Kindergarten-age Cognitive Skills as Predictors of Reading Comprehension Assessed by PISA Reading

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Suomalaisten tyttöjen ja poikien välinen ero lukutaitoa mittaavassa PISA-testissä on kansainvälisesti yksi suurimmista. Tämän tutkimuksen tarkoituksena oli tarkastella, ilmenikö päiväkoti-ikäisten lasten kognitiivisissa taidoissa sukupuolieroja sekä sitä, kuinka paljon taidot ja sukupuoli olivat yhteydessä suoriutumiseen PISA-testissä. Lisäksi tarkoituksena oli selvittää, ennustivatko kognitiiviset taidot samalla tavalla sekä tyttöjen että poikien suoriutumista.

Tutkimuksen aineisto on osa Alkuportaat-seurantatutkimusta, jossa vuonna 2000 syntyneitä lapsia neljältä eri paikkakunnalta on seurattu vuodesta 2006 alkaen. Esikouluvuoden aikaisiin testeihin osallistui 1839 lasta. Heidän taitojaan arvioitiin fonologisessa tietoisuudessa, nopeassa nimeämisessä, kirjaintuntemuksessa ja sanavaraston laajuudessa. Yhdeksännellä luokalla heistä 1015 osallistui PISA-testiin. Aineiston analyysissä käytettiin kahden riippumattoman otoksen t-testiä, Pearsonin korrelaatiokerrointa ja hierarkkista lineaarista regressioanalyysiä.

Tulokset osoittivat, että tyttöjen fonologinen tietoisuus ja kirjaintuntemus olivat merkitsevästi paremmat ja että he odotetusti menestyivät poikia paremmin PISA-testissä. Kaikki kognitiiviset taidot olivat yhteydessä suoriutumiseen PISA-testissä, ja yhdessä sukupuolen kanssa ne selittivät siitä 19,7 %. Sekä tyttöjen että poikien menestystä ennustivat nopea nimeäminen ja sanavaraston laajuus. Sen sijaan kirjaintuntemus osoittautui merkitsevästi ennustavaksi vain pojille. Tutkimus osoitti, että yhdeksännen luokan lukutaitoa voidaan ennustaa jo esikouluvuoden kognitiivisten taitojen perusteella.

Asiasanat: luetun ymmärtäminen, kognitiiviset taidot, PISA, sukupuoliero

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1 INTRODUCTION

To become a competent citizen of the society and to be able to participate in it, one needs to learn to read and comprehend different types of texts. The ability to read is complex and involves several cognitive skills and advanced processes. Additionally, reading comprehension requires that, first, one is capable of to decode —that is, to match letters to their sounds— in order to acquire the correspondence between the written and the spoken language, and, second, one needs to have general language skills (Gough & Tunmer, 1986; Hoover & Gough, 1990; Florit & Cane 2011; Kirby & Savage, 2008). Many Finnish adolescents struggle with their reading (e.g., Kairaluoma, Torppa, Westerholm, Ahonen & Aro, 2013) which emphasizes the importance of early identification of children at risk to develop difficulties in their reading achievement. Identification and knowledge of possible difficulties can help in targeting early individual support for children in need and in the development of teaching practices.

The PISA (The Programme for International Student Assessment launched by the Organisation for Economic Co-operation and Development, OECD) Reading test is an international assessment of 15-year-old students near the end of compulsory education. The status of PISA and its influence on educational policymaking are widely accepted and the success of Finnish students has increased Finnish education export. However, research concerning the cognitive basis of PISA Reading is scarce. Yet, predicting later reading skills is possible already in kindergarten-age (e.g., Torppa, Lyytinen, Erskine, Eklund & Lyytinen, 2010; Lyytinen et al., 2004; Gallagher, Frith & Snowling, 2000; Scarborough, 1990). Therefore, it is just to aim to identify and examine possible linkages between children's cognitive skills and their performance in PISA Reading. Furthermore, Finland belongs to the countries in which the gender gap in reading comprehension is one of the largest (OECD 2016; Brozo et al., 2014). It indicates that some Finnish boys have significantly poorer reading skills than a certain

amount of top-performing girls. It is reasonable to explore if gender differences originate from boys' poorer cognitive skills in kindergarten.

The aims of this study are to identify whether gender differences in the cognitive skills are visible in kindergarten and to what extent kindergarteners' cognitive skills are associated with their performance in PISA Reading in the ninth grade. In addition, the goal is to examine if these skills are similarly predictive of PISA Reading among boys and girls. Reading comprehension is usually measured by reading fluency tasks. However, since kindergarten-age children do not read yet, phonological awareness, rapid naming and letter knowledge are examined as the best predictors of reading fluency while vocabulary represents language skills in this study. Together, they are examined as the key cognitive predictors of PISA Reading that serves as a reading comprehension assessment.

1.1 Simple View of Reading

The Simple View of Reading (SVR) is a theoretical account on reading proposed by Gough and Tunmer (1986). It is broadly used in research and practice concerning reading and it offers a framework for conceptualizing reading comprehension (Florit & Cain, 2011; Kirby & Savage, 2008). The SVR model derives from the view that reading comprehension is regarded as the product of one's efficient decoding ability and linguistic comprehension. Both aspects can be estimated in the range from 0 (skill not present) to 1 (perfect performance). The simple view states that reading (R) equals the product of decoding (D) and comprehension (C), $R = D \times C$. (Gough & Tunmer, 1986; Hoover & Gough, 1990.) Gough and Tunmer (1986, 7) define decoding as the ability to "read isolated words, quickly, accurately, and silently", and linguistic comprehension as "the process by which, given lexical (i.e., word) information, sentences and discourses are interpreted". Furthermore, they note that linguistic comprehension should be measured and assessed through listening comprehension. Hoover and Gough (1990) highlight that decoding and linguistic comprehension are both essential

for reading comprehension and neither of them cannot work on the sufficient level without the other. However, research has shown that vocabulary measures are excellent predictors of reading comprehension as well (e.g., Ouellette, 2006; Cain, Oakhill & Bryant, 2004).

