE	9. SIKA	10. KOTI
16. ÄÄN	17. AAR	18. IIK	11. HYVIN	12. MIKÄ
19. PÖY	20. HIE	21. VUO	13. LAHJA	14. ILTA
22. AUK	23. ÄYS	24. UIT	15. OLI	16. VIE
25. KÄM	26. HET	27. LIP	17. YÖ	18. ISÄ
28. UNS	29. AMP	30. YRT	19. SITÄ	20. ÄITI
31. HAAS	32. VIIL	33. SUUR	21. PUU	22. PALLO
34. KUOL	35. VÄIT	36. JOIS	23. EI	24. UNI
37. SULT	38. PONT	39. LINS	25. MISSÄ	26. KESÄ
40. VÄLK	41. HARP	42. JYRK	27. ERI	28. YLI
			29. ALTA	30. AVAIN

APPENDIX B
Items of the Phoneme Awareness Tasks

Phoneme Identification		Phoneme Deletion[a]	
1. SYÖ	-S	1. SYÖ	YÖ
2. RAPU	-R	2. RAPU	APU
3. LUKKO	-L	3. LUKKO	UKKO
4. MAILA	-M	4. MAILA	AILA
5. VESA	-V	5. VESA	ESA
6. NASTA	-N	6. NASTA	ASTA
7. KAARRE	-K	7. KAARRE	AARRE
8. HAAMU	-H	8. HAAMU	AAMU
9. PARKA	-P	9. PARKA	ARKA
10.TAKKA	-T	10.TAKKA	AKKA

[a]Underlined letter is letter to be deleted.

APPENDIX C
Items of the Phonological Awareness Tasks

Phoneme Blending		Syllable Deletion		Deleted Syllable
1. Y-Ö	YÖ	1. KUUSI	-SI	KUU
2. I-S-Ä	ISÄ	2. KAISA	-SA	KAI
3. S-U-U	SUU	3. SATAMA	-MA	SATA
4. L-U-U	LUU	4. PUHELIN	-LIN	PUHE
5. I-S-O	ISO	5. PAISUU	-PAI	SUU
6. O-V-I	OVI	6. TOVERI	-TO	VERI
7. R-I-S-U	RISU	7. KULKURI	-KUL	KURI
8. L-A-S-I	LASI	8. SANKARI	-SAN	KARI
9. S-A-M-A	SAMA	9. PERUNA	-RU	PENA
10. A-I-T-O	AITO	10. SARANA	-RA	SANA

Study 2
Predicting Delay in Reading Achievement in a Highly Transparent Language

by

Leena Holopainen, Timo Ahonen, and Heikki Lyytinen
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Predicting Delay in Reading Achievement in a Highly Transparent Language

Leena Holopainen, Timo Ahonen, and Heikki Lyytinen

Abstract

A random sample of 91 preschool children was assessed prior to receiving formal reading instruction. Verbal and nonverbal measures were used as predictors for the time of instruction required to accurately decode pseudowords in the highly orthographically regular Finnish language. After 2 years, participants were divided into four groups depending on the duration of instruction they had required to reach 90 % accuracy in their reading of pseudowords. Participants were classified as precocious decoders (PD), who could read at school entry; early decoders (ED), who learned to read within the first 4 months of Grade 1; ordinary decoders (OD), who learned to read within 9 months; and late decoders (LD), who failed to reach the criterion after 18 months of reading instruction at Grade 2. Phonological awareness played a significant role only in differentiating PD from ED and OD. However, phonological awareness failed to predict the delayed learning process of LD. LD differed from all other groups in visual analogical reasoning in an analysis not containing phonological awareness measures. Letter knowledge and visual analogical reasoning explained above 90% of the PD–LD difference. Preschool composite (objects, colors, and digits) naming speed measures best predicted reading fluency at the end of Grade 2. The supportive role of orthographic knowledge in phonological awareness, the role of visual analogical reasoning, and the inability of phonological measures to discriminate late decoders are discussed.

Recent research has documented statistically significant predictors of later reading skills. However, the success of this prediction appears dependent on the time of assessment in relation to reading instruction. Few studies to date have tried to predict how individual children's reading skills will benefit in relation to the median rate of instruction. Such data could be used to mediate individually adapted rates of instruction and to provide additional support toward the prevention of reading failure. A number of developmental cognitive and language skills have been shown to predict the development of reading acquisition. However, most studies have presupposed this development to follow a uniform progression and, thus, have failed to accommodate individual differences in the rate and efficiency of acquisition. The most salient correlates of reading have been phonological processes that comprise a set of mental activities that involve perceiving, storing, accessing, and manipulating phonological information (e.g., Badian, 1988; Bradley & Bryant, 1983; Goswami & Bryant, 1990; Liberman, Liberman, Mattingly, & Shankweiler, 1980; Liberman & Shankweiler, 1985; Stanovich, 1988.). In relation to reading difficulties, it has been proposed that this phonological view is incomplete without a naming speed aspect (Torgesen, Wagner, & Rashotte, 1994; Wagner & Torgesen, 1987). A naming speed deficit has been seen as an independent and critical core feature of dyslexia (e.g., Bowers & Wolf, 1993; Lovett, 1987; Wolf, 1984; Wolf & Bowers, 1999) or an associated feature co-ocurring with (or even resulting from) a phonological deficit (Badian, 1993, 1997; McBride-Chang & Manis, 1996; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Wimmer, 1993). Letter knowledge, which is the key to the discovery of the alphabetic principle, helping children to understand that print represent sounds, has been shown to be a notable predictor of reading skills (e.g., Stahl & Murray, 1994; Treiman & Zukowski, 1996).

It is difficult to find studies of the relation between phonological awareness and reading abilities in which English and Finnish children would be at the same chronological age and have the same amount of formal teaching, because Finnish children start preschool—where very little formal reading instruction is given—at the age of 6 and school at the age of 7. However, a study on learning to read English by Wagner et al. (1997) followed children of almost the same age group and had a design close to the present study. These authors examined the association between phonological processing and reading levels from kindergarten to fourth grade and showed that children whose phonological and word reading skills were significantly impaired at first grade almost invariably scored below average on these skills 2 years later. Torgesen and Wagner (1998) have stated that it is not necessary to be consciously aware of the phonological structure of words in order to speak or to understand words in the spoken language. In contrast, in order to understand the written alphabetic language, children must become aware that words are actually composed of segments at the phonemic level. Torgesen and Burgess (1998) studied the causal relationship between phonological awareness and reading skills in English and found that directional influences were stronger from phonological processing to reading than from reading to phonological processing. This relationship may be different in transparent languages, where grapheme–phoneme/phoneme–grapheme correspondences are one-to-one and where teaching emphasizes the use of phonics (Holopainen, Ahonen, Tolvanen, & Lyytinen, 2000; Wimmer, 1993). Thus, the relationship between reading acquisition and phonological awareness is often thought to be reciprocal because usually children do not attain full development of explicit phonological awareness until reading instruction begins (Torgesen et al., 1994).

A large body of phonological, letter knowledge, and memory information was gathered early and late in kindergarten and early in first grade (mean age of children was less than 6.1 years) and used as predictors of reading acquisition at the end of first grade in a study by O'Connor and Jenkins (1999). Measures closer in time to the point of reading measurement (early first grade) were better than earlier ones (April or November in kindergarten) in their prediction of reading ability at the end of first grade. At all three screening points, rapid letter naming and phoneme segmentation were the two best predictors.

Ellis and Large (1988) found a clear change in the order of the predictors of reading skill in a longitudinal study in which reading development was followed over 3 years. In a group who had some reading ability at age 5, the best predictors from ages 5 to 6 were phonological awareness skills (e.g., syllable and phoneme segmentation) and visual pattern recognition skills (e.g., letter search, visual digit span). From ages 6 to 7—at the same age group as in the present study—the strongest predictors were again phonological awareness and phonological processing tasks, but at this point the auditory–verbal tasks (e.g., auditory digit span, token test) were better predictors than the visual tasks. Thus, the critical skills affecting the speed of progress varied according to the stage of reading, and the change was not uniform.

Several studies have shown that children and adults with dyslexia are slower than most other readers to name visually presented stimuli, particularly when these stimuli are presented in series (Bowers & Wolf, 1993; Wolf & Bowers, 2000; Wolf, Bowers, & Biddle, 2000). Wolf and Bowers (1999) have described subgroups of children whose reading was limited by naming speed only, by phonological awareness only, or by what they termed a *double deficit*, characteristic to children with deficits in both naming speed and phonological awareness. Children who were below average in naming speed were below average in reading speed and comprehension and in word reading accuracy, but not in their accuracy of reading pseudowords. Children with phonological deficits were below average in word and nonword reading accuracy as well as in reading comprehension. Children with both phonological and naming speed deficits had more severe reading difficulties than did children with either deficit alone.

Bowers, Sunseth, and Golden (1999) examined the relationship between rapid naming and reading progress in Grades 2 and 3. Using findings from earlier studies, children were assigned to four groups according to their phoneme deletion and naming skills: no deficit in phoneme deletion and normal naming skills (typical readers), poor phonological skills (i.e., phonological deficit), slow naming speed (i.e., naming speed deficit), and deficit in both (i.e., double deficit). Children with a single naming speed deficit were quite accurate in their reading of words and nonwords compared to those in the single phonological deficit group. In contrast, the reading speed of the naming speed deficit group was significantly slower in comparison to the phonological group. The double deficit group also did very poorly in reading. The authors interpreted the double deficit as affecting both top-down and bottom-up processes in limiting the use of compensatory skills in reading.

Manis, Seidenberg, and Doi (1999) also examined the relationship between phonological measures, rapid naming, and reading skills with younger children from Grade 1 to Grade 2. They found that both sound deletion and rapid naming accounted for independent variance in the second-grade reading scores, although the contribution from both of these was reduced compared to Grade 1. Rapid naming in particular was a strong predictor of orthographic skills (orthographic choice, word likeness assessment, and exception word pronunciation), and phoneme awareness was a good predictor of nonword reading and paragraph comprehension.

