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The Precursors of Double Dissociation between Reading and Spelling in a Transparent Orthography

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Abstract

Research and clinical practitioners have mixed views whether reading and spelling difficulties should be combined or seen as separate. This study examined: (a) if double dissociation between reading and spelling can be identified in a transparent orthography (Finnish) and (b) the cognitive and non-cognitive precursors of this phenomenon. Finnish-speaking children (n = 1,963) were assessed on reading fluency and spelling in Grades 1, 2, 3, and 4. Dissociation groups in reading and spelling were formed based on stable difficulties in Grades 1–4. The groups were compared in kindergarten phonological awareness, rapid automatized naming, letter knowledge, home literacy environment, and task-avoidant behaviour. The results indicated that the double dissociation groups could be identified even in the context of a highly transparent orthography: 41 children were unexpected poor spellers (SD), 36 were unexpected poor readers (RD), and 59 were poor in both reading and spelling (RSD). The RSD group performed poorest on all cognitive skills and showed the most task-avoidant behaviour; the RD group performed poorly particularly on rapid automatized naming and letter knowledge; and the SD group had difficulties on phonological awareness and letter knowledge. Fathers' shared book reading was less frequent in the RD and RSD groups than in the other groups. The findings suggest that there are discernible double dissociation groups with distinct cognitive profiles. This further suggests that the identification of difficulties in Finnish and the planning of teaching and remediation practices should include both reading and spelling assessments.

Keywords: Reading difficulty, spelling difficulty, cognitive skills, task avoidance, home literacy environment

The Precursors of Double Dissociation between Reading and Spelling in a Highly Consistent Orthography

Good readers tend to be good spellers, and poor readers tend to be poor spellers. Several studies have documented that reading and spelling are strongly associated with each other in different languages and age groups (e.g., Babayiğit & Stainthorp, 2010; Cardoso-Martins & Pennington, 2004; Desimoni, Scalisi, & Orsolini, 2012; Furnes & Samuelsson, 2011; Georgiou, Torppa, Manolitsis, Parrila, & Lyytinen, 2012; Landerl & Wimmer, 2008; Leppänen, Niemi, Aunola, & Nurmi, 2006; Vaessen & Blomert, 2013; Yeung et al., 2011). However, the imperfect correlation between the two (*r*s range from .60 to .80; see meta-analysis by Swanson, Trainin, Necoechea, & Hammill, 2003) leaves open the window for a dissociation in which good readers can also be poor spellers (known as *unexpected poor spellers*) and poor readers can also be good spellers (known as *unexpected poor readers*). A few large-scale studies have indeed shown that these two performance profiles are not rare and may each affect 3–7% of school-age children (Fayol, Zorman, & Lété, 2009; Moll, Kunze, Neuhoff, Bruder, & Schulte-Körne, 2014; Moll & Landerl, 2009; Wimmer & Mayringer, 2002).

Despite the fact that these dissociation profiles do occur, very little is known about the precursors of the unexpected reading and spelling deficits. Obviously, any information on the precursors is important not only for theoretical reasons, but also for the development of early support systems within schools and intervention programs for those in need. Researchers acknowledge that there are at least three limitations of the previous studies on this topic (Kamhi & Hinton, 2000; Perfetti, Rieben, & Fayol, 1997): First, the few studies have only examined the possible role of cognitive factors (e.g., phonological awareness and short-term memory) and have neglected the possible effects of non-cognitive factors, such as the home literacy

environment and motivational factors. Second, with the exception of Wimmer and Mayringer's (2002) study, none of the previous studies on double dissociation have been longitudinal and none have assessed the precursors of these deficit patterns in kindergarten (before children get exposed to formal reading and spelling instruction at school). Finally, to our knowledge, there are no studies conducted in a transparent orthography (e.g., Finnish, Turkish) with high forward and backward consistency.

The existence of dissociation in reading and spelling profiles is intriguing in the context of orthographies with both forward (from graphemes to phonemes) and backward (from phonemes to graphemes) consistency. In these orthographies, spelling errors cannot be attributed to poor word-specific orthographic representations since mastery of phoneme-grapheme mappings would suffice to spell any given word correctly. Thus, the first goal of our study was to examine if we could identify dissociated groups in reading and spelling in an orthography with high forward and backward consistency, Finnish. Ziegler et al. (2010) estimated the onset entropy of Finnish to be .00 and that the consistency is high in both the direction of reading and spelling (see Aro, 2004, in press, for a detailed description of Finnish orthography). The dissociated profiles in reading and spelling might also suggest that the underlying factors causing the deficits may differ. Thus, the second goal of our study was to examine the role of cognitive (letter knowledge, rapid automatized naming, and phonological awareness) and non-cognitive (home literacy environment and task avoidance) factors in the manifestation of unexpected reading and spelling deficits.

Frith (1978) was the first to report the existence of a group of individuals who were efficient readers but "atrocious" spellers. Frith (1980) further explored the profile of these children and argued that their poor performance in spelling was due to inefficient orthographic

processing during reading. More specifically, Frith (1980) found that good readers/poor spellers made significantly more phonetic errors (e.g., writing “bred” instead of “bread”) than poor readers/poor spellers. In addition, good readers/poor spellers deployed different reading strategies than good readers/good spellers: whereas good readers/good spellers used all the cues available in a word, good readers/poor spellers relied on “partial cues” to read. She concluded that poor spellers do not pay attention to all details in words (e.g., the correct sequence of letters). If minimal cues are used for reading, reading may be efficient, but at the same time, limited information becomes available for spelling, which relies on high-quality orthographic representations. Since 1980, several studies have replicated Frith’s findings in both children and adults (e.g., Holmes & Castles, 2001; Holmes & Ng, 1993; Holmes & Quinn, 2009). Although Frith’s conclusion regarding the less adequate orthographic representations of unexpected poor spellers has been endorsed (Holmes & Castles, 2001; Holmes & Ng, 1993; Holmes & Quinn, 2009), Holmes and Quinn (2001) proposed an alternative explanation according to which the underspecified orthographic representations of poor spellers may not be a consequence of a partial-cue reading strategy, but a result of inadequate practice of accurate spelling by poor spellers.

Unexpected spelling deficits have also been linked to problems in phonological processing, even though there is less agreement among researchers regarding their impact. Wimmer and Mayringer (2002), for example, found that good readers/poor spellers performed significantly worse than good readers/good spellers in phonological short-term memory and phonological awareness. They argued that an efficient memory storage for orthographic word patterns is based on multiple associations between the phonological segments of a word and the letters of its written form. Landerl and Wimmer (2008) further argued that children with

phonological deficits might not be able to establish such associations. This seems to be in line with the findings of studies with unselected samples of German-speaking children showing that phonological awareness and phonological short-term memory are significant predictors of spelling, but not of reading fluency (e.g., Landerl & Wimmer, 2008; Mann & Wimmer, 2002; Mayringer, Wimmer, & Landerl, 1998; Moll et al., 2014). However, working with a group of third- and fourth-grade German-speaking children, Moll and Landerl (2009) failed to find differences between good readers/poor spellers and good readers/good spellers in phonological awareness. Similarly, Chatzoudi and Papadopoulos (2013) found no significant differences between groups on phonological short-term memory in Greek. Thus, the role of phonological processing in unexpected reading and spelling deficits warrants further investigation.