The ability to decode has a greater influence than linguistic comprehension on reading comprehension in the early stages of learning to read when beginning readers are becoming aware of the writing system of their language (Florit & Cain, 2011) which means that very slow or inaccurate decoding will make comprehension difficult. In Finland, children master decoding early since more than one third of them can read before gaining any formal reading instruction, and more than 95% are accurate decoders after the first grade (Holopainen, Ahonen & Lyytinen, 2001). It means that they have reached the ability to acquire grapheme-phoneme connections. Finnish children with typical reading achievement can read quite accurately and fluently any word or words that are pronounceable nonwords at the end of the second grade (Lyytinen et al., 2006). The relative fastness of these processes is due to the transparency of the Finnish orthography —i.e. an almost perfect one-to-one grapheme-phoneme correspondence which differs, for example, from the English-speaking countries (Aro, 2004). In a language with a highly transparent orthography, letter knowledge is close to decoding which makes accurate reading easier even though words would be unfamiliar (Torppa et al., 2010). The development of skills in letter knowledge requires that children are early exposed to letters and have printed material around them (Torppa, Poikkeus, Laakso, Eklund & Lyytinen, 2006). Additionally, print exposure seems to be moderately linked to oral language skills and basic reading skills among children from 2 to 6 years old (Mol & Bus, 2011).

After decoding is relatively fast and automatized, more of the cognitive resources can be used for reading comprehension (Perfetti, 1985). As Finnish children become relatively fast readers early, the effect of reading fluency on their reading comprehension diminishes early as well and, instead, listening comprehension seems to have a more central role in reading comprehension

(Torppa et al., 2016). Also, Lerkkanen, Rasku-Puttonen, Aunola and Nurmi (2004) showed that listening comprehension of Finnish children in the first grade predicted reading comprehension in the second grade when previous reading skill was controlled for. Furthermore, Florit and Cain (2011) have verified broadly that accurate and fluent reading and good linguistic comprehension predict reading comprehension in transparent orthographies. This applies to the development of reading comprehension among Finnish children as well (e.g., Torppa et al., 2016; Dufva, Niemi & Voeten, 2001; Torppa, Tolvanen et al., 2006).

However, the effect of reading fluency on reading comprehension does not cease to exist completely (Torppa, Eklund, Sulkunen, Niemi & Ahonen, 2018; Artelt, Schiefele & Schneider, 2001). Problems in reading fluency are critical since reading comprehension requires that a sufficient level of fluency is achieved or, otherwise, one is not able to read and comprehend demanding texts (Torppa et al., 2010). Yet, comprehension problems are not necessarily visible. According to Cain (2016, 12), serious difficulties may occur clearly only "when the cognitive system is taxed, a range of knowledge stores must be accessed and processes are engaged simultaneously as a text unfolds." These viewpoints highlight that children can manage with reading tasks easy enough and have visible difficulties only when comprehension requires one to process previous knowledge and retrieve facts at the same time. Children who are slow readers need much time to finish with texts and, for example, during a task they may forget what they already have read which hinders comprehension.

1.2 Cognitive Skills as Predictors of Reading Comprehension

The basis for accuracy and fluency in reading is formed already during the early language development, and reading ability requires that a child can use several component skills developed years before the actual reading skill emerges (Torppa et al., 2010). Kindergarteners have several skills related to their later reading skills even though they do not read yet. As children have become skilled fluent readers, they identify and read familiar words by sight without effort

(Ehri, 2005) and their word recognition functions in multiple contexts and activates semantic processes (Eklund, Torppa, Aro, Leppänen, & Lyytinen, 2015). The several findings of a Finnish follow-up study, The Jyväskylä Longitudinal Study of Dyslexia (JLD, see Lyytinen et al., 2004), have shown, for example, that letter knowledge, phonological awareness and rapid naming are the best predictors of reading acquisition in Finnish (Aro, 2017; Puolakanaho et al., 2007; Lyytinen, Erskine, Aro & Richardson, 2007). For example, in Torppa et al.'s (2010) study, language development of Finnish children was followed from the age of 1,5 years until school-age. At the age of 2,5 years, children who were diagnosed as disabled readers at the end of the second grade performed poorer on all measures, except the one of expressive language, when compared to children who developed typical readers. The strongest predictors of reading disability were letter naming, rapid naming, morphology and phonological awareness. Similar findings have been reported on children with other languages. English-speaking children with familial risk of dyslexia had poorer performance in tasks of vocabulary, expressive language and phonological processing at the age of 45 months, and their literacy development was delayed at the age of 6 years (Gallagher, Frith & Snowling, 2000). Among Danish preschoolers, measures of phoneme awareness, rapid naming and vocabulary predicted later reading difficulties (Elbro, Borstrøm & Petersen, 1998). Therefore, differences in reading skills can be identified already in kindergarten as children at risk for later reading difficulties typically show different types of problems relating to language and literacy before they enter school.