Because orthographies vary in their phonological transparency, cross-linguistic studies of reading and reading-related skills have focused on ascertaining which elements of reading are universal and which are specific to particular orthographies (e.g., Liberman et al., 1980; Wimmer, 1993; Wimmer & Landerl, 1997). Elbro, Borstrøm, & Petersen (1998) followed Danish children of parents with and without dyslexia from 1 year before the onset of reading instruction (at the age of 6) until 1 year into reading instruction. It was shown that letter naming, phoneme identification, and the distinctness of phonological representations (i.e., correct pronunciation of words) contributed independently to the prediction of dyslexia. It was also found that the distinctiveness of phonological representations made a statistically significant additional contribution to the prediction of poor phoneme awareness in Grade 2 after controlling for effects of letter naming, articulation accuracy, and vocabulary. The conclusion was that phonological representations form a significant linguistic prerequisite of reading development. Another Danish study by Olofsson and Niedersøe (1999) showed significant paths from early language abilities (e.g., vocabulary, phonology, and morphology) at age 3 through expressive and receptive language in kindergarten via language awareness in kindergarten and word decoding in Grade 2 to sentence reading in Grades 3 and 4. These results from Danish were similar to findings in English.

Wimmer (1993, 1996; Wimmer, Mayringer, & Landerl, 1998) has shown that the nature of reading difficulties is different in a transparent language (e.g., German) than in languages with deep orthographies such as English or Danish. German-speaking children with dyslexia at Grade 2 showed rather high reading accuracy of pseudowords but very slow reading speed and poor spelling. With respect to cognitive deficits, impaired performance on the rapid naming tasks was shown as typical for children with dyslexia. Numeral naming speed turned out to be the most important predictor of reading speed differences. Bowers and Wolf (1993) suggested that slowness in naming may harm the automatic induction of good quality orthographic codes and their rapid connection to phonological representations. In German children with dyslexia in the early phase of reading, difficulties occurred with phonological coding in reading and with phonemic segmentation, but these difficulties, in contrast to those of English-speaking children, were not seen at later grades (at ages 10 to 11) in German-speaking dyslexic children (Wimmer et al., 1998).

On the other hand, in Spanish, another language with transparent orthography, Rodrigo and Jiménez (1999) found that poor phonological skills are also a characteristic of children with reading disabilities at the age of 9 and 10. However, this was seen only in the frequency of errors in nonword, low frequency word, and long nonword reading, all of which require extensive phonological computation.

Näslund and Schneider (1996) conducted a study in which the reading performance of German-speaking first- and second-graders was predicted by various phonological awareness measures, verbal memory, and letter knowledge assessed at the age of 6. In hierarchical regression models for early second grade, letter knowledge was significant when placed first, second, or last in the models. When phonological tasks were placed first in the model, they explained a significant proportion of the variance, but placed after letter knowledge in the models, only rhyme detection, sound in word, and phoneme oddity were significant. When placed after letter knowledge, word span, and verbal IQ in the models, only rhyme detection and phoneme oddity tasks were significant. The results of that study showed that the predictive value of different phonological awareness tasks varied with reading experience. The best predictor among phonological awareness tasks at late second grade was the phoneme oddity task. Another significant predictor for late second grade decoding was letter knowledge. The interaction of the memory span and the phoneme oddity tasks was significant in all comparisons. In short, the results from German language studies showed a larger variety of abilities than phonological awareness alone predicting later reading ability.

Difficulties in learning to read Finnish are especially interesting because the grapheme–phoneme correspondence is more consistent in Finnish than in most other European languages. On the other hand, the duration (marked as single versus repeated double letters) of vowels and consonants carries semantic information, as in *mato* (worm)—*matto* (carpet); *tuli* (fire)—*tuuli* (wind); and is thought to constitute a special difficulty for Finnish readers and spellers. This phonological characteristic demands accuracy in reading and spelling, especially at the word and phoneme levels and especially if the word is unfamiliar to the reader/speller (e.g., pseudoword). Finnish words usually consist of a relatively large number of syllables, and monosyllabic words are rare (Karlsson, 1983). Moreover, using systematic phonics-oriented instruction in reading reinforces grapheme–phoneme correspondences relatively fast (within the first 9 months of instruction) among the great majority of Finnish children.

Only a few published studies have examined the association between phonological processing and reading in Finnish. Poskiparta, Niemi, and Vauras (1999) executed a training study from the beginning of first grade to the end of first grade with 26 children who obtained the lowest quartile performance in phonological awareness tasks. The intention was to ascertain which children benefited from training in linguistic awareness. The children were divided into cognitively below average and cognitively almost average groups, and linguistic awareness instruction was given. The group comparisons led to the conclusion that the lack of phonological awareness alone does not cause poor reading, but rather that poor reading manifests as a combination of factors including poor phonological awareness and letter knowledge, poor working memory, and low verbal intelligence.

Korhonen (1991a, 1991b, 1995) followed Finnish-speaking children with learning disabilities from third grade (age 9 to 10) onward. Subgrouping the children into four groups according to their results on neuropsychological tests aided in the identification of a naming speed subgroup, which differed from the control group longer than any other—at least up to the age of 18 years. The results showed that not only did specific difficulties in rapid automatic naming (found at age 9) persevere until the end of the 18th year, but also that the reading and spelling problems persisted in most of the members of the subgroup who had originally shown this naming deficit.

Korkman, Barron-Linnankoski, and Lahti-Nuuttila (1999) conducted a predictive study of reading among Finnish children. They assessed 315 children of ages 5 to 12 with the Developmental Neuropsychological Assessment (NEPSY; Korkman, Kirk, & Kemp, 1997a, 1997b) using subtests of phonological processing, naming speed, and sentence repetition. The aim of the study was to examine the development of these factors and reading from ages 5 to 6 and to determine the influence of the years of formal instruction of reading and spelling on these factors at Grade 4 (ages 10 to 11). Korkman et al. (1999) showed that all significant changes between neighboring grade levels took place by Grade 2, before the age of 9 years. Formal reading and spelling instruction (among other instruction) did not seem to exert a strong influence on naming speed or sentence repetition. The scores on a task requiring word segment deletion started to improve before formal reading instruction, but the tasks requiring phonemic analysis were clearly influenced by the start of formal reading instruction.

The main focus of this study is the identification of preschool measures that can explain the differences in the chronological ages when children reach an accurate decoding skill, independent of the program of reading instruction. Instead of treating decoding as a continuous, uniformly developing skill, we suggest that reading acquisition may not differ linearly between individuals. To show this, we predicted the achievement of subgroups differing in the time they needed to reach accurate decoding skill by comparing groups of children who acquired reading skill

1. without any formal instruction (as close to 25% of Finnish children do),
2. after 4 months,
3. after 9 months (which is a typical time to acquire accurate decoding), or
4. not before 18 months of instruction.

Following the results of Näslund and Schneider (1996) and Poskiparta et al. (1999), we hypothesized that the predictive power of phonological awareness would vary with reading experience due to the possibility of using orthographic support in the performance of the phonological awareness tasks. On the other hand, due to the regularity of the orthographic rules that a decoder has to learn in Finnish, we predicted that nonphonological measures may also be involved in late decoding, even when controlling for IQ. The differential role of reading accuracy and reading speed in the expression of reading difficulties has been of recent interest in comparisons of transparent and nontransparent languages. Problems in reading speed have been seen as characteristic to poor reading of a transparent language, whereas decoding accuracy has been the typical dependent measure in most English studies of children with reading difficulties. Following the results of Korhonen (1991b, 1995) in Finnish and Wimmer et al. (1998) in German, we hypothesized that naming speed at preschool age plays a central role in predicting later reading speed.

Method

Participants

Children ($N = 160$; 71 girls and 89 boys) from 13 preschool groups in nine daycare centers of Jyväskylä, a town of approximately 80,000 inhabitants in Finland, were selected for the study in March 1997, following their attendance at the preschool for 7 months. The chronological mean age of the children was 6.9 years ($SD = 0.3$ years). Parental socioeconomic status and parental education were representative of the distribution in the Finnish urban population between the ages of 28 and 55 (Statistical Yearbook of Finland, 1996). Five children were excluded because they did not speak Finnish as their first language, and one girl moved away. The parents of six children refused to give their consent for the study.

Participants were divided into three groups on the basis of their results on letter knowledge and word reading measures:

1. 23 girls and 37 boys who were unable to name letters or to read,
2. 31 girls and 34 boys who knew letters but could not read accurately,
3. 12 girls and 12 boys who knew letters and could read accurately.

To be able to follow children with sufficient intensity, 92 children (about 40% of each group) were randomly selected.

Procedure and Measures

The first assessment was carried out in March 1997, when nonverbal ability was assessed after 7 months at preschool. Reading and other verbal and nonverbal abilities were assessed in May 1997, at the end of preschool. The children's reading level was assessed again in January 1998, when they had been attending school for 5 months. The fourth assessment took place at the end of the first school year in May 1998, and the last assessment of reading in May 1999, after the second school year. All children were always tested individually. Each assessment lasted approximately 2 hours, including breaks when required by the child. As far as possible, the same examiner tested the child on each occasion. Tests were presented in the same fixed order to all children.

Letter Knowledge. Letter knowledge (Dufva, Niemi, & Voeten, 2001; Poskiparta, Niemi, & Lepola, 1994) was tested with uppercase and lowercase letters. Children were shown a random sequence of 19 Finnish uppercase letters printed on sheets of paper with five letters per sheet. Letters were shown one by one, with the other letters covered over. The children were asked to give the name of each letter. The same procedure was repeated with lowercase letters. The results of the assessment revealed that the correlation between lowercase letter knowledge and uppercase letter knowledge was high, $r = .87$, $p < .01$, and the sum of these variables was computed as the score of letter knowledge, which was used for grouping children into three groups as described earlier.