The second dissociation indicates that some children experience reading difficulties in the presence of adequate spelling. Lovett (1987) identified a group of 10-year-old English-speaking Canadian children who were slow (albeit accurate) readers but as accurate in spelling as normal readers. Wimmer and Mayringer (2002) also found that 4% of their sample in Study 1 and 6% of their sample in Study 2 were slow readers with no reliable spelling deficits. Dysfluent reading in consistent orthographies, such as Finnish, German, Greek, Italian, Spanish, or Dutch is the norm for poor readers because these orthographies have relatively consistent grapheme-phoneme correspondences in reading that allow even poor readers to read accurately, albeit slowly (e.g., de Jong & van der Leij, 2003; Escribano, 2007; Landerl et al., 1997; Lyytinen et al., 2008; Mouzaki & Sideridis, 2008; Tressoldi, Stella, & Faggella, 2001; Wimmer, 1993).

It is, however, surprising that children with high-quality orthographic representations (as indexed by their good spelling) can be dysfluent readers. Could these children use their orthographic knowledge for spelling, but not for reading? Wimmer and Mayringer (2002) found

that these readers exhibited a pronounced naming speed deficit. The fluency problem might originate from extensively practiced phonological recoding, which helps children develop their orthographic representations (see self-teaching hypothesis by Share, 1995). However, because of overreliance on phonological recoding, children do not move quickly from a sequential processing of letters to a parallel processing of letters. In turn, Moll and Landerl (2009) suggested that this performance pattern may be due to unexpectedly slow access to orthographic representations. As spelling is generally slower than reading, a deficit in the speed with which orthographic representations are accessed would impact word recognition speed, but not spelling accuracy.

Rapid automatized naming (RAN), an index of the speed of lexical access, has long been identified as a marker of reading speed deficits in several consistent orthographies (e.g., Brizzolara et al., 2006; de Jong & van der Leij, 2002; Eklund et al., 2013; Georgiou, Parrila, Manolitsis, & Kirby, 2011; Landerl et al., 2013; Wimmer, Mayringer, & Landerl, 1998). In the only study that examined the role of RAN in the context of unexpected reading and spelling deficits, Wimmer and Mayringer (2002) confirmed that poor readers/good spellers suffered from a selective RAN deficit. On the other hand, the group of good readers/poor spellers did not experience RAN deficits. An explanation for the pronounced deficits of poor readers/good spellers on RAN may relate to the way reading and spelling have been measured. More specifically, because RAN is a speeded measure, selecting poor readers in consistent orthographies with reading fluency measures, may have inflated the role of RAN. In contrast, selecting poor spellers with spelling accuracy measures (as in Wimmer & Mayringer, 2002 or Moll & Landerl, 2009), may have deflated the role of RAN. Examining the role of RAN in the context of unexpected reading and spelling deficits is interesting in light of Bowers and Wolf's

(1993) proposal, according to which RAN is related to reading because of its contribution to the development of orthographic knowledge. If RAN contributes to the development of orthographic knowledge and spelling relies on good orthographic knowledge, RAN should be deficient in the group of good readers/poor spellers. However, more recent studies challenged the role of RAN in orthographic processing (e.g., Bowey & Miller, 2007; Conrad & Levy, 2007; Lervåg, Bråten, & Hulme, 2009). Certainly, the role of RAN in reading and spelling deficits needs to be further examined.

The Present Study

The purpose of this longitudinal study was to examine double dissociation between reading and spelling and the role of cognitive (letter knowledge, phonological awareness, and RAN) and non-cognitive (home literacy environment and task avoidance) factors as precursors of this dissociation in a highly transparent orthography (Finnish). The present study makes four important contributions to the literature: First, to our knowledge, this is the first longitudinal study on double dissociation following the same children from kindergarten until Grade 4. We assessed the emergent literacy skills of children before they had been exposed to formal reading or spelling instruction. If the cognitive basis of reading and spelling deficits differs, the kindergarten cognitive profiles of the deficit groups might differ as well. Because reading in our study was operationalized with reading fluency measures (due to lack of variability in reading accuracy measures in Finnish) and spelling with an accuracy measure, we expected that slow reading would be associated with slow RAN (e.g., de Jong & van der Leij, 2002; Eklund et al., 2013; Georgiou et al., 2011; Landerl et al., 2013; Wimmer et al., 1998) and inaccurate spelling would be associated with phonological problems (e.g., Furnes & Samuelsson, 2011; Landerl & Wimmer, 2008; Mayringer et al., 1998; Moll et al., 2014; Niolaki, Masterson, & Terzopoulos,

2013). Second, letter knowledge in kindergarten has been found to be a key predictor of reading and spelling skills (e.g., Georgiou et al., 2012; Kirby, Parrila, & Pfeiffer, 2003; Leppänen, Niemi, Aunola, & Nurmi, 2004; Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2004; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004), and in the present study the role of letter knowledge is for the first time examined with respect to unexpected reading and spelling deficits. We expected it to be deficient in both the unexpected poor readers' and the unexpected poor spellers' groups. Third, unlike previous studies, the children in each of our deficit groups were selected based on persistently deficient performance on reading/spelling. More specifically, we selected our dissociated groups based on a performance at least one standard deviation below mean on reading/spelling in three out of four measurement times. This is important, as it reduces the possibility of including children in either group because of a temporary failure in one of the measures at a specific grade level.

We also examine the role of non-cognitive factors (home literacy environment and task avoidance) in unexpected reading and spelling deficits. Home literacy environment, an umbrella term that encapsulates diverse facets of experiences with written speech that children engage in with their parents, has been found to predict future reading (e.g., Manolitsis, Georgiou, & Parrila, 2011; Sénéchal, 2006; Stephenson, Parrila, Georgiou, & Kirby, 2008; Torppa et al., 2006) and spelling (e.g., Hood, Conlon, & Andrews, 2008; Niklas & Schneider, 2013; Sénéchal, 2006). We included two commonly used measures of home literacy environment: direct teaching of literacy skills and the amount of parent-child shared book reading (Sénéchal, 2006). We assume that the effects of the home literacy environment on word reading and spelling are likely to be mediated by letter knowledge and phonological awareness (e.g., Manolitsis et al., 2011; Niklas & Schneider, 2013; Sénéchal, 2006; Torppa et al., 2007). Thus, if good readers/poor spellers have a

deficit in letter knowledge and/or phonological awareness then this may also be manifested in lower scores (less engagement by parents in reading activities with their children at home) in early home literacy environment.

Several studies investigating student's motivation have also shown that task avoidance, the extent to which a child chooses to avoid approaching or completing a task rather than investing effort, particularly as task demands increase, is a unique predictor of reading (e.g., Georgiou, Manolitsis, Zhang, Parrila, & Nurmi, 2013; Onatsu-Arvilommi & Nurmi, 2000) and spelling (e.g., Georgiou, Manolitsis, Nurmi, & Parrila, 2010; Liao, Georgiou, Zhang, & Nurmi, 2013). Reading proficiency in Finnish can be achieved relatively effortlessly (Lerkkanen et al., 2004), but learning to spell poses more difficulties for children (Aro, 2004; in press). Although words can be spelled phoneme-by-phoneme in Finnish, spelling requires more detailed phonological analysis than reading. For example, learning the rule that short versus long phonemes are marked differently, with single versus double letter (e.g., *tuli*-fire vs. *tuuli*-wind) takes more time than acquisition of accurate reading. It is quite common even among older Finnish children to make these type of errors in spelling, whereas the majority of them learn to read with almost 100% accuracy by mid-Grade 1. Thus, task avoidance should exert a stronger effect on spelling than on reading (Georgiou et al., 2010; Hirvonen, Georgiou, Lerkkanen, Aunola, & Nurmi, 2010). In other words, our good readers/poor spellers should demonstrate more task avoidance than good readers/good spellers.