Phonological skills include, for example, phonological awareness, phonological sensitivity and phonological memory. Torgesen, Wagner and Rashotte (1994, 276) define phonological awareness as "one's sensitivity to, or explicit awareness of, the phonological structure of the words in one's language." It is said to play the most significant role in the development of reading ability (Kirby, Parrila & Pfeiffer, 2003) and it is related to accuracy (e.g., Holopainen, Aho, Tolvanen & Lyytinen, 2000). Tasks measuring phonological awareness demand one to recognize, isolate and blend phonemes in words. As Finnish is a

very agglunative language in its morphology, it contains several inflections and stem variations. A child learning Finnish must have "well-specified phonological representations" to be able to use these inflections differing sometimes only by one phoneme, such as 'talossa' [in a house] and 'talosta' [from a house] (Torppa, Georgiou, Salmi, Eklund and Lyytinen, 2012, 310). Moreover, a child must analyze sounds carefully when learning to recognize differences between single and double vowels and consonants, such as 'mato' (a worm) and 'matto' (a carpet), which concerns spelling as well since marking the double vowels and consonants is a very common spelling error in Finnish (Torppa, Georgiou, Niemi, Lerkkanen & Poikkeus 2017). Studies of regarding transparent orthographies suggest that the effect of phonological awareness on reading fluency decreases after the grades 1 or 2 (Landerl & Wimmer, 2000; de Jong & van der Leij, 2002) since after learning to decode children's individual differences in reading performance relate primarily to reading speed than accuracy (Bekebrede, van der Leij & Share, 2009).

Rapid naming is widely found to be linked to reading achievement (e.g., Manis, Seidenberg & Doi, 1999) and it relates to reading fluency in particular (e.g., Torppa et al., 2012; Georgiou, Parrila & Papadopoulos 2008; Savage & Frederickson, 2005). Tasks measuring rapid naming require that a child rapidly names aloud sequential familiar items such as digits, letters, colors and objects. In transparent orthographies, rapid naming seems to be a strong predictor of reading fluency at every age (Bekebrede, van der Leij and Share, 2009). In Finnish, the most common reading problems concern fluency and can be directly predicted by naming fluency (Torppa et al., 2010). Among Finnish adolescents, rapid naming is linked to reading speed at all skill levels, and difficulties in it cause slow reading (Kairaluoma et al., 2013). Difficulties seem to be persistent (Torppa et al., 2012; Kirby, Parrila & Pfeiffer, 2003) which means enduring problems in reading fluency.

Letter knowledge has an important role in reading acquisition (e.g., Snowling, Gallager & Frith, 2003) and it can be measured by tasks in which children name the letters of their native language. The association between letter

knowledge —along with phonological awareness— and reading development is clear since struggling in processing speech sounds or letters will cause difficulties in the development of decoding (e.g., Puolakanaho 2007; Torppa et al., 2016). The findings by Torppa et al. (2006) demonstrated that kindergarten-age phonological sensitivity, phonological memory and rapid naming predicted delayed letter knowledge, and children with delayed letter knowledge were likely to have problems in reading fluency or reading comprehension in the first grade. In addition, Torppa et al. (2016) showed that letter knowledge and vocabulary in preschool-age were the strongest predictors of reading comprehension in the first and second grade.

Tasks involving vocabulary knowledge require that a child defines words or selects a matching synonym or a picture for a spoken or written word. When acquiring new words, children have to process them and set the new vocabulary in their mental lexicon which is in constant change since children acquire new upcoming words and their phonological similarities always when being exposed to spoken language (Metsälä & Walley, 1998). Naturally, a child may not fully understand all new words but, over time, their meanings are refined which increases the depth of the child's vocabulary (Ouellette, 2006). Manolitsis, Georgiou and Parrila (2011) showed that kindergarten-age vocabulary correlated significantly with reading comprehension of Greek pupils in the fourth grade. Furthermore, English-speaking children, classified as reading disabled by age 8, had deficits in their vocabulary skills from the age of 3 onward (Scarborough, 1990). Weak vocabulary knowledge can cause problems when one should know precise vocabulary to be able to make inferences from a less explicit text but, instead, comprehension does not seem to be hindered if a text is well-structured and explicit (Cain, 2016). These viewpoints emphasize the importance of linguistic comprehension as an essential part of reading comprehension along with decoding. All in all, the predictors of both reading fluency and language skills are essential to examine as the key cognitive predictors of reading comprehension.

1.3 Cognitive Predictors of Reading Comprehension Assessed by PISA Reading

Reading comprehension is examined and assessed broadly in PISA in which 15-year-old students participate worldwide. It is a triennial international survey aiming to test skills and knowledge essential for full participation in modern societies (OECD, 2017a). Students are assessed in science, mathematics and reading, and reading has been the major domain in the first and the fourth PISA assessments in 2000 and 2009. In the sixth PISA assessment in 2015, collaborative problem solving was also included for the first time. OECD (2017b, 51) defines the term Reading Literacy in PISA as "understanding, using, reflecting on and engaging with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society."

Research on cognitive skills related to PISA Reading is limited. Furthermore, there are no PISA studies based on the SVR model. Yet, it is reasonable to assume that the SVR would be relevant in this context since students participating in PISA Reading need to read and comprehend what they have read. According to the OECD report (2016, 146), "The PISA assessment of reading focuses on students' ability to use written information in real-life situations." The tasks are focused on the large amount of situations in which people read texts and texts are presented, and additionally, on the multiple ways in which readers need to approach and use texts (OECD, 2016). The tasks require that readers interpret, reflect and evaluate information presented in text, tables and graphs. There are seven proficiency levels from Level 1b, the lowest level, to Level 1a, Level 2 and so on up to Level 6. Each proficiency level requires certain reading skills, knowledge and understanding. Level 2 is considered a baseline level of proficiency which one needs to achieve in order to participate in the society actively and to continue to further education (OECD, 2014). In 2015, 11% of Finnish students did not achieve this level (Vettenranta et al., 2016).