Pseudoword List Reading. The pseudowords were chosen from the five most common Finnish ABC books used in the first grade on the basis of the frequency of the Finnish syllable structures in initial syllables. In this material, the six most common syllable structures ordered by frequency were CV, VC, CVV, CVC, CVVC and CVCC. Seven syllables (i.e., pseudowords) from each structure group (a total of 42 syllables) were chosen and written on a sheet of paper in uppercase letters. Pseudowords were shown one by one, beginning with the shortest words and covering the other pseudowords. Children were asked to read the pseudoword aloud "as well as they could." Assessments were terminated after three consecutive failures. The list of the pseudowords used in May 1997 is shown in Appendix A. During the first grade (January and May 1998), reading was assessed with the Finnish reading test, which includes 36 short bisyllabic words and 18 bisyllabic pseudowords (pseudowords are shown in Appendix A). During second grade in May, reading was assessed by age-normed word list reading and pseudoword list reading tests (see Appendix B). In first and second grade, reading was audiotaped for later measurement of reading accuracy and list reading speed. The time taken to complete the reading of all words and pseudowords was measured, and the total number of items read correctly was used in the analyses. All items read correctly in each test formed the accuracy measure.

Nonverbal Abilities. Raven's (1962) Colored Matrices were used to assess nonverbal IQ.

Phonological Processing. Phonological awareness was assessed using a single phoneme identification task, two phoneme deletion tasks, and one phoneme blending task. Each of these four different tasks contained 10 items (Dufva et al., 2001; Poskiparta et al., 1994). Before each task, a training set containing three items was presented. In the *single phoneme identification task,* the child was asked to say aloud the first phoneme of the word (e.g., saying /r/ when given the word *rapu*). If the child did not know the phoneme, he or she was asked to say the name of the first letter of the word. In the *phoneme deletion task,* the child was asked to delete the initial phoneme and to say aloud the remaining part, which formed a new word (e.g., saying /apu/ when given the word *rapu*). In the *syllable deletion task,* the examiner deleted one syllable of the word (in initial, medial, or final position), and the child was asked to say aloud the remaining part, which formed a new word. The *phoneme blending task* included two-, three-, and four-letter words that were presented phoneme by phoneme, and the child was asked to say aloud the resulting word (e.g., saying *iso* when given the sounds /i/, /s/, /o/).

Naming Tasks. Rapid naming tasks used were derived from the Rapid Automatized Naming task (Denckla & Rudel, 1974). In these tasks, the aim is to name as fast as possible separate series of common objects, colored squares, and digits displayed on a card in five rows, 50 items per card. The time used for completing each card was used as an index of naming speed.

Receptive Vocabulary. The Peabody Picture Vocabulary Test–Revised (PPVT-R; Dunn & Dunn, 1981; shortened 121-item Finnish version) was used to assess children's receptive vocabulary.

Auditory Reasoning. The Auditory Reasoning test from the Finnish version of the Illinois Test of Psycholinguistic Abilities (ITPA; Kuusinen & Blåfield, 1974) was selected to assess children's association processes when working from auditory concepts at preschool. Standard procedure was followed. The number of correct answers was taken as the child's score.

Phonological Short-Term Memory. At the end of preschool, short-term memory was assessed using the Digit Span subtest of the Wechsler Intelligence Scale for Children–Revised (WISC-R; Wechsler, 1974). In a pseudoword repetition test (from NEPSY; Korkman et al., 1997a, 1997b), the child was asked to repeat 16 pseudowords that were presented on audiotape. The number of correct repetitions amounted to the child's score (maximum 16 points). Phonologically plausible misarticulations and incorrect stress placements were not counted as errors.

Oral–Motor Coordination. In the Oral Dynamic Praxis test (from NEPSY; Korkman et al., 1997a, 1997b), the child was asked to repeat 14 sound sequences and tongue twisters such as /pataka/pataka/pataka/ eight times in a sequence presented at a rate of one sequence per second for Items 1 to 8, and one sequence per 2 seconds for Items 9 to 14. The number of correct sequences was counted for each item (maximum 8 points per item) at the end of preschool. The total raw score is the sum of all items.

Analogical Reasoning. From the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983), the Matrix Analogies subtest was selected for measuring analogical thinking using pictorial analogies.

Background Variables. Two questionnaires, one pre-established and the other compiled specifically for the purpose of this study, obtained information concerning the children's family and school background. The questionnaire for parents included reading practices at home during the child's pre-school year (Lyytinen, Laakso, & Poikkeus, 1998). The answers were classified into categories from 1 (*little practice*) to 5 (*much practice*). A composite measure termed *print exposure at home* was used in the analysis. It included the following variables: the amount of reading to the child, the amount of the child's self-reading, the amount of books at home, and the number of visits to the library. The questionnaire for children's teachers included questions of teaching practices in the classroom in the first school year. For every class relevant to this study, the teaching method for learning to read emphasized sound–letter correspondences, and the teaching rate was about one letter/sound per week during the first grade. The law in Finland regulates the amount of hours per week designated for teaching writing and reading. The questionnaire gathered information on the time allocated for other linguistic activities (e.g., rhyming, linguistic play, and self-reading) in the class. A composite time measure termed linguistic practices at school was used in the analysis.

Independent and Dependent Variables

Predictors. The measures of analytic and synthetic phonological awareness showed a high correlation ($r = .75$), which led us to use the combined variable. The composite score was transformed to a natural logarithm to make the distribution statistically acceptable. Naming speed measures (object, color, and digit naming) were also combined into a single composite score. The following preschool measures were used as predictors: nonverbal intelligence (Raven), receptive vocabulary (PPVT-R), auditory reasoning, analogical reasoning, short-term memory, phonological awareness, letter knowledge, naming speed, oral–motor coordination, and pseudoword repetition.

Reading Groups. Analyses were based on the categorization of participants according to the amount of instruction time needed to be able to decode pseudowords at 90% accuracy. Pseudoword decoding was chosen for the grouping criterion because it measures grapheme–phoneme decoding without involving lexical access processes that would have been more influenced by other verbal abilities. In a transparent language such as Finnish, children usually learn letter–sound correspondences very efficiently because they are simple and consistent one-to-one rules. Thus, most children learn to read both words and nonwords quite accurately soon after learning the required letter–sound rules. The teaching method supports this approach very efficiently by drilling each grapheme–phoneme/phoneme–grapheme pair sufficiently for most children to automate their application. This makes the chosen 90% criterion for pseudoword decoding quite feasible in the Finnish language. Four reading groups were derived according to the following criteria. The first group, termed *precocious decorders* (PD, $n = 18$), included children who already fulfilled the criterion at the end of preschool without any formal instruction. The second group of children, termed *early decoders* (ED, $n = 27$), could read correctly 90% of pseudowords by the end of first grade January, after 4 months of instruction. The third group, termed *ordinary decoders* (OD, $n = 25$), reached this criterion by the end of May in the first school year, after 9 months of instruction. In the fourth group, 12 pupils fulfilled the criterion by the end of the second school year (after 18 months of instruction at school), and 7 did not yet reach this level; these children were subsequently included in the fourth group, termed *late decoders* (LD, $n = 19$).

Results

Table 1 summarizes the assessment results for each group separately in the order in which the tests were presented to the participants. Multivariate analysis of variance (ANOVA) revealed significant differences between all groups (PD, ED, OD, and LD). To determine which pairs of groups differed, a multiple comparison post hoc test (LSD) was used. In addition to reading and associated measures (letter knowledge and phonological awareness), the means for the LD group also differed significantly from PD and ED on other verbal and nonverbal measures. Background measures and auditory reasoning scores failed to show any difference between the groups and were not taken into later analyses. As shown Table 1, there are a number of significant differences between the groups. The most interesting are those that differentiated the LD group from earlier decoders. The differences between other groups are mainly associated with phonological measures and letter knowledge. The most explicit single variable differentiating the LD group from other groups is pseudoword repetition. A less well known predictive measure is analogical reasoning, where LD differs from all other groups at a $p = .01$ level.

Correlation

The Pearson correlation matrix of the independent variables and the pseudoword reading measure is presented in Table 2. Of the linguistic measures, those closest to reading show the highest intercorrelation. The phonological measures, such as phonological awareness and pseudoword repetition, as well as letter knowledge are significantly connected to reading accuracy only, and measures such as naming speed correlate significantly with reading speed only.

Predictors of Reading Accuracy

A multinomial logistic regression analysis was carried out to find out which of the preschool measures—nonverbal intelligence (Raven), receptive vocabulary (PPVT-R), auditory reasoning, analogical reasoning, short-term memory, combined measure of phonological awareness, letter knowledge, combined measure of naming speed, oral–motor coordination, and pseudoword repetition—could explain, as sets of more than one single measure, differences between the decoding groups PD, ED, OD, and LD. Goodness of fit of the model and pseudo R-square index $\chi^2(27, N = 86) = 103.00, p = .000$, R^2 Nagelkerke = .75) showed that independent variables were significantly associated with the outcome, taking into account the number of simultaneous tests. To ascertain the single best predictor between the different reading groups, the following logistic regression analyses were executed. The four reading groups (PD, ED, OD, LD) were entered in pairs into the logistic regression analysis (in every comparison, the first group was coded as 0, and the second group as 1) as dependent variables. A backward stepwise method was used, and the preschool measures listed earlier were entered into the analyses at the same time as the predictors. The first two variables of the list (Raven and PPVT-R) were entered into the analysis first to control for general nonverbal and verbal ability. A significance level of .05 was used. Overall classification rate (%) is given in the statistics.