Method

Participants and Procedure

The children of this study are participants in an extensive longitudinal study (AUTHORS, 2006) in which a community sample of about 2,000 Finnish children are followed yearly from

kindergarten age onwards. There were altogether 2,133 children participating in at least one of the assessments in Grades 1, 2, 3, and 4 (the spring term). In this study, we included all those who had participated in at least three of the four school-age assessment waves (Grades 1 to 4, n = 1963). Most of the participants also had data on their early reading-related skills in the fall term of kindergarten (n = 1,624), and in the spring term of kindergarten (n = 1,632) year. Ninety-eight percent of the age cohort participated in kindergarten education although it was optional in Finland at that time. Therefore, the reasons for the increase in the number of participants in Grade 1 were that not all the children had attended kindergarten (these children were recruited at school entry), new families had also moved to these locations when school started, and few children who were one year older than the others had repeated first grade. However, our analyses did not show any differences with respect to the major study variables between the children who dropped out of the study and those who did not. In Finland, children start their nine-year comprehensive school in the fall of the year in which they turn seven. Six-year-olds are entitled to kindergarten education for one year before school entrance. Finnish kindergarten education is not divided into subject area lessons; instead, it focuses on children's social skills and learning through playful activities. Although children's development in phonological awareness and letter knowledge and their interest towards reading is supported in kindergarten (Lerkkanen et al., 2012), systematic literacy instruction using phonics-based methods does not begin before Grade 1 (Soodla, Lerkkanen, Kikas, Niemi, & Nurmi, 2015).

Participants were recruited from three medium-sized towns and one municipality, two in Central, one in South-West, and one in Eastern Finland. We used data from the fall assessment in kindergarten (September 2006) as wells as spring assessments in kindergarten (April 2007), Grade 1 (April 2008), Grade 2 (April 2009), Grade 3 (April 2010), and Grade 4 (April, 2011).

At the beginning of the study, parents and teachers were asked for written consent. Of the parents who were contacted, 78–89%, depending on town or municipality, agreed to take part in the study. The sample was comparable to the general population in terms of parental educational level (Statistics Finland, 2007): 6% had the nine-year compulsory education (6% in the general population), 30% had completed a secondary education (30% in the general population), 36% had a bachelor's degree or vocational college degree (35% in the general population), and 28% had a master's degree or higher (29% in the general population).

Measures

Children's reading fluency and spelling accuracy were assessed in Grades 1, 2, 3, and 4, with group tests administered by trained testers in the children's classrooms. In the kindergarten fall (September) term, phonological awareness and letter knowledge were assessed, and in the spring (April) term, phonological awareness, rapid automatized naming, and letter knowledge were assessed in individual test sessions. The testers were undergraduate students in education or psychology. In a one-week period, they received eight hours of training and three hours of practice. In addition, questionnaires were used to collect data on children's task avoidance from teachers and testers and home literacy environment measures from mothers and fathers (frequency of teaching literacy and shared book reading) in the spring kindergarten term.

Reading fluency. Two group-administered tests were used to assess reading fluency: a sentence reading and a word-reading fluency task. The word-reading fluency task is a subtest of the nationally normed reading test battery (ALLU; Lindeman, 2000). Each of the 80 items consisted of a picture with four phonologically similar words attached to it. The child silently read the four words and then drew a line connecting the picture with the word, semantically matching it. The words and pictures were easy and frequently used words by very young

children. The score was the number of correct answers within a two-minute time limit. The Test of Silent Reading Efficiency and Comprehension (TOSREC; Wagner, Torgesen, Rashotte, & Pearson, 2009; the Finnish version was developed by Lerkkanen & Poikkeus, 2009) was also used to assess silent reading efficiency. Children were given three minutes to read 60 sentences and verify the truthfulness of as many sentences as possible. The Cronbach's alphas for the reading fluency task composites were .86 for Grade 1, .82 for Grade 2, .82 for Grade 3, and .83 for Grade 4.

Spelling to dictation. Spelling to dictation was assessed with a pseudoword spelling task that included eight items. The test was adopted from the task developed in Jyväskylä Longitudinal Study of Dyslexia and has been used in several previous studies (e.g., Puolakanaho et al., 2007; Torppa, Parrila, Niemi, Lerkkanen, Poikkeus, & Nurmi, 2013). The children were asked to write on a piece of paper the pseudowords that the tester dictated one by one. Each item was presented orally twice. In Grades 1 and 2, the pseudowords were four to nine letters long (e.g., kirk, raalsku, hiuruutti). In turn, in Grades 3 and 4, the pseudowords were four to 11 letters long (e.g., vuil, paunitteri, nuppasengit) and included the most difficult letter-to-sound combinations (diphthongs and double consonants). Kuder-Richardson reliability coefficient in our sample was .76 for Grade 1, .65 for Grade 2, .57 for Grade 3, and .49 for Grade 4.

Phonological awareness. The initial phoneme identification test from the ARMI test battery (Lerkkanen, Poikkeus, & Ketonen, 2006) was used to assess phonological awareness in kindergarten. ARMI is a test battery for reading-related cognitive skills and reading development in Grade 1 with national norms. The children viewed a row of four pictures of objects, which the experimenter named. The experimenter then asked "At the beginning of which word do you hear the sound /?/" and children had to point to the correct picture. All sounds were single phonemes.

The score was the number of correct responses (max = 10). Kuder-Richardson reliability coefficient in our sample was .78 in the fall and .76 in the spring.

Letter knowledge. The children named all 29 letters in the Finnish language in kindergarten, which were randomly arranged in three rows (the ARMI test battery; Lerkkanen et al., 2006). The children named the letters, one row at a time, while the other rows were covered. The score was the number of correctly named letters (max = 29). Kuder-Richardson reliability coefficient in our sample was .96 in the fall and .94 in the spring.

Rapid automatized naming (RAN). RAN was assessed in kindergarten using the standard procedure (see Denckla & Rudel, 1976) in which children are asked to name as fast as possible a series of five objects (fish, car, house, pen, and ball; kala, auto, talo, kynä, and pallo in Finnish) arranged in semi-random order in five rows of 10. A practice trial preceded the test to ensure that each child was familiar with the objects. The total time to name all stimuli served as the children's score. Only a few errors occurred, and for this reason, they were not considered further. Split-half reliability coefficient in our sample was .80.

Task avoidance. The kindergarten teachers were asked to evaluate the children's task-avoidant behaviour using the Behavior Strategy Rating Scale (Onatsu-Arvilommi & Nurmi, 2000; see also Zhang et al., 2014 for the psychometric properties of the task), which uses a 5-point scale (1 = not at all, and 5 = to a great extent). The following five items were used: *(a) "Does the child have a tendency to find something else to do instead of focusing on the task at hand?" (b) "If the activity or task is not going well, does the child lose his/her focus?" (c) "Does the child give up easily?" (d) "Does the child actively attempt to solve even difficult situations and tasks?"* (reversed)*, and (e) "Does the child demonstrate initiative and persistence*

in his/her activities and tasks?" (reversed). A participant's score was the average of the five items. Cronbach's alpha reliability coefficient in our sample was .92.

Testers also assessed each child's task-avoidant behaviour using the task avoidance subscale in the Observer-rating Scale of Achievement Strategies (OSAS; Nurmi & Aunola, 1998; Zhang et al., 2014). The task contains four items, of which two are positively worded ("Although the task turns difficult for the child, s/he tries hard to finish it."; "The child tries persistently to do the task.") and two are negatively worded "(If there are problems with the task, the child starts doing something else."; "If the child cannot cope with the task, s/he becomes interested in other things in the room."). After testing each child on an individual basis, the testers were asked to consider how the child's behaviour unfolded as the task became more difficult and then to rate his or her behaviour on a 7-point scale (1 = not at all; 7 = always or almost all the time this kind of behaviour). A participant's score was the average of the four items. Cronbach's alpha reliability coefficient in our sample was .80.