There are some studies of cognitive skills in PISA Reading. Arnbak (2012) showed that concurrently measured word recognition and vocabulary explained

41% of the PISA Reading scores of Danish students. The findings by Artelt, Schiefele and Schneider (2001) indicated that concurrently measured decoding speed explained 13% of the variance in PISA Reading among German students. Among Finnish students, Torppa et.al (2018) proved the linkage between reading fluency and reading comprehension as reading fluency predicted 15% of the variance. Yet, there seems to be only one study in which children's language skills and pre-literacy skills were observed together with PISA reading performance. Eklund, Torppa, Sulkunen, Niemi and Ahonen (submitted) showed that kindergarten-age language skills (articulation, vocabulary knowledge, grammar) predicted 59% of the PISA Reading variance among the group with high risk for dyslexia and 25% among the group with low risk for dyslexia. Pre-literacy skills (phonological awareness, rapid naming, letter knowledge) through reading fluency at school-age predicted 11% of the variance among the high-risk group and 6% among the low-risk group. However, the sample in the study was relatively small (n = 158).

Based on the findings of these studies, cognitive skills may predict students' performance in PISA Reading. However, cognitive skills are not examined more closely in studies reporting on PISA Reading since they are expected to be well-established by middle school level (Arnbak, 2012). Yet, many students are slow and struggling readers at the age of 15 (Kairaluoma et al., 2013). For example, Eklund et al. (2015) showed that Finnish eight-graders with reading difficulties read with the same speed as average third-graders. Furthermore, Korhonen's (1995) small-scale follow-up study with Finnish adolescents indicated that reading difficulties associated with slow naming speed seemed to be persistent. It is likely that problems of this type are related to performance in PISA Reading.

1.4 Gender Differences in Cognitive Skills and PISA Reading

In addition to cognitive skills, the focus of this study is in gender differences in reading comprehension. Internationally, the size of the gender gap in reading

varies considerably between countries (OECD, 2010a) but PISA has consistently shown that girls outperform boys (OECD, 2014). In 2015, girls outperformed boys on PISA Reading in every participating country and economy (OECD, 2016) which emphasizes the fact that boys and girls have differences in their reading skills. The OECD report (2010a) states that explanations for the gender gap can be found in boys and girls' different attitudes and behaviors. Furthermore, the report states that boys read less for pleasure and are less engaged in reading and, as a result, they are not as aware of effective strategies to summarize information as girls are. Yet, in order to succeed in PISA Reading, one should have a large variety of skills and qualities. According to the OECD report (2010a, 27), those who perform well in the PISA Reading test are

> "…students who read for enjoyment, who self-direct their learning, i.e. use control strategies, and particularly students who enjoy reading and who know what they should do when they have to understand, remember and summarise complex information…"

In Finland, gender differences were clearest in the task types requiring written responses and evaluation and reflecting on the material (Torppa et al., 2018).

Among Finnish students, the gender gap has been reported to be one of the largest of the countries participating in PISA (OECD, 2016; Brozo et al., 2014). The tendency was noticed already in the first PISA assessment in 2000 as Finnish boys were three times as likely as girls to be at Level 1 or below (OECD, 2001) but signs of growing differences in reading skills have been noticed since 1990s (Lappalainen, 2000). According to the publication of the PISA results in Finland in 2015 (Vettenranta et al., 2016), Finnish girls were in the first place (551 points) and Finnish boys in the seventh place (504 points) when they were compared by gender to students from other countries and economies. The rankings indicate that, in general, Finnish students are very good readers. However, according to the PISA publication (Vettenranta et al., 2016), the difference of 47 points between boys and girls is estimated to correspond a one-year gap in the mastery of the national curriculum. In addition, the difference between the poorest performing girls and boys was reported to be 65 points for girls, and, between the best performing girls and boys, it was 31 points for girls. Besides, 16% of boys and 7%

of girls did not achieve the baseline level of proficiency (Level 2), meanwhile 9% of boys and 19% of girls achieved the highest levels 5 and 6.

The gender differences confirm that Finnish girls outperform boys at every skill level. The problem in the tendency is that the differences are relatively big. It can be argued if girls' better performance relates to more positive attitude toward and interest in reading. For example, Finnish girls participating in PISA Reading in 2009 enjoyed reading, spent notably more time on it and showed higher diversity of print reading when compared to boys, and these differences were all statistically significant (Brozo et al., 2014). Yet, Torppa et al. (2018) showed that Finnish students who performed well, despite of the gender, were those who read more books, spent more time with homework and were mastery oriented in general. However, the main reason for the gender gap was boys' poorer basic reading fluency although minor effects were mediated via the amount of time spent in leisure book reading and homework activity. Therefore, along with cognitive skills, reading habits seem to be associated with performance in PISA Reading.