Comparisons with Late Decoders

The logistic regression analysis run between the OD and the LD groups with all preschool predictors revealed that

TABLE 1
Multiple Comparisons of Variables Between Reading Groups

Measure	PD group *M*	PD group *SD*	ED group *M*	ED group *SD*	OD group *M*	OD group *SD*	LD group *M*	LD group *SD*	*F*[k]
Age at start of study	6.79	0.31	6.92	0.31	6.96	0.32	6.82	0.24	
Time 1									
Nonverbal intelligence	22.83	4.88[n]	21.44	3.14	21.24	4.24	19.79	4.58	1.67
Letter knowledge[a]	17.17	2.33[lmn]	11.96	4.84[op]	8.64	5.12	8.74	4.81	15.12****
Nonword list reading[b]	27.60	4.41[lmn]	2.67	3.04	1.60	2.63	1.53	2.37	85.73****
Phonological awareness									
Composite[c]	27.30	7.65[lmn]	13.81	8.97[op]	7.16	6.43	6.47	6.28	23.52****
Letter identification[d]	9.44	1.46[lmn]	6.44	3.90[op]	3.72	3.39	3.58	3.86	13.10****
Sound deletion[d]	5.67	4.01[lmn]	1.44	3.11	0.56	1.83	0.26	0.56	16.52****
Sound blending[d]	7.22	2.37[lmn]	2.41	2.56[op]	0.92	1.19	0.95	1.72	40.83****
Syllable deletion[d]	4.94	2.58[lmn]	3.52	2.69[op]	1.96	1.93	1.68	1.57	8.81****
Naming speed[e]	170.33	29.40[m]	198.37	54.00[o]	232.91	46.90[q]	200.00	47.52	5.98****
Receptive vocabulary	86.28	12.01[mn]	82.30	9.01[o]	75.38	14.84	77.21	13.16	3.32**
Auditory reasoning[f]	16.61	7.45	16.70	8.23	12.92	6.64	14.84	7.51	1.33
Pseudoword repetition[g]	10.67	2.11[n]	9.63	2.29[p]	9.42	2.47[q]	7.84	2.75	4.38***
Short-term memory	8.22	2.10[lmn]	6.93	1.17[o]	5.88	2.07	5.89	1.97	7.21****
Oral–motor coordination[h]	76.56	13.69[mn]	68.33	16.38[o]	59.46	15.76	64.79	12.23	4.75***
Analogical reasoning[g]	11.11	2.47[n]	10.63	2.59[p]	10.16	2.19[q]	8.74	1.91	3.74***
Time 2									
Nonword list reading[i]	16.47	2.25[mn]	17.44	0.75[op]	10.32	4.36	8.76	4.87	35.41****
Time 3									
Nonword list reading[i]	17.33	0.84[n]	16.88	1.76[p]	17.00	0.76[q]	11.39	4.43	29.21****
Time 4									
Nonword list reading[j]	18.88	1.36[n]	18.73	1.19[p]	18.32	1.94[q]	15.89	3.25	9.08****
Nonword reading time[e]	33.35	12.30[mn]	33.62	11.87[op]	44.64	17.90	46.84	24.86	3.53**
Background measures									
Print exposure at home	46.61	9.17	45.87	8.84	49.48	6.22	49.86	8.22	0.90
Linguistic practices at school	229.41	50.50	260.77	60.61	240.00	56.12	230.00	60.44	1.47

Note. PD = precocious decoders, $n = 18$; ED = early decoders, $n = 25$; OD = ordinary decoders, $n = 27$; LD = late decoders, $n = 19$. Time 1 = preschool; Time 2 = Grade 1 January; Time 3 = Grade 1 May; Time 4 = Grade 2 May.
[a]maximum = 19. [b]maximum = 30. [c]maximum = 40. [d]maximum = 10. [e]computed, in seconds. [f]maximum = 32. [g]maximum = 16. [h]maximum = 112. [i]maximum = 18. [j]maximum = 20. [k]one-way ANOVA, *df* vary between 79 and 89. ANOVA post hoc (LSD) comparisons as follows: [l]PD/ED; [m]PD/OD; [n]PD/LD; [o]ED/OD; [p]ED/LD; [q]OD/LD.
$^{**}p < .01$. $^{***}p < .001$. $^{****}p < .0001$.

TABLE 2
Pearson Correlation Coefficients Among Variables for All Participants

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Raven	—																
2. PPVT-R	.33**	—															
3. STM	.29**	.49***	—														
4. OMC	.14	.39***	.57***	—													
5. ITPA	.28**	.43***	.42***	.39***	—												
6. RAN	–.20	–.24*	–.38***	–.33**	–.11	—											
7. AR	.30**	.25*	.23*	.28**	.11	–.13	—										
8. PWE	.24*	.46***	.51***	.48***	.28**	–.19	.18	—									
9. LK	.33**	.41***	.44***	.35**	.18	–.34**	.16	.24*	—								
10. PA	.29**	.37***	.48***	.50***	.35**	–.32**	.28**	.39***	.55***	—							
11. NWR1	.22*	.23*	.33**	.29**	.05	–.39***	.13	.28**	.60***	.61***	—						
12. NWR2	.24*	.32**	.42***	.33**	.28*	–.27*	.25*	.29**	.48***	.63***	.29**	—					
13. NWR3	.30**	.29**	.30**	.09	.22*	–.07	.24*	.51***	.26*	.34**	.22*	.45***	—				
14. NWR4	.24*	.16	.21	–.22*	.23*	–.04	.11	.34**	.16	.28*	.15	.33**	.57***	—			
15. NWRT4	–.02	–.13	–.26*	–.22*	–.08	.53***	–.06	–.06	–.09	–.24*	–.13	–.38**	.62***	–.19	—		
16. Print exposure	.08	.28**	.25*	.10	.33**	–.08	.08	.19	.19	.26*	.13	.12	.14	.28*	–.17	—	
17. Linguistic activities	–.01	–.18	.02	–.11	–.03	.06	.06	.02	–.10	–.07	–.11	.01	–.12	.12	–.12	.14	—

Note. 1. Raven = nonverbal intelligence; 2. PPVT-R = receptive vocabulary; 3. STM = short-term memory; 4. OMC = oral–motor coordination; 5. ITPA = auditory reasoning; 6. RAN = rapid naming speed; 7. AR = analogical reasoning; 8. PWR = pseudoword repetition; 9. LK = letter knowledge; 10. PA = phonological awareness; 11. NWR1 = nonword reading at preschool; 12. NWR2 = nonword reading at Grade 1 January; 13. NWR3 = nonword reading at Grade 1 May; 14. NWR4 = nonword reading at Grade 2 May; 15. NWRT4 = nonword reading time at Grade 2 May; 16. Print exposure at home; 17. Linguistic activities at school.
*$p < .05$. **$p < .01$. ***$p < .001$.

performance in *pseudoword repetition* significantly predicted the group difference with an accuracy of 80.5%, B = –.60, Wald = 6.45, p = .01. In this analysis, the phonological measures and letter knowledge showed no independent contribution in predicting reading. *Letter knowledge* was the only statistically significant predictor of the difference between the ED and LD groups, B = –.18, Wald = 4.09, p = .04, 73.3% predicted correctly, and in the PD/LD comparison, B = –.65, Wald = 6.45, p = .01, 77.8% correctly predicted.

The same preschool predictors, with the exception of the phonological awareness measures and letter knowledge, were taken into the next analysis to see if there were other significant predictors. In a highly orthographically regular language such as Finnish, the manipulation of phonemes in phonemic awareness tasks is heavily supported by mental manipulation allowed by orthographic knowledge. Similarly, letter knowledge is a direct precedent of the skill to assemble the letter sounds that each letter of the word represents. Analyses with measures other than phonological awareness revealed that in the OD/LD comparison, *analogical reasoning,* B = –.45, Wald = 4.32, p = .04, and *pseudoword repetition,* B = –.60, Wald = 6.45, p = .01, significantly discriminated the groups (80.5% correctly). In the ED/LD comparison, *letter knowledge* again independently discriminated the groups with an accuracy of 73.3%, B = –.18, Wald = 4.09, p = .04, and in the PD/LD comparison *letter knowledge,* B = –.95, Wald = 5.12, p = .02, and *analogical reasoning,* B = –.68, Wald = 4.03, p = .05, discriminated the groups with a combined accuracy of 91.7%. When letter knowledge and phonological awareness were excluded from the computation, the results of the OD/LD comparison remained the same, but in the ED/LD comparison *analogical reasoning,* B = –.35, Wald = 4.09, p = .04, significantly differentiated the groups with 62.2% overall accuracy. In the comparison between PD and LD, again *analogical reasoning* remained as a significant predictor, B = –.39, Wald = 3.84, p = .05, but now *short-term memory* added significantly to the differentiation, B = –.31, Wald = 4.41, p = .04, 77.8% accuracy). This indicated that in addition to limited letter knowledge, problems in working memory and visual reasoning ability might delay the acquisition of decoding skills.

Comparisons Among Other Reading Groups

Phonological awareness significantly differentiated the precocious decoders and the early decoders from ordinary decoders. For each of the comparisons, the results were as follows: PD/ED comparison, B = –3.33, Wald = 5.39, p = .02, 80% correct; PD/OD comparison, B = –6.88, Wald = 2.53, p = .006, 87.8 % correct; ED/OD comparison, B = –1.37, Wald = 5.58, p = .02, 68% correct. These results indicated that those children who succeeded well in phonological awareness measures had achieved reading skill very early on.