Home Literacy Environment. The home literacy environment was assessed with a questionnaire for mothers and fathers. Parents were asked to rate the teaching of reading by answering the following questions: "How often do you teach/have previously taught letters to your child?" and "How often do you teach/have previously taught your child to read?" on a 5-point Likert scale (1 = not at all/very rarely to 5 = very often/daily). Cronbach's alpha reliability coefficient in our sample was .74 and .78 for mothers and fathers, respectively. Parents were also asked to rate shared book reading by answering the following question: "How often do you read to your child/read books together with your child?" on a 5-point Likert scale (1 = less than once a week, 2 = 1–3 times a week, 3 = 4–6 times a week, 4 = once a day, and 5 = more than once a day).

Results

Identification of Children with Spelling and Reading Fluency Difficulties

The children who performed at least one standard deviation below the mean of the whole sample on at least three out of the four test points on either the pseudoword spelling task or on the composite of the two reading fluency tasks, or in both were identified as having persistent difficulties. Four groups were formed: good readers/good spellers who had no difficulties in reading and spelling skills in any of the assessments (n = 1,090, 55.5%), children with reading difficulties only (RD group, n = 36, 1.8%), children with spelling difficulties only (SD group, n = 41, 2.1%), and children with both reading and spelling difficulties (RSD group, n = 59, 3.0%). Note that because we focused on the persistent cases of reading and/or spelling deficits to increase the reliability of our classification, the children who had one or two incidences of difficulties in reading and/or spelling were omitted from the comparison analyses (n = 737, 37.5%).

Descriptive Statistics and Group Comparisons

Before performing any comparison analyses, we examined the distributional properties of the measures used in the study, separately for each group. The distributions of the reading fluency measures and RAN were close to normal. The distributions of phoneme identification, letter knowledge, and spelling were negatively skewed. Therefore, all analyses were conducted with both parametric and nonparametric methods. However, because no differences emerged between the results of the parametric and nonparametric analyses, we report here only the results of the parametric analyses.

Table 1 reports means, standard deviations, and group comparisons (one-way ANOVA results), and Appendix A reports the effect sizes in the reading and spelling skills assessed in

Grades 1–4. On word reading fluency, all groups differed significantly from each other in Grades 1–2. In Grades 3 and 4, the difference between the RD group and the RSD group on word reading fluency was no longer significant. In addition, the SD group caught up with the good readers/good spellers group in word reading fluency by Grade 3, but were significantly slower readers in sentence reading fluency task in all grades. On sentence reading fluency, all groups differed from each other significantly in all grades. On spelling, the RD group and good readers/good spellers were not significantly different in any of the grades, although the effect size for Grade 1 was large (-.84). Both the SD and RSD groups were poorer in spelling than the RD and good readers/good spellers groups in all grades. In Grade 4, the difference between the SD group and the RSD group in spelling disappeared. Figure 1 depicts reading and spelling development in all four groups.

Table 2 reports means, standard deviations, and group comparisons, and Appendix B reports the effects sizes in kindergarten measures of cognitive skills, home literacy environment, and task avoidance. The good readers/good spellers group had the highest performance in kindergarten cognitive skills, and the reading and spelling deficit (RSD) group had the lowest performance. The reading only deficit (RD) group was poorer than the good readers/good spellers group in letter knowledge and RAN, whereas the spelling only deficit (SD group) was poorer than the good readers/good spellers group in phoneme identification and letter knowledge. The RD group was as poor as the RSD group in RAN, but outperformed the RSD group in all other assessed kindergarten skills. The SD group was as poor in kindergarten skills as the RSD group except from their better performance in RAN and spring letter knowledge. The RD and SD groups were similar in kindergarten skills except for the poorer phoneme identification skill in the kindergarten spring term in the SD group.

The comparisons on task avoidance showed that the RSD and SD groups were reported to be more task avoidant by both their kindergarten teachers and the tester of the children than the good readers/good spellers group. There were no differences between the RD and SD groups or RD and good readers/good spellers group. The comparisons on home literacy environment showed that the frequency of teaching literacy skills (letters and reading) at home or the mother's shared reading frequency with the child did not differentiate between groups. However, the father's shared reading frequency with the child showed significant differences: fathers reported reading less with their child in the RSD and RD groups than in the SD or good readers/good spellers groups.

To summarize, our findings suggest that there are discernible double dissociation groups with distinct cognitive profiles in our sample. The differences between the groups with and without difficulties grew larger each year in reading fluency, but not in spelling. The comparison of the kindergarten cognitive skills revealed that the RSD group had the lowest performance in all skills, the SD group had problems in phoneme identification and letter knowledge, but not in RAN, and the RD group had difficulties in RAN and letter knowledge, but not in phoneme identification. The RSD and SD groups also showed increased levels of task avoidance, and the amount of father's shared reading with their child was lower in the RD and RSD groups than in the other two groups.

Discussion

This longitudinal study examined double dissociation between reading and spelling in a highly transparent orthography (Finnish) and the role of kindergarten cognitive (letter knowledge, phonological awareness, and RAN) and non-cognitive (home literacy environment and task avoidance) factors in the dissociated patterns. In regard to our first goal, we identified a substantial number of children that fit the profile of unexpected poor spellers and readers. With

the strict criteria of persistent poor performance in reading and/or spelling in at least three out of four measurement points, 2% of our sample had persistent deficits in spelling despite their fluent reading, and 2% of our sample had persistent deficits in reading fluency despite their normal spelling. Also, 3% of our sample had deficits in both skills. Kindergarten cognitive skills, task avoidance, and fathers' shared reading with their child differentiated between the groups, suggesting that partially different precursors underlie unexpected reading and spelling difficulties.

The identification of double dissociation groups despite the transparency of the orthography and the stringent criteria (requiring persistent reading and/or spelling difficulties) complements the findings of previous studies on this topic conducted in less transparent alphabetic orthographies than Finnish (Greek: Chatzoudi & Papadopoulos, 2013; German: Moll & Landerl, 2009; Wimmer & Mayringer, 2002). Our identification procedure, which was based on persistent difficulties, minimized the chance of misclassification due to measurement issues. The group differences on reading and spelling were clear in each grade, and the differences between the groups with and without difficulties in reading even seemed to increase over the years. It is interesting that the dissociated groups were identified in a Finnish sample. Finnish orthography is consistent from graphemes to phonemes and from phonemes to graphemes with almost no exceptions. This makes reading Finnish very straightforward, and reading errors are rare, even for poor readers after the beginning stages of reading acquisition (e.g., Aro, 2004, in press). However, slow reading and erroneous spelling are not uncommon in Finnish (see Eklund et al., 2015; Kairaluoma et al., 2013; Landerl et al., 2013). These findings show that reading and spelling difficulties do not necessarily co-occur and support the development of clear diagnostic criteria and early intervention programs that would target each condition.

The second goal of our study was to examine the precursors of double dissociation between reading and spelling. We assessed these precursors in kindergarten when formal literacy instruction had not yet begun because we wanted to minimize the effects that teaching and the development of reading and spelling skills may have on cognitive skills (see Perfetti, Bell, & Hughes, 1986, for a reciprocal relationship between phonological awareness and reading and Compton, 2003, for a reciprocal relationship between RAN and reading). Notice that the Finnish kindergarten curriculum does not include direct teaching of reading and spelling, although letters are usually introduced in a play-like fashion. As expected, the group with both reading and spelling difficulties (RSD) had the greatest difficulties, and they performed more poorly on all kindergarten cognitive skills than good readers/good spellers and more poorly than the RD group on most of the tasks. This performance profile aligns well with that of children with dyslexia, who have been shown in several previous studies to have deficits in RAN (e.g., de Jong & van der Leij, 2013; Georgiou, Papadopoulos, Zarouna, & Parrila, 2012; Wimmer, 1993), letter knowledge (e.g., Eklund, Torppa, & Lyytinen, 2013; Lervåg, et al., 2009; Torppa et al., 2006), and phonological awareness (e.g., Landerl et al., 2013; Nikolopoulos, Goulandris, & Snowling, 2003). Previous studies on double dissociation between reading and spelling have also shown that the group with both reading and spelling difficulties has the most severe cognitive difficulties (e.g., Chatzoudi & Papadopoulos, 2013; Fayol et al., 2009; Moll & Landerl, 2009).