Gender differences in reading in favor of girls are shown to be visible early on. For example, German girls, aged 3 to 6 years, had better language competence than boys (Lange, Euler & Zaretsky, 2016). In addition, better processing speed of English-speaking girls, aged 4 to 7 years, is suggested to contribute to better reading and writing skills (Palejwala & Fine, 2015). Furthermore, Finnish boys with high or low risk for dyslexia had poorer language skills than high risk girls, who outperformed boys particularly at the age of 2 to 2,5 years (Eklund et al., submitted). The gender gap is proven to be visible in elementary school as well. For example, Quinn and Wagner (2015) showed that U.S. boys were more often identified as reading impaired in the second grade. Yet, there are studies which do not show clear gender differences in reading skills and reading motivation (e.g., McGeown, Goodwin, Henderson & Wright, 2012) or in the frequency of reading difficulties (e.g., Jimenez et al., 2011; Moll, Kunze, Neuhoff, Bruder & Schulte-Körne, 2014;.

There are several reasons which have been argued to explain gender differences. For example, the level of society, culture or school environment but also pedagogical approaches favoring girls have been suggested for possible explanations (Stoet and Geary, 2013). In addition, girls are shown to be more engaged in school and become rated higher in academic performance by teachers (Lam et al., 2012). Differences between boys and girls' reading frequency, interest in and attitude toward reading have been explanations for differing reading performance as well. For example, U.S. girls had more favorable attitude toward reading in the grades from 1 to 6 and the gender difference was not linked to reading ability (McKenna, Kear & Ellsworth, 1995). Yet, there is evidence showing that reading difficulties run in families and family risk attributes strongly to genetic factors (e.g., Olson & Byrne, 2005; Swagerman et al., 2017). Gender differences are, therefore, likely to relate to cognitive vulnerabilities (e.g., Quinn & Wagner, 2015). Based on these multiple suggestions, it is reasonable to examine if gender differences in reading comprehension can be visible already at the age of 6 when children have not entered school nor been divided by their reading frequency.

1.5 **Research Questions**

The aims of this study are to identify whether gender differences in the cognitive skills are visible in kindergarten and to what extent kindergarteners' cognitive skills are associated with their performance in PISA Reading in the ninth grade. In addition, the goal is to examine if these skills are similarly predictive of PISA Reading among boys and girls. The purpose of the study is to answer the following questions:

1. Are there gender differences in kindergarteners' cognitive skills and PISA Reading performance?
2. To what extent are the kindergarten-age cognitive skills — phonological awareness, rapid naming, letter knowledge, and vocabulary— associated with performance in PISA Reading?

3. Are the kindergarten-age cognitive skills similarly predictive of PISA Reading among boys and girls?

As previous research (Lange, Euler & Zaretsky, 2016; Palejwala & Fine, 2015; Eklund et al., submitted) has shown, gender differences in cognitive skills can be visible already in kindergarten. Therefore, it is possible that they can be identified in the sample of this study as well. In addition, early cognitive skills are shown to predict reading development and later reading difficulties (e.g., Torppa et al., 2010; Lyytinen et al., 2004; Gallagher, Frith & Snowling, 2000; Scarborough, 1990) along with performance in PISA Reading at least in the context of familial risk for dyslexia (Eklund et al., submitted). Therefore, it can be assumed that kindergarten-age phonological awareness, rapid naming, letter knowledge and vocabulary can be used as the key cognitive predictors of reading comprehension assessed by performance in PISA Reading. Furthermore, probable gender differences in kindergarten can relate to the gender gap in PISA Reading. Therefore, it is possible that the cognitive skills are somewhat differently predictive among boys and girls.

2 METHODS

2.1 Participants

The data of this study is from the longitudinal study, The First Steps, (see Lerkkanen et al., 2006) in which a community sample of about 2000 children were followed from kindergarten to the end of elementary school. Children were born in 2000 and came from four municipalities, two in Central Finland, one in Western Finland and one in Eastern Finland. The children participating in this study attended to kindergarten (n = 1839; 896 girls and 984 boys) and grade 9 assessments (n = 1015; 485 girls; 530 boys). At spring 2006, the mean age of children in the sample was 6.1 years. The kindergarten curriculum aims to fostering children's personal and social development. There is no formal reading instruction, but children are encouraged to play and have fun with letters, words and numbers. About a half of children learn to decode at least some words during the last year in kindergarten before school (Torppa et al., 2013) which they enter in the year of the seventh birthday. The First Steps has the ethical consent from The University of Jyväskylä Ethical Committee which means that all participation is voluntary, participants' anonymity is secured, the data is held in a secure place and no harm is caused to the research subjects.

2.2 Measures

The kindergarteners' phonological awareness, rapid naming, letter knowledge and vocabulary were assessed in April 2006 by trained testers in individual test sessions. Testing of the students in the ninth grade was carried out by trained testers who were either university researchers or final-phase psychology graduate students. Testing took place in November 2015.

Phonological awareness. The initial phoneme identification test from the test battery (Lerkkanen, Poikkeus & Ketonen, 2006) was used to assess phonological awareness. The experimenter named a row of four pictures of

objects which the children viewed. After that, the experimenter asked, "At the beginning of which word do you hear the sound /?/", and the children had to point out the correct picture. All sounds were single phonemes. The children's score was the number of correct responses (max. = 10). The Cronbach's Alpha reliability coefficient was .76.

Rapid naming. Rapid naming was assessed by using the standard procedure (Denckla & Rudel, 1970). The children were asked to name as fast as possible a series of five pictures of objects arranged in semirandom order in five rows of 10. There was a practice trial before the test to ensure that each child was familiar with the objects. Total time to name all stimuli served as the children's scores. Only a few errors occurred and for this reason they were not considered further. The kindergarten - grade 1 retest correlation was .62.