Analyses with measures other than phonological awareness revealed that a relatively accurate classification could also be found with other measures. In the PD/ED comparison, significant predictors were *pseudoword repetition,* B = –.53, Wald = 4.13, p = .04, and *letter knowledge,* B = –.55, Wald = 8.34, p = .04, predicting the difference between these groups with an accuracy of 84.4%. *Letter knowledge* also significantly predicted precocious decoding in the PD/OD comparison, B = –1.48, Wald = 5.08, p = .02, 90.2% correctly predicted. On the other hand, *naming speed* differentiated the ED and OD groups significantly, B = .32, Wald = 4.54, p = .03, with *oral–motor coordination,* B = –.06, Wald = 3.87, p = .05, 66.0% correctly predicted. When letter knowledge was not included in the model, *short-term memory* was the only significant predictor in the PD/ED comparison, B = –.53, Wald = 4.91, p = .03, 73.3% correctly predicted. In the comparisons where PD and ED were compared to OD, *naming speed* predicted the difference as follows: PD/OD, B = 1.11, Wald = 6.47, p = .01, 82.9% correctly predicted, and ED/OD, B = .32, Wald = 4.54, p = .03. Moreover, in the ED/OD comparison *oral–motor coordination* remained as a significant predictor, B = –.06, Wald = 3.87, p = .05, 66% correctly predicted.

Prediction of Reading Speed

The second research question concerned the prediction of reading speed as compared to the prediction of reading accuracy. Linear stepwise regression analysis was used to estimate which preschool measures best predicted the reading speed—the time taken to complete the reading of all pseudowords—at the end of the second grade. The following preschool measures were used as predictors: nonverbal intelligence and receptive vocabulary (entered at the first step), auditory reasoning, analogical reasoning, short-term memory, phonological awareness (phoneme awareness, phoneme deletion, phoneme blending, and syllable deletion), letter knowledge, naming speed (colors, objects, and digits), oral–motor coordination, and pseudoword repetition. Of the background variables, the print exposure at home and the linguistic activities at school were taken into the analysis. The results showed that *naming speed* at preschool age significantly predicted reading speed at the end of the second grade, β = .54, t = 5.29, p < .001, R^2 = .30. None of the other measures made any significant additional contribution. Neither did the general measures of cognitive skills (Raven) or language (PPVT-R).

Discussion

The present study attempted to ascertain whether preschool skills could predict the rate of acquisition of decoding skills in an ordinary synthetic phonics program of reading instruction. A number of predictor measures were shown to independently differentiate children who learned decoding skills at an expected rate from children who failed to do so (i.e., late decoders). The late decoders, who failed to learn to decode accurately before the end of the first semester of the second school year (when ordinary decoding instruction ends), scored significantly lower in pseudoword repetition at preschool age than the ordinary decoders, who had already acquired decoding skills 1 year earlier. The pseudoword repetition task requires several phonological processes, including accurate phonological representation in the perception phase, good phonological working memory to keep an odd word in mind, and the ability to keep phonological representations distinct for accurate co-articulation in production. It is also notable that no other phonological measure was able to add significantly to the discrimination between children in these two groups, most of whom had low phonological awareness at preschool.

Phonological awareness seems to play a significant role only in the discrimination of precocious and early readers from typical readers but not from those whose reading acquisition processes are still in a beginning stage. This finding challenges the value of phonological awareness measures as an early predictor of reading, because the association of phonological awareness with reading acquisition is only relevant during a few months and it predicts only a skill level that is quite easily acquired in a transparent language. In this study, of those children who had acquired phonological awareness, most were already able to read or became readers very quickly. However, phonological awareness failed to predict the earlier and later decoders among children acquiring decoding accuracy several months later. Other measures were better for a longer term prediction of late decoders. Consistent with the doubts about the utility of phonemic awareness as a sufficient predictor of reading in a language with a regular orthography even within a short time, we discovered relatively low phonological awareness scores in our data among early decoders who only 6 months later were accurate readers. This can be illustrated by the example of two boys from the same class. Both of these boys knew 17 out of 19 letters by name in the preschool assessment. The first child scored very poorly on all phonological awareness tasks (He had no items correct in sound blending, sound deletion, or syllable deletion tasks.) and failed to read any (even short) words. However, within 4 months of being at school he was able to read all pseudowords correctly in the reading task. The other boy had better phonological skills (He had 7 out of 10 items correct in sound blending, 1 out of 10 in sound deletion, and 4 out of 10 in syllable deletion tasks.), although he was unable to read in the preschool assessment. Still, it took him 2 school years to reach the level of decoding skills that about 75% of pupils reached within 1 year.

A very intensive time-series follow-up is required to uncover the order of different subskills of phonological awareness, which may, however, turn out to be complex, as demonstrated by Aro et al. (1999). A concrete example of the advantage the children in the PD group enjoyed through orthographic knowledge in phonological awareness tasks transpired when they were questioned as to how they solved the sound blending task. Many children reported that they "see the sounds like letters written in the air and read the word aloud." Moreover, precocious readers (and some typical readers) had good letter knowledge at the time the predictive measures were collected. Letter knowledge helps children in all phonological tasks in a transparent language, as has been shown with German children by Näslund and Schneider (1996).

Consequently, to avoid circular reasoning we computed the comparison models without phonological awareness and letter knowledge measures, which shed new light on the predictors of different decoding age. In an analysis without phonological measures, visual analogical reasoning had significant independent explanatory power to contrast late decoders with precocious and ordinary decoders. In a language where letter–sound correspondences are very close, good visual abilities may hasten or secure the learning process. Moreover, OD learned to read 1 and ED 1½ years earlier than LD apparently due to their better articulation skills as reflected in pseudoword repetition and oral–motor coordination. The two earliest achievers differed from each other significantly in letter knowledge. This difference shows that children whose letter knowledge is low—for instance because they have not been interested in written language before school entry—can be very accurate decoders in Finnish 6 months later. We should also note that this is not the only reason why early decoders had not learned to read spontaneously, as did precocious decoders. Specifically, lower pseudoword repetition skill also contributed toward keeping early decoders in need of formal reading instruction.

In the analyses without letter knowledge, working memory seemed to be a significant discriminator of spontaneous learners from later decoders. This finding indicates that good memory skills may be important for early, spontaneous discovery of the orthographic code. A good short-term memory score may also be a sign of a better attentive orientation that may contribute to literacy skill development. The next critical finding was the role of naming speed as a discriminator in PD/OD and ED/OD comparisons. It is noteworthy that in studies executed in the English language, naming dysfluency has been shown to be an important predictor of poor reading. In the present study, naming speed predicted the difference between children who had learned to read easily and children who required 1 school year to achieve accurate decoding ability but had no reading problems.

Naming speed measures may not be highly critical predictors of reading accuracy, but they might contribute substantially in predicting reading fluency. Our results support Wimmer's (1993) earlier findings with German-speaking children with reading disabilities at Grade 2 in two ways. First, they confirmed his findings that late decoders read pseudowords quite accurately but slowly. Second, our results were comparable with the results of Wimmer in that rapid naming speed was one of the most important predictors of reading speed differences at the age of 8. Because Finnish words are long and generally consist of a large number of syllables due to often numerous inflectional affixes, slow reading is also a general characteristic among Finnish adults with dyslexia (Leinonen et al., in press). If the fluency problem concerns letter naming, for instance, it is not difficult to assume that it has especially severe effects on the decoding of unfamiliar long Finnish words.

In summary, this study has demonstrated that early prediction of the duration of individual instruction time needed for accurate decoding is possible. This knowledge could be used in identifying children in need of early guidance in literacy. The results also support our contention that a number of different measures are required for predicting achievement in reading acquisition. It seems obvious that the kinds of measures used to assess phonological awareness in languages with deep orthographies do not function as long-term predictors of reading achievement in language with transparent orthographies, where the use of orthographic knowledge can easily help solve phonological awareness tasks and grapheme–phoneme rules can be learned rapidly. Phonological awareness measures seem to be especially poor predictors of at-risk reading development. None of the phonological measures contributed in prediction models involving the late decoders. We found, however, that phonological processing and language skills other than phonemic or syllabic awareness skills are relatively good predictors of late reading achievement. This result indicates that the assessments of and apparently also the interventions for children with potential problems in reading acquisition should be expanded to include a wider battery of functions than only phonological awareness–related functions. Even measures that represent a more general domain than language, such as visual analogical reasoning, may be important. The prediction of the time of instruction required for accurate reading seems to provide an informative way to identify functions that should be attended to when designing tools for the assessment and prevention of reading delays.

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APPENDIX A

Items in the Pseudoword Reading Tasks at Preschool and First Grade

Preschool			First grade	
1. II	2. OO	3. EE	1. VÄRÖ	2. AME
4. AA	5. UU	6. ÄÄ	3. HOPA	4. YPÖT
7. LA	8. MO	9. TI	5. ONUT	6. EHI
10. ES	11. UP	12. ÄK	7. IMAN	8. OLUS
13. HOO	14. JUU	15. MEE	9. KAJU	10. YSÖ
16. ÄÄN	17. AAR	18. IIK	11. VAMI	12. EVOT
19. PÖY	20. HIE	21. VUO	13. RYHE	14. EDÄ
22. AUK	23. ÄYS	24. UIT	15. UKES	16. PILO
25. KÄM	26. HET	27. LIP	17. ATU	18. OJUN
28. UNS	29. AMP	30. YRT		
31. HAAS	32. VIIL	33. SUUR		
34. KUOL	35. VÄIT	36. JOIS		
37. SULT	38. PONT	39. LINS		
40. VÄLK	41. HARP	42. JYRK		

APPENDIX B

Items in the Pseudoword Reading Task at Second Grade

1. EEMI	2. TAPURA	3. TIRKEMÄ	4. KEMPPA
5. VÄTJÖ	6. AUTTILO	7. KAPLA	8. MUNGOS
9. PAHDATA	10. NOIHKI	11. NELLEKKI	12. RÄNKYÄ
13. TASVANA	14. KÄLLÖ	15. UUNTIMA	16. HALLAS
17. PENKIJÄ	18. VOIKKI	19. TAPEKKAAT	20. LINTTI

Study 3

The Role of Reading by Analogy in First-grade Finnish Readers

by

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The Role of Reading by Analogy in First Grade Finnish Readers