The early skills of the unexpected poor readers and spellers are of great interest. Although these groups did not differ significantly from each other on any of the assessed kindergarten measures, comparisons to the RSD group and to the good readers/good spellers revealed some interesting differences. The unexpected poor readers' group had particular

difficulties in RAN and letter knowledge, whereas the unexpected poor spellers group had the clearest difficulties in phonological awareness and letter knowledge.

The RD group performed relatively well on the phonological skills, but differed from the group of good readers/good spellers in RAN and letter knowledge. It should be noted, however, that their letter knowledge was already high at the end of kindergarten (they could recognize more than 21 letters out of 29). Their level of letter knowledge should thus not explain subsequent problems in reading directly. Their relative problem in letter knowledge likely reflects other problems underlying both reading and letter knowledge and which likely cause slower development in both. In Finnish, development of letter knowledge has been found to be predicted by phonological awareness, short-term memory, and RAN (Torppa et al., 2006). The identification of problems in RAN in the group of dysfluent readers fits nicely in with the findings of previous studies showing a link between RAN and reading fluency in consistent orthographies (e.g., Brizzolara et al., 2006; Caravolas et al., 2012; de Jong & van der Leij, 2002; Eklund et al., 2013; Georgiou, Parrila, Cui, & Papadopoulos, 2013; Landerl & Wimmer, 2008; Lervåg et al., 2009) and challenge Bowers and Wolf's (1993) theoretical account according to which RAN is involved in the development of orthographic knowledge. Children in the RD group learned to read and spell accurately, but had problems developing reading fluency. There might be four explanations for this finding: First, it may reflect difficulties in accessing orthographic representations (e.g., Moll & Landerl, 2009). Second, it may reflect slow orthographic-phonological connectivity (e.g., Wimmer & Schurz, 2010). Third, it may reflect overreliance on phonological recoding skills, which are necessary for the development of orthographic representations (used in spelling), but insufficient for the development of reading fluency (e.g., Wimmer & Mayringer, 2002). Finally, this result may be an artefact of the

selection procedure since RAN is a speeded task and poor readers have been selected using reading fluency measures.

The unexpected poor spellers (SD) group had problems in phonological awareness and letter knowledge, but not in RAN. These findings are in line with those of previous studies (e.g., Furnes & Samuelsson, 2011; Moll et al., 2014; Wimmer & Mayringer, 2002). Despite the short-lived importance of phonological awareness as a predictor of reading in Finnish (e.g., Silvén, Poskiparta, Niemi, & Voeten, 2007; Torppa et al., 2015) and in other transparent orthographies (e.g., Georgiou, Parrila, & Papadopoulos, 2008; Mann & Wimmer, 2002), it has been shown to be an important predictor of spelling (e.g., Babayiğit & Stainthorp, 2010; Caravolas et al., 2012; Furnes & Samuelsson, 2011). The importance of phonological awareness in general and phoneme identification in particular is easy to understand in the case on Finnish. Considering spelling, Finnish features long and short vowels and consonants. In writing, the length of the sound is marked with one letter reflecting a short sound and two letters reflecting a long sound. The difference in words such as mato (worm) and matto (carpet), despite the consistent grapheme-phoneme mapping, requires a refined analysis of sounds and letters and are also a challenge for beginning spellers in Finnish. Errors in marking the double vowels and consonants are among the most common spelling errors. The link between problems in phoneme identification and inaccurate spelling in Finnish is thus expected, particularly when a pseudoword spelling task is used.

In addition to problems in kindergarten cognitive skills, the RSD group had the highest level of task-avoidant behaviour based on both teachers' and testers' scoring. In the process of becoming a proficient reader and speller, the combination of poor cognitive skills and a high level of task-avoidant behaviour can be very problematic (see Eklund et al., 2013). It is possible

that the RSD children had low motivation towards kindergarten literacy-related activities (reflected in the kindergarten teachers' evaluation) and also during individual assessment situations (reflected in the testers' evaluations). However, it is also possible that task avoidance taps self-regulation or inattention that co-exists with reading and spelling disability (e.g., Willcutt et al., 2007). Previous studies have shown links between task avoidance and reading (e.g., Georgiou et al., 2013; Onatsu-Arvilommi & Nurmi, 2000) as well as between task avoidance and spelling (e.g., Georgiou et al., 2010; Liao et al., 2013). In this study, however, the RD group did not demonstrate task avoidance. The RSD and SD groups, on the other hand, were more task avoidant than the group of good readers/good spellers. Taken together, these findings suggest that there is no association between task avoidance and unexpected poor reading, unless poor reading is accompanied by poor spelling.

In regards to home learning environment, we found that mother's and father's teaching of literacy skills as well as mother's amount of shared book reading did not differentiate between groups. In contrast, father's shared reading was less frequent in the RD and RSD groups than in the SD group or among the children with no deficits in reading and spelling. There might be two explanations for the relatively weak contribution of home literacy environment in double dissociation between reading and spelling. First, some researchers have suggested that in orthographies with high forward consistency (e.g., Finnish, Greek), parents do not engage in teaching literacy skills unless they notice that their children experience some difficulties (e.g., Manolitsis, Georgiou, & Tziraki, 2013; Silinskas et al., 2012; Torppa et al., 2007). Given that we assessed home learning environment before children had received formal reading and spelling instruction and possibly before showing any signs of problems, we may have reduced our chances of finding significant differences between the groups. It is also possible that the results

reflect fathers' literacy skills that were not assessed here (e.g., Grigorenko, 2001; Lyytinen et al., 2008; Olson, 2006; van Bergen, de Jong, Plakas, Maassen, & van der Leij, 2012). Father's poor reading skills may for example be manifested in the low amount of shared reading with their children.

Some limitations of the present study are worth mentioning. First, our constructs were based mostly on single tasks. The large longitudinal sample is beneficial in many ways, but sets limits to the number of measures that can be included. Because of the large longitudinal sample, we were able to employ a strict cut-off score for the identification of difficulties in reading and spelling and to use multiple measurement points in identification. This allowed us to select persistent cases and increase the reliability of the identification process. We are confident that the children who were identified as having difficulties in reading and/or spelling were true cases, despite the single measure of spelling in each time point. It is, however, possible that we would have identified more cases had we had a more comprehensive and reliable spelling measure. Second, focusing on the persistent cases caused us to discard a large proportion of the data, and further analyses should also examine the development of reading and spelling in the complete data. However, for the reliable identification of clinically important extreme groups, our decision is considered valid. Third, to give a more detailed description of the cognitive profiles of the groups, a more detailed assessment of early skills is needed. Future studies should also examine the role of vocabulary, paired associate learning, and orthographic processing because of their documented relationship with both reading and spelling development (e.g., Caravolas, Vólin, & Hulme, 2005; Georgiou et al., 2008; Lervåg et al., 2009). Fourth, although our reading tasks were speeded, our spelling task assessed accuracy. This may have inflated the role of RAN in the group of poor readers/good spellers and the role of phonological awareness (assessed with an

accuracy task) in the group of good readers/poor spellers. Future studies should consider possibilities to assess spelling fluency in order to test whether the nature of the literacy outcome impacts the type of underlying cognitive deficits. Finally, the reliability coefficients of our spelling task were relatively low and declined across time. This is due to the relatively small number of items and the high performance in spelling which reduced variability observed in the later grades. In transparent orthographies, accuracy in spelling and reading become close to perfect for those without specific difficulties very early on. After the early grades, even in pseudoword dictation tasks, only the children with spelling difficulties continue to make errors in spelling tasks. Thus, it could be argued that for the purpose of our study (identifying children with spelling problems in Finnish), the task worked well, particularly given the fact that we defined spelling problems on the basis of persistent difficulties across several time-points.