Letter knowledge. The children named all 29 Finnish letters which were arranged in three rows (Lerkkanen, Poikkeus & Ketonen, 2006). The children had to name the letters, one row at the time, while the other rows were covered. The score was the number of correctly named letters (max. = 29). The Cronbach's Alpha reliability coefficient was .94.

Vocabulary. As a measure of receptive language, a 30-item shortened version of the Peabody Picture Vocabulary Test-Revised (PPVT-R, Form L; Dunn & Dunn, 1981). In PPVT, the children selected a picture correctly representing a spoken word from four alternatives. The items for the shortened version were selected based on the data from the full-scale administration of the PPVT-R in the Jyväskylä Longitudinal Study of Dyslexia (Lyytinen et al., 2004). The score was the number of correct responses. The Cronbach's Alpha reliability coefficient was .61.

Programme for International Student Assessment Reading. The students had 60 minutes to complete the reading tasks which were the PISA Reading link items and used repeatedly in each cycle of the survey in order to ensure that the measurement was comparable (OECD, 2010b, 26). The booklet included eight different texts for which students were asked to read and answer several questions. There were texts, tables, graphs and figures in the reading

materials. There were 15 multiple-choice questions and 16 questions which required written responses. Of the questions, 12 required students to access and retrieve information, 12 to integrate and interpret information and 7 to reflect and evaluate information. The total score for all PISA Reading items was calculated. The Cronbach's Alpha reliability coefficient was .75.

2.3 Data Analysis

The analysis was performed by using the IBM SPSS Statistics 24. Vocabulary was the only variable which approached the normal distribution. Phonological awareness was left-skewed, as 59% of the kindergarteners answered to all questions correctly. No transformation could correct the left-skewness of this measure. Therefore, phonological awareness was regarded as a nominal variable with three classes (0-5 = 1, 6-9 =2, 10 = 3). The distribution of letter knowledge was leptokurtic because 37% of the kindergarteners knew either 28 or all 29 letters. The variable was recoded into four classes (0-9 = 1, 10-18 = 2, 19-27 = 3, 28-29 = 4). After this, it approached the normal distribution. Rapid naming was right-skewed and had to be inverse transformed. One outlier was removed to the end of the right-tail of the distribution. After this, rapid naming approached the normal distribution.

3 RESULTS

3.1 Gender Differences in Kindergarteners' Cognitive Skills and PISA Reading

The first research question was if there were gender differences in kindergarteners' cognitive skills (phonological awareness, rapid naming, letter knowledge, vocabulary) and their PISA Reading performance. When Independent-Samples t-Test was conducted, the differences in the means of phonological awareness, letter knowledge and PISA Reading were significant ($p \leq .001$) and girls outperformed boys. The effect sizes were in the small range. Gender differences for rapid naming and vocabulary were not significant. The means, standard deviations, t-test and effect sizes (Cohen's *d*) are given in Table 1.

TABLE 1. Gender comparison: *t*-test results.

	Boys			Girls				
	N	Mean	SD	N	Mean	SD	t-test	Cohen's d
Phonological awareness	964	8.66	1.91	872	9.23	1.42	-7.32***	-0.34
Rapid naming	963	71.15	17.20	872	69,34	18.36	2.18	0.10
Letter knowledge	965	22.27	7.35	871	24.26	5.50	-6.60***	-0.31
Vocabulary	966	19.83	3.51	873	19.81	3.23	0.10	0.01
PISA Reading	530	19.45	6.29	485	22.12	5.32	-7.31***	-0.46

$p^{***} \leq .001$

3.2 **Prediction of PISA Reading**

The second research question was to what extent the kindergarten-age cognitive skills were associated with PISA Reading performance. The means, standard deviations and mutual correlations of the skills and the PISA Reading score among all the students are presented in Table 2. All the cognitive skills correlated significantly with the PISA Reading score. The positive correlations between phonological awareness, letter knowledge, vocabulary and PISA Reading indicate that accurate phoneme identification and recognition of letters along with rich vocabulary are associated with one's success in PISA Reading. The negative correlation between rapid naming and the PISA Reading score (-.25) indicates that slow rapid naming is related to poorer performance. The correlation between phonological awareness and letter knowledge (.56) needs to be taken into account in a regression analysis because of the possible multicollinearity. The correlations between the measures separately for boys and girls are presented in Table 3 and Table 4, respectively. Between the genders, all other correlation coefficients except of letter knowledge were in the same range. The value of boys' letter knowledge was .33 and girls' .16. The difference was significant (Z = 2,88, $p \leq .01$) which suggests that, among boys, letter knowledge is associated with PISA Reading performance to bigger extent.

TABLE 2. Means, standard deviations and mutual correlations of the variables among boys and girls (n = 1015).

	1.	2.	3.	4.	5.
1.PISA Reading					
2.Phonological awareness	.23***				
3.Rapid naming	-.25***	-.29***			
4.Letter knowledge	.28***	.56***	-.33***		
5.Vocabulary	.31***	.27***	-.19***	.27***	
Mean	20.26	2.54	70.30	3.10	19.80

SD	6.20	.60	17.78	.87	3.38

***$p \leq .001$

TABLE 3. Means, standard deviations and mutual correlations of the variables among boys (n = 530).