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ABSTRACT *Computer-based assessment of the use of beginning and end analogies based on clue syllables of five different syllable structures was developed to examine the role of analogy in beginning reading of a orthographically regular language, Finnish. Forty-seven Grade 1 children with a mean age of 7.5 years participated in the study. Unlike English, the most clear-cut result is that for all the syllable structures the use of clue syllables produced no significant differences in reading speed and accuracy of the following same beginning or same end syllables. The findings also show that the benefit to the readers varied according to the size of the syllables. No benefit was found in two letter syllables but some benefit was observed in three and four letter syllables for reading accuracy. Vowels and consonants have no clear effect on the use of analogy, probably in part because in Finnish all letters are sounded irrespective of their placement in a syllable. It is argued that the improvement from pre-test to test is due to phonological and orthographic similarities between the shared condition and clue syllables at the phoneme/letter level. Reading is based on single phoneme/letter analogies instead of the effect found in English where children benefit significantly from analogy based on larger units.*

Keywords: *analogy, beginning reading, interactive analogy model, reading by analogy*

INTRODUCTION

Analogy is a powerful cognitive mechanism used by people to make inferences and to learn new abstractions. It is a process of understanding a novel situation in terms of one that is already familiar (Gentner & Holyoak, 1997). Analogies in reading refer to the use of the spelling–sound pattern of one familiar word, for example *light*, as a basis for decoding a new word, for example *fight* (Goswami & Bryant, 1990). This similarity in spelling allows for the inference that the pronunciation of the two words may also be analogous. The systematic relationship between letters and sounds forms the basis for analogical prediction.

However, there are inconsistencies in the empirical research regarding the use of analogy in the reading of English. It is especially interesting to observe these

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findings with respect to the transparency of a language, as Scandinavian languages are more transparent than English and in Finnish the grapheme–sound correspondence is almost perfect, as described later in text. The main sources of concern have dealt with three issues: firstly, at what age and reading level learning based on analogy is used in reading; secondly, to which type of spelling segment a reader successfully applies analogy; thirdly, to what extent the possible benefits resulting from analogical learning in reading are affected by or based on phonological priming, not merely on the use of orthographic similarities. It has been proposed (Marsh *et al.*, 1977, 1980) that readers could best use analogical processes in the late stages of reading development (e.g. from 16 years of age onwards). However, Baron (1977) has shown in his study that even 5-year-old English kindergarten children in the beginning stages of reading are able to spontaneously use analogies based on a speech unit. Furthermore, Goswami (1986, 1988) observed that reading words by analogy appeared before beginning readers could phonologically decode words. On the other hand, Muter *et al.* (1994) used the clue word task and found the analogy effect only in readers. It has also been suggested that the process of learning associations based on analogy is tied to a growth in reading vocabulary, which is also correlated with age (Wimmer & Goswami, 1994).

The second question concerns the segments on which the analogies that the reader learns are based. It is apparently closely tied in with the age/grade issue. As vowels in the English language are always part of rhymes (i.e. words that start differently but end the same; Bowey, 1991) or rimes (i.e. used in linguistics, meaning the end vowel and following consonants, called *end* in this study), Goswami (1993) tested the transfer of vowel graphemes and found that beginning readers initially code vowels in the context of the grapheme cluster representing the entire rime, but older children also showed the transfer of vowel digraphs (e.g. beak/heap). A study by Ehri & Robbins (1992) investigated the ability of kindergarten children (divided into non-decoders and decoders) to benefit from analogous relations. The decoders used phonemic decoding and analogy to read novel non-words and the most common miss-readings occurred with medial and long vowels. Bruck & Treiman (1992) showed that 6-year-old children who were explicitly shown that the rime of the new word had the same sound and spelling as the rime of the known word required fewer learning trials than children who were shown that the vowel or the initial consonant (C) + vowel (V) of each new word was the same as in the known word. However, the children in the rime group succeeded less well in generalizing the training to non-words than the children in the other groups. These results have led Bruck and Treiman to conclude that children need information between single graphemes and single phonemes in order to read and that instruction in the relationship between groups of graphemes (such as rimes) and phonemes may not be enough.

Thirdly, the extent to which beginning readers spontaneously use orthographic analogy has been discussed and it has been claimed that orthographic analogy in young children is partly due to a phonological priming effect (Bowey *et al.*, 1998). Goswami (1999) has shown that, due to phonological priming, rhyming pronunciation of the clue word may help towards accurate reading of a test word, even when analogy based on a shared spelling pattern is inappropriate (e.g. head/said). A study by Bowey *et al.* (1998) investigated the beginning reader's use of beginning, vowel and orthographic rime analogies in Grade 1 and 2 readers. The study also included tests of phonologically primed words (rime) and control words with no letters in common with the clue words. The results (of their experiment 1) revealed a greater improvement in reading phonologically primed words than control words. When all phonological priming and re-testing effects were controlled (in experiment 2), the analogy effect was no stronger for end-same, beginning-same or middle-same words. Based on these results they stated that Grade 1 children might not be able to use orthographic rimes independently. Strong phonological priming was also observed with grade 2 readers, but greater between-session improvement was seen for words sharing an orthographic rime sequence than words that primed the clue word phonologically but not orthographically. The results of a study by Muter *et al.* (1994) revealed that children analogize more effectively if they have an opportunity to refer back to the clue word than if the clue word is not present when reading new words. Moreover, in a study by Goswami (1990) a degree of phonological priming of rimes was involved in the rime analogy effect in the clue word task. However, as Goswami *et al.* (1998) have pointed out, it is more important to find out whether the full strength of the use of analogy in reading can be explained by phonological priming.

It seems apparent that the weight of analogical reading in a given language depends on its orthographic nature (Goswami, 1995; Sprenger-Charolles *et al.*, 1998). Research has shown that orthographic redundancy in written English is lowest for the onset–rime (onset means the initial consonant group, called *beginning* in this study) juncture, making this the most useful level at which to parse English orthography (Treiman *et al.*, 1995). Wylie & Durrell (1970) have documented that knowledge of just 37 rimes enables the child to read 500 of the most frequently occurring words in primary grade texts. Hence, onsets and rimes are very useful units for young readers of English.

On the other hand, in regular orthographies, rime units would not be expected to confer a particular advantage to beginning readers. Early analogies in these orthographies may depend on phonemes (Goswami, 1995; Goswami *et al.*, 1998). What would happen if the grapheme to phoneme translation rules were consistent and almost or fully sufficient for assembling written units as speech without any need to learn exceptions? It may be that children learning to read orthographically regular languages continue to apply alphabetic mechanisms for a longer period and rely on simple association learning only or may apply analogical mechanisms based on strings of more than one letter unit later. At least, this may happen later than among children learning to read languages with deeper orthographies, where the underlying rules governing translation of the written to the spoken language are less consistent, and it is more complex to operate at the different phonological levels at which the rules must be applied. Thus, it may initially be more adaptive to learn spelling patterns for individual words and to use various strategies such as analogy to read new words (Wimmer & Goswami, 1994). In a study conducted by Goswami *et al.* (1998) analogical reading development of English, French and Spanish children was assessed. The results showed that pseudo-words, sharing both phonology and orthography with real words, were better read than pseudo-words that shared neither phonology nor orthography. However, the difference between these two types of pseudo-words was less salient in the performance of Spanish children than in the French and English children. This means that Spanish children relied on orthographic and phonological similarities at the rime level to a lesser extent than did French and English children. Wimmer & Goswami (1994) and Wimmer *et al.* (1994) have suggested that such graphemic units as onsets and rimes may also emerge later in reading development of orthographically regular language such as German. They investigated the relationship between onset and rime sensitivity and reading development in German and found that the onset–rime measures were only weakly predictive of early reading development in German, but become predictive later on in the reading process at around 9–10 years of age. These authors concluded that continued reliance on assembled pronunciations would not allow German children to become fast readers and accurate spellers, whereas the establishment of larger than one letter recognition units for written words would (Wimmer & Hummer, 1990; Wimmer, 1993, 1996). Concerning accuracy, however, the more transparent the writing system, the more strongly beginning readers rely on phonological processing (Sebastian-Gallés & Vacchiano, 1995; Sprenger-Charolles *et al.*, 1998).

In addition, the consistency of the orthography could have an indirect effect on reading development via the teaching of reading (Wimmer & Goswami, 1994). The high orthographic regularity and synthetic structure of the Finnish language provides a good opportunity to apply a synthetic method to the teaching of beginning reading by using phonemes and their corresponding signs (letters) by putting the emphasis of learning on phonemic level associations. In Finnish all letters, including vowels, are sounded irrespective of their placement in a word and the same letter always indicates each phoneme. Letters are not used only as markers, as is the case with English orthography. In spoken Finnish, as in English, rhymes are important units, but the orthographic transparency of the Finnish language raises a question as to whether ends (rimes) or beginnings (onsets) can have any advantage in comparison with single letter/phoneme units because their separate learning is not necessary; all larger units can be assembled from the phoneme/letter size units without difficulty in Finnish. School entry in Finland occurs in the year the child reaches the age of seven. The method of teaching reading includes letter recognition, listening and sounding out and even practising sounding in front of the mirror. At the beginning of teaching one letter–sound correspondence is taught per week, with the result that it takes six months to progress through all 21 Finnish letters. As soon as the pupils know a few letters and sounds, letters are combined to form CV/VC syllables and CV/VC-CV/VC words. The only larger units that are taught after single phonemes/letters are long vowels (such as double vowels, e.g. aa) and double consonants (Korkeamäki & Dreher, 1993). Because Finnish is an agglutinative language and words generally consist of relatively large number of syllables, in ABC books words are divided into syllables with a hyphen. The important role of syllables in learning to read and the minimal number of monosyllabic words (about 50) in Finnish led us to carry out this study using syllables as spelling segments.