To conclude, double dissociation between reading and spelling can be identified even in an orthography with a high backward and forward consistency. The cognitive and non-cognitive requirements for reading and spelling also differ, as reflected in the findings of the different profiles of early cognitive skills and task avoidance. These findings suggest that identification of literacy-related difficulties in Finnish and the planning of teaching and remediation practices should include both reading and spelling assessments. The findings also support the separate diagnosis criteria for reading and spelling. Some definitions of dyslexia combine reading and spelling difficulties (e.g., the International Dyslexia Association and British Dyslexia Association), whereas ICD-10 separates reading disorders, dyslexia, spelling disorders, and dysorthographia. DSM-5 combines reading and spelling difficulties (as well as math) under “specific learning disorder” (American Psychological Association, 2013), but stresses the separate coding of each deficit. Although for many individuals, reading and spelling difficulties

coincide and the combined criteria may be a good choice for research purposes, there are individuals with clearly dissociated skills in reading and spelling. To understand better the cognitive basis of the dissociated groups, future studies should, however, use more specific predictors, as the cognitive differences were surprisingly mild despite the clear differences in reading and spelling. Further investigation of the mechanisms linking environmental, instructional, and motivational factors to reading and spelling is also warranted, as our findings indicate differences in these domains before school entry.

References

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

Aro, M. (in press). In L. T. W. Verhoeven & C. A. Perfetti (Eds.), Reading acquisition across languages and writing systems: An international handbook. Cambridge: University Press.

Babayiğit, S., & Stainthorp, R. W. (2010). Component processes of early reading, spelling, and narrative writing skills in Turkish: A longitudinal study. *Reading and Writing, 23,* 539–568. doi: 10.1007/s11145-009-9173-y

Bowers, P. G., & Wolf, M. (1993). Theoretical links among naming speed, precise timing mechanisms and orthographic skills in dyslexia. *Reading and Writing, 5,* 69–85. doi: 10.1007/BF01026919

Bowey, J. A., & Miller, R. (2007). Correlates of orthographic learning in third-grade children's silent reading. *Journal of Research in Reading, 30,* 115-128. doi: 10.1111/j.1467-9817.2007.00335.x

Brizzolara, D., Chilosi, A. M., Cipriani, P., Di Filippo, G., Gasperini, F., Mazzotti, S.,…Zoccolotti, P. (2006). Do phonologic and rapid automatized naming deficits differentially affect dyslexic children with and without a history of language delay? A study of Italian dyslexic children. *Cognitive and Behavioral Neurology, 19,* 141–149. doi: 10.1097/01.wnn.0000213902.59827.19

Caravolas, M., Lervåg, A., Mousikou, P., Efrim, C., Litavsky, M., Onochie-Quintanilla, E. et al. (2012). Common patterns of prediction of literacy development in different alphabetic orthographies. *Psychological Science, 23,* 678–686. doi:10.1177/0956797611434536

Caravolas, M., Vólin, J., & Hulme, C. (2005). Phoneme awareness is a key component of alphabetic literacy skills in consistent and inconsistent orthographies: Evidence from Czech and English children. *Journal of Experimental Child Psychology, 92,* 107–139. doi: 10.1016/j.jecp.2005.04.003

Cardoso-Martins, C., & Pennington, B. F. (2004). The relationship between phoneme awareness and rapid serial naming skills and literacy acquisition: The role of developmental period and reading ability. *Scientific Studies of Reading,* 8, 27–52. doi:10.1207/s1532799xssr0801_3

Chatzoudi, D., & Papadopoulos, T. C. (2013, July). *A longitudinal analysis of component reading and spelling skills among young learners of varying reading and spelling ability*. Paper presented at the 13th European Congress of Psychology (ECP), Stockholm, Sweden.

Compton, D. L. (2003). Modeling the relationship between growth in rapid naming speed and growth in decoding skill in first-grade children. *Journal of Educational Psychology, 95,* 225–239. doi: 10.1037/0022-0663.95.2.225

Conrad, N. J., & Levy, B. A. (2007). Letter processing and the formation of memory representations in children with naming speed deficits. *Reading and Writing, 20,* 201-223. doi: 10.1007/s11145-006-9028-8

de Jong, P.F., & van der Leij, A. (2002). Effects of phonological abilities and linguistic comprehension on the development of reading, *Scientific Studies of Reading, 6*, 51–77. doi:10.1207/S1532799XSSR 0601_03.

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

Denckla, M. B., & Rudel, R. G. (1976). Rapid "automatized" naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia, 14,* 471–479. doi:10.1016/0028-3932(76)90075-0

Desimoni, M., Scalisi, T. G., & Orsolini, M. (2012). Predictive and concurrent relations between literacy skills in Grades 1 and 3: A longitudinal study of Italian children. *Learning and Instruction, 22,* 340–353. doi:10.1016/j.learninstruc.2012.02.002

Eklund, K. M., Torppa, M., & Lyytinen, H. (2013). Predicting reading disability: Early cognitive risk and protective factors. *Dyslexia, 19,* 1–10. doi: 10.1002/dys.1447.

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

Escribano, C. L. (2007). Evaluation of the double-deficit hypothesis subtype classification of readers in Spanish. *Journal of Learning Disabilities, 40,* 319–330. doi: 10.1177/00222194070400040301

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

Frith, U. (1978). From print to meaning and from print to sound, or how to read without knowing how to spell. *Visible Language,* 12, 43–54.

Frith, U. (1980). Unexpected spelling problems. In U. Frith (Ed.), *Cognitive processes in spelling* (pp. 495–515). London: Academic Press.

Furnes, B., & Samuelsson, S. (2011). Phonological awareness and rapid automatized naming predicting early development in reading and spelling: Results from a cross-linguistic longitudinal study. *Learning and Individual Differences, 21*, 85–95. doi:10.1016/j.lindif.2010.10.005

Georgiou, G., Parrila, R., Cui, Y., & Papadopoulos, T. C. (2013). Why is rapid automatized naming related to reading? *Journal of Experimental Child Psychology, 115*, 218–225. doi: 10.1016/j.jecp.2012.10.015

Georgiou, G., Manolitsis, G., Zhang, X., Parrila, R., & Nurmi, J.-E. (2013). Examining the developmental dynamics between achievement strategies and different literacy skills. *International Journal of Behavioral Development, 37*, 173–181. doi: 10.1177/0165025413477007

Georgiou, G., Manolitsis, G., Nurmi, J.-E., & Parrila, R. (2010). Does task-focused versus task avoidance behavior matter for literacy development in an orthographically consistent language? *Contemporary Educational Psychology, 35*, 1–10. doi:10.1016/j.cedpsych.2009.07.001

Georgiou, G., Papadopoulos, T. C., Zarouna, E., & Parrila, R. (2012). Are auditory and visual processing deficits related to developmental dyslexia? *Dyslexia, 18*, 110–129. doi: :10.1002/dys.1439

Georgiou, G., Parrila, R., Manolitsis, G., & Kirby, J. (2011). Examining the importance of assessing rapid automatized naming (RAN) speed for the identification of children with reading difficulties. *Learning Disabilities: A Contemporary Journal, 9*, 5–26.