	1.	2.	3.	4.	5.
1.PISA Reading					
2.Phonological awareness	.23***				
3.Rapid naming	-.27***	-.32***			
4.Letter knowledge	.33***	.58***	-.33***		
5.Vocabulary	.32***	.27***	-.20***	.30***	
Mean	19.45	2.45	-.01	2.98	19.83
SD	6.23	.64	.00	.94	3.50

***$p \leq .001$

TABLE 4. Means, standard deviations and mutual correlations of the variables among girls (n =485).

	1.	2.	3.	4.	5.
1.PISA Reading					
2.Phonological awareness	.19***				
3.Rapid naming	-.20***	-.26***			
4.Letter knowledge	.16***	.50***	-.33***		
5.Vocabulary	.34***	.28***	-.18***	.24***	
Mean	22.12	2.60	-.02	3.23	19.81
SD	5.32	.54	.00	.76	3.23

***$p \leq .001$

The third research question was if the kindergarten-age cognitive skills were similarly predictive among boys and girls. The data was analyzed by performing a hierarchical linear regression analysis with the PISA Reading score as the

dependent variable and gender, the cognitive skills and the interaction terms for gender and the cognitive skills as the independent variables. Gender was the independent variable in the first block, the cognitive skills (phonological awareness, rapid naming, letter knowledge and vocabulary) in the second block and the interaction terms for gender and the cognitive skills in the third block.

The results (see Table 5) indicate that gender, the kindergarten-age cognitive skills and the interaction terms for gender and the cognitive skills predicted 19,7% of performance in PISA Reading ($F(9, 1002) = 27{,}33$, $p \leq .001$). In the first block, gender explained 5% of the PISA Reading score ($F(1, 1010) = 52{,}44$, $p \leq .001$). In the second block, the cognitive skills increased the PISA Reading score by 14% ($F(4, 1006) = 43{,}57$, $p \leq .001$). In the third block, the interaction terms for gender and the cognitive skills increased the PISA Reading score by 0,7%, an increase which was close to significant ($F(4, 1002) = 2{,}30$, $p \leq .06$).

TABLE 5. Results of the hierarchical linear regression analysis on the linkage between the kindergarten-age cognitive skills, gender and performance in PISA Reading.

		Stand. Beta	ΔR^2
Step 1			.05***
	Gender	.222***	
Step 2			.14***
	Gender	.191***	
	Letter knowledge	.128***	
	Phonological awareness	.021	
	Rapid naming	-.139***	
	Vocabulary	.239***	
Step 3			.007
	Gender	.193***	
	Letter knowledge	.200***	
	Phonological awareness	-.021	
	Rapid naming	-.171***	

	Stand. Beta	ΔR^2
Vocabulary	.195***	
Gender + Letter knowledge	-.107*	
Gender + Phonological awareness	.055	
Gender + Rapid naming	.040	
Gender + Vocabulary	.063	

*p** ≤ .05; *p**** ≤ .001

Rapid naming, letter knowledge and vocabulary predicted significantly the PISA Reading score. The relation between rapid naming and the PISA Reading score was negative. This finding suggests that slow rapid naming in kindergarten-age predicts poorer performance in PISA Reading. Letter knowledge and vocabulary were positively related to the PISA Reading score which showed that the better these skills a child had in kindergarten the better was performance in PISA Reading. Phonological awareness was not significant, and because of the possible multicollinearity problem between phonological awareness and letter knowledge, tolerances and VIF values were examined. The tolerance of phonological awareness was .65 and of letter knowledge .64. The VIF for phonological awareness was 1.54 and for letter knowledge 1.57. These values suggest that there was no multicollinearity. The interaction term for gender and letter knowledge was significant ($p \leq .05$). A further regression analysis split by gender showed that letter knowledge was a significant predictor of PISA Reading only for boys ($p \leq .001$).

4 DISCUSSION

The purpose of the present study was to examine gender differences in the cognitive skills among Finnish kindergarteners, the association between the cognitive skills and children's later PISA Reading performance and the predictive power of these skills among boys and girls. Phonological awareness, rapid naming and letter knowledge were included as the best predictors of reading fluency while vocabulary represented language skills. Reading fluency itself could not be measured since the kindergarteners could not read yet. Together, the cognitive skills were the key predictors of reading comprehension which requires both reading fluency and language skills in order to develop (Gough & Tunmer, 1986; Hoover & Gough, 1990; Florit & Cane 2011; Kirby & Savage, 2008). Reading comprehension was assessed by the PISA Reading test in the ninth grade. This study is in accordance with previous research suggesting that later reading skills can be predicted already in kindergarten-age (e.g., Torppa et al., 2010; Lyytinen et al., 2004; Gallagher, Frith & Snowling, 2000; Scarborough, 1990). Therefore, it is just to early identify possible reading difficulties and, additionally, to predict performance in reading comprehension before entering school.

The first research question was if there were gender differences in kindergarteners' cognitive skills and PISA Reading performance. Girls outperformed boys on phonological awareness and letter knowledge. These findings support the previous studies reporting on girls' better cognitive skills in kindergarten (Lange, Euler & Zaretsky, 2016; Palejwala & Fine, 2015; Eklund et al., submitted). In addition, girls outperformed boys on PISA Reading as well which is in line with previous research on the gender gap both internationally (OECD, 2016) and in the Finnish context (Brozo et al., 2014; Vettenranta et al., 2016).