As Sebastian-Gallés & Vacchiano (1995) have stated, the most challenging problem in studying analogy in beginning reading comes from the fact that young children may not show any effect of analogical reading either because they do not use this kind of strategy or because they know too few words from which to produce analogies. Due to differences in orthographies, the experimental model of Goswami (1993) had to be modified. Goswami's (1993) interactive analogy model of reading suggests that even the earliest recognition units that the child establishes have phonological coding and that this coding is made at the onset–rime level. As knowledge about reading and phonology develops, the child can make finer comparisons between the spelling patterns and sounds of different words in English. Because Finnish children learn to read very fast in comparison with English children, in our study, instead of using monosyllabic words as targets, we used syllables to enable the use of semantic cues. In addition to the role of onset–rime units, there were between one and three letters in common with the target syllables in order to find out if phoneme–grapheme level analogies were also used. The computer was used for measuring the reading speed properly.

Based on the reviewed evidence of the role of analogy in reading, the following research questions were set in this study. (i) Do Finnish beginning readers read syllables more accurately in clue syllable situations (containing a visible and spoken clue sharing an element with the to-be-read syllable) than without clue syllables? Our hypothesis is that they do not, because larger units do not provide a clear advantage to an early reader, especially when he/she is taught to read by phoneme decoding. (ii) Does the reading accuracy or reading speed change due to the cued recognition units (beginning, end) compared with control syllables? We expect no difference, because single letters/phonemes lead straight to accurate and fast reading at the beginning stage of reading acquisition. (iii) Does the size of the syllable structure and the size of the spelling segment affect the accuracy or speed of reading in a cued situation compared with a control one? Although in English three primed letters with the clue syllable might speed up or help reading, our hypothesis is that in Finnish the size of the syllable structure does not have an effect on the accuracy or speed.

METHOD

Subjects

Ninety-one Grade 1 pupils from nine schools in the town of Jyväskylä (approximately 80,000 inhabitants) were selected for assessment of reading development (see Holopainen *et al.*, 2000). From those children, 47 (20 girls and 27 boys) were randomly selected for this study. The mean age of the children at the beginning of this study was 7.5 years. All had average or above average cognitive functioning (at or above the fiftieth percentile point on Raven's Coloured Matrices; Raven, 1962).

Materials

The syllables used in this study were chosen from the contents of five Finnish ABC books on the grounds of the syllable structure in initial and final syllables of the most common bisyllabic words. These structures were: CV (consonant + vowel), VC (vowel + consonant), CVV (consonant + long vowel or consonant + diphthong), CVC (consonant + vowel + consonant), CVVC (consonant + long vowel + consonant or consonant + diphthong + consonant) and CVCC (consonant + vowel + consonant + consonant). For these five syllable structures 30–60 of the most common syllables were chosen and 14 Finnish letters (a, i, u, s, n, e, o, l, r, m, t, ä, p and k) were used. Following Goswami's (1986, 1993) test procedure, there were clue syllables, test syllables and control syllables. In the CV structure the test syllables shared one letter, beginning (C) or end (V), with the clue syllables. In the CVV structure the same two beginning letters were CV and the same end letters were VV. In the CVC structure the two same beginning letters were also CV, but the same end letters were VC. In the CVCC structure the same beginning was CV and the same end was CC. In the CVVC structure the same beginning letters were CVV and the same end letters were VVC. In no structure did the control syllables share letters with the clue syllables. All items were programmed in a computer-based (Cognitive Workshop v.1.11) test and the reaction time (ms) for starting to read and the reading time (ms) of the items read were saved.

Procedure

All pre-tests and analogy tests were presented to the children at school in a separate room. The first author of this article carried out all pre-tests and tests. CV structure was tested at the end of October 1997, CVV structure in November, CVC structure in December and the CVCC and CVVC structures at the beginning of January 1998. All items used are presented in the Appendix.

In the pre-test situation all syllables to be shown in the test later on that same day were shown in randomized order on a 15 inch computer screen one at a time as capital letters (usually children learn some capital letters at pre-school) in Helvetica font at a size of 72 point (at a distance of approximately 50 cm in front of the reader) and the child was asked to read the syllable as soon as he saw it. If the child could not read half of the syllables the experiment was to be discontinued, but none failed to reach this criterion. If the child could not read all clue syllables, they were taught to the child. After teaching, the syllables were presented on the computer screen in random order between other, untrained syllables, to be sure that the child could read these trained clue syllables. The pre-test situation lasted from 20 to 60 minutes, depending on the child's reading level.

After a break (1–2 hours) the test was carried out. In the test situation the clue syllable was read aloud to the child. She/he was then told that this clue syllable would remain at the top of the screen (where it was shown as 32 point capital letters) and that this could help them read the other syllables (i.e. same beginning, same end and control syllables). The child was also told that the new syllable would appear in the middle of the screen (printed as 72 point capital letters). The child was told to read aloud the new syllable, as soon as he knew what it was. This procedure was repeated after each new clue syllable. Beginning, end and control syllables were presented in randomized order. The test situation lasted from 15 to 30 minutes.

RESULTS

The mean numbers of syllables read correctly in the pre-test and test situations are presented in Table I. Inspection of Table I shows that in both the pre-test and test children read even four letter syllables surprisingly accurately and this almost ceiling effect must be kept in mind in interpreting the results for reading accuracy. However, some interesting changes in reading accuracy from the pre-test to test situations for different syllable structures can be seen.

We also wanted to investigate the role of reading speed in reading by analogy. Table II shows computed measures of reading speed (reaction time and reading time, in seconds) of beginning, end and control syllables read accurately in different syllable structures.

The Reading Accuracy Analysis

The accuracy results were analyzed using a 2 × 3 × 5 (test: pre-test, test × shared condition: beginning, end, control × syllable structure: CV, CVV, CVC, CVCC, CVVC) repeated measures of multivariate analysis of variance (MANOVA, Pillai's Trace). It was important to include the test effect in all analyses to control for pre-test differences in knowledge of the different syllable types. The main result showed a significant three-way interaction between test × shared condition × syllable structure [$F(8,39) = 4.82$, $P < 0.001$]. This result indicated that the difference between pre-test and test was dependent on the shared conditions and syllable structures, and the next three analyses were executed to further examine these relationships.

Three 2 × 2 × 5 (test: pretest, test × shared condition: pair-wise comparisons with beginning, end, control × syllable structure: CV, CVV, CVC, CVCC, CVVC) repeated measures of MANOVA were executed. Significant three-way interactions were found between test, shared condition (beginning versus control) and syllable structure [$F(4,43) = 6.76$, $P < 0.001$] and between test, shared condition (end versus control) and syllable structure [$F(4,43) = 6.96$, $P < 0.001$]. In the third analysis (with pair-wise comparison of beginning versus end) only significant two-way interactions between test and syllable structure [$F(1,46) = 2.90$, $P < 0.05$] and shared condition and syllable structure [$F(1,46) = 2.77$, $P < 0.05$] were found. These results indicated that the transfer seen from pre-test to analogous test was due to the difference in beginning and end conditions compared to control syllables, but not compared to each other, and that there were transfer differences for the different syllable structure types. Based on these results, the means of the beginning and end conditions were computed as one analogy measure and 2 × 2 ANOVAs (test versus

TABLE I. Mean number of syllables read correctly in the pre-tests and in the two conditions shared with the clue syllables and control syllables in the tests

	Shared condition = beginning		Shared condition = end		No shared condition (control)	
Syllable structures	Pre-test (no clue)	Test	Pre-test (no clue)	Test	Pre-test (no clue)	Test
CV (9)[a]	8.60 (1.04)	8.85 (0.36)	8.47 (1.08)	8.89 (0.48)	8.53 (1.04)	8.83 (0.43)
CVV (9)	8.64 (0.74)	8.91 (0.28)	8.38 (1.29)	8.70 (0.69)	8.66 (0.81)	8.11 (0.56)
CVC (9)	8.91 (0.35)	8.74 (0.64)	8.87 (0.34)	8.72 (0.71)	8.91 (0.35)	8.60 (0.77)
CVCC (9)	8.62 (0.68)	8.77 (0.63)	8.57 (0.62)	8.87 (0.45)	8.57 (0.68)	8.55 (0.83)
CVVC (12)	11.60 (0.88)	11.91 (0.42)	11.43 (0.88)	11.85 (0.35)	11.45 (0.90)	11.70 (0.66)

Standard deviations are in parentheses.
[a] Maximum score.

TABLE II. Mean reading speed (seconds) of syllables read correctly in two shared conditions and in control situation in the pre-tests and tests

	Shared condition = beginning		Shared condition = end		No shared condition (control)	
Syllable structures	Pre-test (no clue)	Test	Pre-test (no clue)	Test	Pre-test (no clue)	Test
CV	21.0 (9.1)	24.6 (10.4)	21.6 (9.5)	25.3 (9.9)	20.0 (7.2)	23.6 (10.0)
CVV	26.6 (9.9)	29.9 (13.2)	25.1 (8.7)	28.1 (11.9)	26.7 (10.8)	31.9 (13.5)
CVC	20.2 (8.6)	21.6 (8.9)	20.1 (9.1)	20.2 (8.5)	19.5 (7.7)	21.3 (9.8)
CVCC	24.9 (11.4)	25.1 (12.3)	25.0 (11.7)	25.1 (12.0)	24.4 (10.5)	25.6 (13.1)
CVVC	23.4 (10.9)	22.9 (9.3)	23.6 (9.7)	22.6 (9.4)	24.5 (9.9)	24.5 (10.3)

Standard deviations are in parentheses.

pre-test × analogy versus control) with repeated measures was conducted separately for each syllable structure.

CV structure, one of two letters shared (beginning = C, end = V). Only a statistically significant main effect of test [$F(1,46) = 5.05$, $P < 0.05$] but no interaction was found, indicating no difference between the reading accuracy of analogous and control syllables.