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

Georgiou, G. K., Torppa, M., Manolitsis, G., Lyytinen, H., & Parrila, R. (2012). Longitudinal predictors of reading and spelling across languages varying in orthographic consistency. *Reading and Writing,* 25, 321–346. doi: 10.1007/s11145-010-9271-x

Grigorenko, E. (2001). Developmental dyslexia: An update on genes, brains, and environments. *Journal of Child Psychology and Psychiatry*, *42*, 91–125. doi: 10.1111/1469-7610.00704

Hirvonen, R., Georgiou, G. K., Lerkkanen, M.-K., Aunola, K., & Nurmi, J.-E. (2010). Task-focused behaviour and literacy development: A reciprocal relationship. *Journal of Research in Reading*, *33*, 302–319. doi: 10.1111/j.1467-9817.2009.01415.x

Holmes, V. M., & Castles, A. E. (2001). Unexpectedly poor spelling in university students. *Scientific Studies of Reading, 5*, 319–350. doi:10.1207/S1532799XSSR0504_02

Holmes, V. M., & Ng, E. (1993). Word-specific knowledge, word-recognition strategies, and spelling ability. *Journal of Memory and Language*, *32*, 230–257. doi:10.1006/jmla.1993.1013

Holmes, V. M., & Quinn, L. (2009). Unexpectedly poor spelling and phonological-processing skill. *Scientific Studies of Reading, 13,* 295–317. doi:10.1080/10888430903001225

Kairaluoma, L., Torppa, M., Westerholm, J., Ahonen, T., & Aro, M. (2013). The nature and factors related to reading difficulties among adolescents in a transparent orthography. *Scientific Studies of Reading, 5*, 315–332. doi: 10.1080/10888438.2012.701257

Kamhi, A. G., & Hinton, L. N. (2000). Explaining individual differences in spelling ability. *Topics in Language Disorders, 20,* 37–49. doi:10.1097/00011363-200020030-00006

Kirby, J., Parrila, R., & Pfeiffer, S. (2003). Naming speed and phonological awareness as predictors of reading development. *Journal of Educational Psychology, 95,* 453–464. doi: 10.1037/0022-0663.95.3.453

Landerl, K., Ramus, F., Moll, K., Lyytinen, H., Leppänen, P. H. T., Lohvansuu, K., … Schulte-Körne, G. (2013). Predictors of developmental dyslexia in European orthographies with varying complexity. *Journal of Child Psychology and Psychiatry, 54,* 686–694. doi:10.1111/jcpp.12029

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

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

Leppänen, U., Niemi, P., Aunola, K., & Nurmi, J.-E. (2004). Development of reading skills among preschool and primary school pupils. *Reading Research Quarterly, 39,* 72–93. doi: 10.1598/RRQ.39.1.5

Leppänen, U., Niemi, P., Aunola, K., & Nurmi, J.-E. (2006). Development of reading and spelling Finnish from preschool to grade 1 and grade 2. *Scientific Studies of Reading, 10,* 3–30. doi: 10.1207/s1532799xssr1001_2

Lerkkanen, M.-K., Kiuru, N., Pakarinen, E., Viljaranta, J., Poikkeus, A.-M., Rasku-Puttonen,

… Nurmi, J.-E. (2012). The role of teaching practices in the development of children's interest in reading and mathematics in kindergarten. *Contemporary Educational Psychology, 37,* 266–279. doi: 10.1016/j.cedpsych.2011.03.004.

Lerkkanen, M.-K., Rasku-Puttonen, H., Aunola, K., & Nurmi, J.-E. 2004. Predicting reading performance during the first and the second year of primary school. *British Educational Research Journal, 30,* 67–92. doi: 10.1080/01411920310001629974

Lerkkanen, M.-K., & Poikkeus, A.-M. (2009). Reading comprehension: Sentences. Unpublished measure. Jyväskylä, Finland: University of Jyväskylä.

Lerkkanen, M.-K., Poikkeus, A.-M., & Ketonen, R. (2006). *ARMI. Luku- ja kirjoitustaidon arviointimateriaali 1. luokalle.* Helsinki, Finland: WSOY.

Lervåg, A., Bråten, I., & Hulme, C. (2009). The cognitive and linguistic foundations of early reading development. *Developmental Psychology, 45,* 764–781. doi: 10.1037/a0014132

Liao, C.-H., Georgiou, G., Zhang, X., & Nurmi, J.-E. (2013). Cross-lagged relations between task-avoidant behavior and literacy skills in Chinese. *Learning and Individual Differences, 25,* 73–79. doi:10.1016/j.lindif.2013.02.003

Lindeman, J. (2000). *Ala-asteen lukutesti: käyttäjän käsikirja*. [The comprehensive school reading test]. Oppimistutkimuksen keskus, Turun yliopisto. [Center for Learning Research, University of Turku, Finland].

Lovett, M. (1987). A developmental approach to reading disability: Accuracy and speed criteria of normal and deficient reading skill. *Child Development, 1,* 234–260. doi: 10.2307/1130305

Lyytinen, H., Erskine, J., Ahonen, T., Aro, M., Eklund, K., Guttorm, T.,… Viholainen, H.(2008). Early identification and prevention of dyslexia: Results from a prospective follow-up

study of children at familial risk for dyslexia. In G. Reid, A. Fawcett, F. Manis, & L. Siegel (Eds.), *The SAGE handbook of dyslexia* (pp. 121–146). New York: Sage Publishers.

Mann, V., & Wimmer, H. (2002). Phoneme awareness and pathways into literacy: A comparison of German and American children. *Reading and Writing, 15*, 653–682. doi: 10.1023/A:1020984704781

Manolitsis, G., Georgiou, G., & Tziraki, N. (2013). Examining the effects of home literacy and numeracy environment on early reading and mathematics acquisition. *Early Childhood Research Quarterly, 28*, 692–703. doi:10.1016/j.ecresq.2013.05.004

Manolitsis, G., Georgiou, G., & Parrila, R. (2011). Revisiting the home literacy model of reading development in an orthographically consistent language. *Learning and Instruction, 21*, 496–505. doi:10.1016/j.learninstruc.2010.06.005

Mayringer, H., Wimmer, H., & Landerl, K. (1998). Phonological skills and literacy acquisition in German. In P. Reitsma & L. Verhoeven (Eds.), *Problems and interventions in literacy development* (pp. 147–161). Dordrecht, The Netherlands: Kluwer.

Moll, K., Kunze, S., Neuhoff, N., Bruder, J., & Schulte-Körne, G. (2014). Specific learning disorder: prevalence and gender differences. *PLoS ONE,* 9, e103537. doi: 10.1371/journal.pone.0103537

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

Mouzaki, A., & Sideridis, G. D. (2007). Poor reader's profiles among Greek students of elementary school. *Hellenic Journal of Psychology, 4*, 205–232.

Niolaki, G.Z., Masterson, J., & Terzopoulos, A.R. (2013) 'Association of single word spelling with visual attention span and phonological ability in English- and Greek-speaking children.'. Proceedings of the '13th European Congress of Psychology', 'The 13th European Congress of Psychology' Held on 9-12 July 2013 in Stockholm, Sweden.

Nikolopoulos, D., & Goulandris, N., & Snowling, M. (2003). Developmental dyslexia in Greek. In N. Goulandris (Ed.). *Dyslexia in different languages: Cross-linguistic comparisons* (pp. 53–57). London: Whurr Publishers.

Nurmi, J.-E., & Aunola, K. (1998). Observer-rating scale of achievement strategies. Unpublished measure. Jyväskylä, Finland: University of Jyväskylä.