The second research question was to what extent performance in PISA Reading was associated with the kindergarten-age cognitive skills. Among all the students, every cognitive skill correlated significantly with the PISA Reading score. However, among boys, letter knowledge was associated with PISA

Reading to bigger extent. Furthermore, the results of the hierarchical linear regression analysis showed that the cognitive skills, gender and the interaction terms for the cognitive skills and gender explained 19,7% of performance. First, gender explained 5% of performance. This finding suggests that it is logical to continue the discussion on gender differences in reading (e.g., Moll, Kunze, Neuhoff, Bruder & Schulte-Körne, 2014; McGeown, Goodwin, Henderson & Wright, 2012; Jimenez et al., 2011). Furthermore, the finding supports the studies showing gender differences in reading (e.g., Quinn & Wagner, 2013; Stoet & Geary, 2013; Berninger et al., 2008). Yet, 5% needs to be considered a small difference. Second, the kindergarten-age cognitive skills explained 14% of performance which is in accordance with the few earlier findings of the relation between kindergarteners' pre-literacy and language skills and PISA performance (Eklund et al., submitted). The importance of rapid naming to the PISA Reading score is in line with the previous finding of the predictive value of decoding speed in PISA Reading (Artelt, Schiefele & Schneider, 2001). If reading is slow, comprehension becomes difficult. As difficulties in rapid naming seem to be persistent among Finnish readers (e.g., Korhonen, 1995; Torppa et al., 2010), it is reasonable to assume that those who were slow readers in the ninth grade were likely to belong to those with poorer rapid naming skills in kindergarten. The other way around, the children with good rapid naming skills were likely to perform better in PISA Reading. In addition, the positive linkages of letter knowledge and vocabulary to the PISA Reading score showed that accurate recognition of letters along with rich vocabulary were associated with one's success. These findings support the previous studies on skills which are needed in PISA Reading (Arnbak, 2012) and which in kindergarten predict one's reading comprehension at school-age (e.g., Torppa et al., 2016; Leppänen, Aunola, Niemi & Nurmi, 2008; Manolitsis, Georgiou & Parrila, 2011). Phonological awareness was not directly predictive which is in line with the previous finding of phonological awareness used as a long-term predictor of reading achievement in Finnish (Holopainen, Ahonen & Lyytinen, 2001). In transparent languages, the orthographic knowledge helps children solve tasks concerning phonological

awareness which diminishes the predictive value. All in all, although the kindergarteners could not read yet, the prediction power of the cognitive skills complies with the view that accurate and fluent reading and good linguistic comprehension predict reading comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990; Florit & Cane 2011; Kirby & Savage, 2008).

Finally, the interaction terms for gender and the cognitive skills increased the PISA Reading score by 0,7% which was close to significant. The interaction term for gender and letter knowledge was significant. The findings showed that letter knowledge was a significant predictor of PISA Reading only for boys**.** The third hypothesis was that the cognitive skills could be somewhat differently predictive, and it was partly confirmed. The finding suggests that assessing kindergarten-age letter knowledge is a way to identify those boys who are in danger of facing difficulties in reading comprehension in Finnish. Letter knowledge in kindergarten has been shown to be a sign of later reading difficulties (e.g., Snowling, Gallagher & Frith, 2003; Pennington & Lefly, 2001; Elbro, Borstrøm & Petersen, 1998). In this sample, letter knowledge is also an early marker of reading comprehension.

Considering the gap between the ages of 6 and 15 years, the prediction of PISA Reading performance by the kindergarten-age cognitive skills and gender with almost 20% is remarkable. In Finland, every child goes to a good school, receives teaching based on the national curriculum and gains strong support for the development of cognitive skills. Yet, a fifth of performance in reading comprehension in the ninth grade can be predicted prior any reading instruction. It can be argued if the Finnish education system should pay more attention to children's inter-individual and gender differences –all of which seem to emerge already before entering school. Furthermore, the requirements for reading comprehension in PISA Reading are broad. To narrow the gender gap, early language and pre-literacy skills should be supported more strongly. One suggestion is that formal reading instruction would be given already in kindergarten. However, in transparent languages, it would most likely not offer any long-term advantage (Soodla et al., 2015; Soodla, Torppa, Kikas, Lerkkanen

& Nurmi, 2018). Instead, early exposure to letters and printed material would support the development of reading skills (e.g., Mol & Bus, 2011; Stephenson, Parrila, Georgiou & Kirby, 2008; Torppa, Poikkeus et al., 2006).

Some limitations of the present study need to be considered. The measures of the cognitive skills were short and only one measure per domain was conducted. For example, a more extensive assessment of language skills could have been included. Yet, in future research, the measures would be easy to perform in schools as well since they do not require much time. In addition, the measures focused only on certain cognitive skills and, for example, no measures of memory or print exposure were included –both of which need further research among kindergarteners. Furthermore, it would be beneficial to examine kindergarteners' achievement behavior assessed by parents and kindergarten teachers. Finally, because of the Finnish context, the results cannot be generalized to other countries or languages. However, the large sample enables the results to be generalized in Finland.

In conclusion, the present study supports the suggestion that gender differences in the cognitive skills predicting later reading development are visible already in kindergarten. In addition, the findings indicate that a fifth of performance in PISA Reading among Finnish students can be predicted by their kindergarten-age cognitive skills and gender. The predictive value of gender is only 5% but, after adding the cognitive skills, it still continues to be an important predictor. Furthermore, the study shows that performance of boys and girls can be predicted by the same cognitive skills, apart from letter knowledge which is predictive only for boys. However, 80% of performance in PISA Reading is explained by something else. Compared to that, 20% is a small proportion. Thus, there is a need for research on other kindergarten-age domains leading to the gender gap in PISA Reading. Further examination is important for the development of teaching practices and early support for those with difficulties in their early literacy.

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