CVV structure, two of three letters shared (beginning = CV, end = VV). The analysis of variance showed a significant interaction between test and analogy [$F(1,47) = 33.71$, $P < 0.001$]. The significant interaction arose because of an improvement for analogous syllables in the test situation compared with the control syllables. In contrast, the clue syllables impaired the reading accuracy of control syllables.

CVC structure, two of three letters shared (beginning = CV, end = VC). The analysis of variance showed a significant interaction between test and analogy [$F(1,47) = 4.77$, $P < 0.05$]. However, the finding that the reading accuracy of both the analogous and control syllables was decreased in the test situation and that the reading accuracy of control syllables decreased significantly more than analogous syllables complicated the results.

CVCC structure, two of four letters shared (beginning = CV, end = CC). This analysis showed a significant interaction between test and analogy [$F(1,47) = 5.64$, $P < 0.05$]. The results look surprisingly different compared to the CVC structure, although the number of shared letters was the same, only the number of letters in the syllable differing.

CVVC structure, three of four letters shared (beginning = CVV, end = VVC). Only a statistically significant main effect of test [$F(1,46) = 5.35$, $P < 0.05$) but no interaction was found, indicating no difference between the reading accuracy of analogous and control syllables.

The Reading Speed Analysis

In order to determine whether the differences in performance with respect to reading accuracy of analogous and control syllables in the pre-test and analogy test were reflected in reading speed, a 2 × 3 × 5 [test: pre-test, analogy test × Analogy (the means of beginning and end conditions) × syllable structure: CV, CVV, CVC, CVCC, CVVC] repeated measures of MANOVA was carried out. The main results showed statistically significant two-way interactions between test × analogy [$F(1,46) = 6.46$, $P < 0.05$] and between analogy × syllable structure [$F(4,43) = 7.20$, $P < 0.001$]. Re-analysing the results with 2 × 2 repeated measures ANOVAs (test versus pre-test × analogy versus control) separately for each five syllable structure, no significant test × analogy interaction was found. This indicated that the small difference seen in reading accuracy between the analogous and control syllables for different syllable structures was not seen for reading speed.

Because there could be no ceiling effect of syllable structure in the reading speed measures, the null results for reading speed strengthened our conclusion that young Finnish readers do not use units greater than the grapheme in reading.

DISCUSSION

The central question addressed in this study was whether and to what extent (if at all) the use of a strategy implying analogical reading emerges in Finnish beginning readers. Analogous reading would have been demonstrated if words that are analogous with the clue words had been read more accurately or faster than control words that do not share anything in common with the clue words presented (see for example Goswami, 1986, 1990, 1993; Ehri and Robbins, 1992). Although we expected a potentially null result, contrary to our expectations a small positive but ambiguous effect on reading accuracy of some syllables that shared parts of the clue syllables was seen. This transfer cannot solely be explained as a function of syllable structure or the number of shared graphemes. Also, the representation of vowel and consonant sounds seems to play some role in the transfer, making the results quite complex. However, the straight benefit for single consonants or onsets found in English (Goswami, 1990; Duncan *et al.*, 1997) was not observed. Instead, interesting issues in our results are the impact of the orthography and the way of teaching reading.

Although the ceiling effect in reading accuracy in some pre-tests left little room for improvement by analogy, we think that together with the reading speed results we could show that different units are important in beginning reading in Finnish than in English. The most clear-cut hypothesized result throughout the syllable structures was that the two shared conditions beginning (onset) and end (rime) did not significantly differ in accuracy or in reading speed from each other. This lack of difference is even more interesting as from test to test the structure of syllables changed and the degree of phonemic overlap increased, from a single shared grapheme to three shared graphemes, and because this difference could not be seen in reading speed. This implies that in a transparent orthography like Finnish, the single letters/phonemes are more important to reading accuracy at the beginning stage of reading acquisition than larger segments, such as rimes or onsets. We were aware of the possibility of a ceiling effect when using syllables and, as a separate part of our study (not reported here), we looked at reading by analogy with two syllable pseudo-words. Those results confirmed our view of high reading accuracy of Finnish beginning readers and the use of single grapheme/phoneme correspondence in reading.

Goswami (1993) showed that the more reading developed, the more refined analysis of the relationship between orthography and phonology the child acquired from a number of different sources. In Finnish the phoneme level is reached soon after the beginning of reading instruction, which explicitly focusses the child's attention on this smallest unit from the very beginning. The significantly more accurate reading of shared condition syllables than control syllables in the test situation (compared to pre-test) for the CVV and CVCC structures showed that some transfer might take place in reading. At the same time, the lack of a significant difference for the CV and CVVC structures requires consideration. The test sessions consistently followed the pre-tests on the same day, such that in the test situation, and especially for easy and short syllables, children might have remembered items, which could explain the slightly higher means but the lack of a difference between clued and control syllables in the test. Compared with the CVCC structure, the observed improvement from pre-test to test in shared condition syllables in the CVVC structure failed to reach statistical significance. Nonetheless, the drop in reading accuracy of both shared condition and control syllables in the CVC structure and of control syllables in the CVV structure from pre-test to test indicated that any benefit gained from the use of clue syllables was not clear.

Another, but not so clear-cut, result was that the quality of the shared spelling unit affects the transfer, but not in the same way as in studies of the English language (Bruck *et al.*, 1992; Ehri *et al.*, 1992; Duncan *et al.*, 1997). In our study the significant differences between analogous and control syllables emerged only in situations where two letters were in common with the clue syllable. This was seen especially for the CVV and CVCC structures where the common letters with the clue syllables were CV in the beginning and VV or CC in the end positions. On the other hand, in the first structure, where the analogy was based on the single shared grapheme (C/V), no significant difference between the shared condition and control syllables was discovered. This could imply that the larger the shared unit (whether a consonant or vowel), the more the clue syllable helps with reading. Thus, there seemed to be a lot of variance in the role of vowels and consonants, probably due to fact that all letters, including vowels, are sounded irrespective of their placement in a word.

In conclusion, reading by analogy is difficult to observe in a transparent language where one can read every word by decoding it grapheme by grapheme. Children in our study had reached very high reading accuracy of syllables by phoneme decoding within six months after initiation of formal instruction (as do over 60% of Finnish children). They apparently had little or no use for an analogy strategy in accurate reading (on which they learn to concentrate in phonics instruction). This means that their attention is not easily transferable from phonemes to larger unit sizes, even if these are very explicitly provided as models in the clue situation. In fluent reading readers are, however, likely to use several levels of analogy processing and have the capacity to use larger segments in reading, as in regular writing systems, but beginning–end analogies seem not to be relevant. We must, however, bear in mind the proximity of the ceiling effect, limiting the accuracy of the results of this study. If a real benefit of analogy had been found, it would certainly have been seen in reading speed. Future research in reading by analogy in Finnish should focus on later stages of reading, where morphological structures are examined. The Finnish language contains large numbers of endings and sequences of endings to which the child is naturally exposed more frequently than to other letter strings. The common occurrence of these units makes them likely candidates for analogous recognition and as spelling units in fluent reading and writing.

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APPENDIX. THE CV, CVV, CVC, CVCC AND CVVC STRUCTURES

TABLE A I. CV structure (examples of pronunciation are in parentheses)

Clue syllables	Shared condition = beginning	Shared condition = end	No shared condition (control)
SA (sa)	SE (se)	MA (ma)	LO (lo)
	SU	NA	MI
	SO	RA	RE
KE	KU	TE	LA
	KÄ	PE	PI
	KI	LE	TO
PU	PÄ	KU	KI
	PE	TU	TO
	PO	NU	NA

TABLE A II. CVV structure (examples of pronunciation are in parentheses)

Clue syllables	Shared condition = beginning	Shared condition = end	No shared condition (control)
LEI	LEU (leu)	REI (rei)	KAU (kau)
	LEO	NEI	MUO
	LEA	MEI	ROU
KAU	KAI	TAU	LEI
	KAE	SAU	NOI
	KAO	PAU	RIE
TUI	TUE	PUI	SIO
	TUO	SUI	REO
	TUA	KUI	MOE

TABLE A III. CVC structure (examples of pronunciation are in parentheses)

Clue syllables	Shared condition = beginning	Shared condition = end	No shared condition (control)
SET	SEP (sep)	RET (ret)	KAP (kap)
	SEK	NET	NIR
	SEL	LET	LAN
KIR	KIL	TIR	PAT
	KIN	PIR	LOS
	KIS	SIR	MUL
TUN	TUS	KUN	MEL
	TUM	PUN	RIS
	TUL	MUN	SOR

TABLE A IV. CVCC structure (examples of pronunciation are in parentheses)

Clue syllables	Shared condition = beginning	Shared condition = end	No shared condition (control)
SILK	SINT (sint)	RILK (rilk)	NART (nart)
	SIRP	NILK	PUNT
	SIMP	MILK	MOMP
TARK	TAMP	LIRK	KILP
	TANS	KERK	PUNS
	TALT	PURK	ROMP
TONT	TORK	MINT	PALT
	TOLP	KANT	SILK
	TOLK	PUNT	MURK

TABLE A V. CVVC structure (examples of pronunciation are in parentheses)

Clue syllables	Shared condition = beginning	Shared condition = end	No shared condition (control)
MUIS	MUIN (muin)	SUIS (suis)	KOAT (koat)
	MUIR	NUIS	PAEN
	MUIL	LUIS	LEOR
PEIK	PEIS	KEIK	SAUT
	PEIT	TEIK	MUOS
	PEIM	NEIK	ROUT
SEEN	SEER	REEN	LIIR
	SEEM	LEEN	PAAK
	SEEL	MEEN	MUUR
TAAN	TAAK	KAAN	REEL
	TAAS	PAAN	SUUK
	TAAT	LAAN	KOOS