Olson, R. K. (2005). Genes, environment, and dyslexia. The 2005 Norman Geschwind Memorial Lecture. *Annals of Dyslexia, 56,* 205–238. doi: 10.1007/s11881-006-0010-6

Onatsu-Arvilommi, T., & Nurmi, J.-E. (2000). The role of task-avoidant and task-focused behaviors in the development of reading and mathematical skills during the first school year: A cross-lagged longitudinal study. *Journal of Educational Psychology, 92,* 478–491. doi: 10.1037/0022-0663.92.3.478

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

Perfetti, C., Rieben, L., & Fayol, M. (1997). *Learning to spell: Research, theory, and practice across languages.* Mahwah, NJ: Lawrence Erlbaum Associates.

Puolakanaho, A., Ahonen, T., Aro, M., Eklund, K., Leppänen, P.H.T., Poikkeus, A.-M.,… Lyytinen, H. (2007). Very early phonological and language skills: Estimating individual

risk of reading disability. *Journal of Child Psychology and Psychiatry*, *48*, 923-931. doi:10.1111/j.1469-7610.2007.01763.x

Rutter, M., Pickles, A., Murray, R., & Eaves, L. (2006) Testing hypotheses on specific environmental causal effects on behavior. *Psychological Bulletin, 127*, 291–324. doi: 10.1037/0033-2909.127.3.291

Schatschneider, C., Fletcher, J. M., Francis, D. J., Carlson, C. D., & Foorman, B. R. (2004). Kindergarten prediction of reading skills: A longitudinal comparative analysis. *Journal of Educational Psychology, 96*, 265–282. doi: 10.1037/0022-0663.96.2.265

Share, D. L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition, 55*, 151-218. doi: doi:10.1016/0010-0277(94)00645-2

Sénéchal, M. (2006). Testing the home literacy model: Parent involvement in kindergarten is differentially related to Grade 4 reading comprehension, fluency, spelling, and reading for pleasure. *Scientific Studies of Reading, 10,* 59–87. doi: 10.1207/s1532799xssr1001_4

Silinskas, G., Parrila, R., Lerkkanen, M.-K., Poikkeus, A.-M., Niemi, P., & Nurmi, J.-E. (2010). Mothers' reading-related activities at home and learning to read during kindergarten. *European Journal of Psychology of Education*, *25*, 243–264. doi:10.1007/s10212-010-0014-9

Silinskas, G., Lerkkanen, M.-K., Tolvanen, A., Niemi, P., Poikkeus, A.-M., & Nurmi, J.-E. (2012). The frequency of parents' reading related activities at home and children's reading skills during kindergarten and Grade 1. *Journal of Applied Developmental Psychology, 33*, 302–310. doi: 10.1016/j.appdev.2012.07.004

Soodla, P., Lerkkanen, M.-K., Kikas, E., Niemi, P., & Nurmi, J.-E. (2015). Does early reading

instruction promote the rate of acquisition? A comparison of two transparent orthographies. *Learning and Instruction, 38,* 14–23. doi: 10.1016/j.learninstruc.2015.02.002

Stephenson, K., Parrila, R., Georgiou, G., & Kirby, J. (2008). Effects of home literacy, parents' beliefs, and children's task-focused behavior on emergent literacy and word reading skills. *Scientific Studies of Reading, 12,* 24–50. doi: 10.1080/10888430701746864

Swanson, H. L., Trainin, G., Necoechea, D. M., & Hammill, D. D. (2003). Rapid naming, phonological awareness, and reading: A meta-analysis of the correlational evidence. *Review of Educational Research, 73,* 407–440. doi: 10.3102/00346543073004407

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

Torppa, M., Poikkeus, A.-M., Laakso, M.-L., Eklund, K., & Lyytinen, H. (2006). Predicting delayed letter name knowledge and its relation to grade 1 reading achievement in children with and without familial risk for dyslexia. *Developmental Psychology, 42,* 1128–1142. doi: 10.1037/0012-1649.42.6.1128

Torppa, M., Tolvanen, A., Poikkeus, A-M. Eklund, K., Lerkkanen, M-K., Leskinen, E., & Lyytinen, H. (2007). Reading development subtypes and their early characteristics. *Annals of Dyslexia, 57,* 3–32.doi: 10.1007/s11881-007-0003-0

Torppa, M., Poikkeus, A.-M., Laakso, M.-L., Leskinen, E., Tolvanen, A., Leppänen, P. H. T., …Lyytinen, H. (2007). Modeling the early paths of phonological awareness and factors

supporting its development in children with and without familial risk for dyslexia. *Scientific Studies of Reading, 11,* 73–103. doi: 10.1080/10888430709336554

Torppa, M., Eklund, K., van Bergen, E., & Lyytinen, H. (2015). Late-emerging and resolving dyslexia: A follow-up study from kindergarten to grade 8. *Journal of Abnormal Child Psychology, 43,* 1389–1401. doi: 10.1007/s10802-015-0003-1

Tressoldi, P.E., Stella, G., & Faggella, M. (2001). The development of reading speed in Italians with dyslexia: A longitudinal study. *Journal of Learning Disabilities, 34,* 414–417. doi: 10.1177/002221940103400503

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

Vaessen, A., & Blomert, L. (2013). The cognitive linkage and divergence of spelling and reading development. *Scientific Studies of Reading, 17,* 89–107. doi: 10.1080/10888438.2011.614665

Wagner, R., Torgesen, J. K., Rashotte, C. A., & Pearson, N. A. (2009). *TOSREC: Tests of Silent Reading Efficiency and Comprehension.* Texas, AU: Pro-Ed.

Willcutt, E. G., Betjemann, R. S., Wadsworth, S. J., Samuelsson, S., Corley, R., Defries, J. C.,… Olson, R. (2007). Preschool twin study of the relation between attention-deficit/hyperactivity disorder and prereading skills. *Reading and Writing, 20,* 103–125. doi:10.1007/s11145-006-9020-3

Wimmer, H. (1993). Characteristics of developmental dyslexia in a regular writing system. *Applied Psycholinguistics, 14,* 1–33. doi: 10.1017/S0142716400010122

Wimmer, H., & Mayringer, H. (2002). Dysfluent reading in the absence of spelling difficulties: A specific disability in regular orthographies. *Journal of Educational Psychology, 94,* 272–277. doi: 10.1037/0022-0663.94.2.272

Wimmer, H., & Schurz, M. (2010). Dyslexia in regular orthographies: Manifestation and causation. *Dyslexia, 16*, 283–99. doi:10.1002/dys.411

Zhang, X., Koponen, T., Räsänen, P., Aunola, K., Lerkkanen, M.-K., & Nurmi, J.-E. (2014). Linguistic and spatial skills predict early arithmetic development via counting sequence knowledge. *Child Development, 85,* 1091–1107. doi: 10.1111/cdev.12173.

Ziegler, J. C., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Faísca, L.,… Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: A cross-language investigation. *Psychological Science, 21*, 551–9. doi:10.1177/0956797610363406

Yeung, P. S., Ho, C. S. H., Chik, P. P. M., Lo, L. Y., Luan, H.,…Chung, K. K. H. (2011). Reading and spelling Chinese among beginning readers: What skills make a difference? *Scientific Studies of Reading, 15,* 285–313. doi: 10.1080/10888438.2010.482149

Table 1

Descriptive Statistics and Group Comparisons in the Reading and Spelling Skills

		Good readers / good spellers		RD group		SD group		RSD group		F
		M	SD	M	SD	M	SD	M	SD	
Word reading fluency										
	Grade 1	21.93[1]	8.29	9.14[2]	3.14	18.00[3]	6.41	5.74[4]	3.54	(3,1182) = 103.34***
	Grade 2	26.98[1]	6.87	14.86[2]	3.37	25.18[3]	5.89	12.29[4]	4.27	(3,1192) = 123.83***
	Grade 3	38.79[1]	7.34	21.47[2]	5.44	38.80[1]	6.02	19.76[2]	6.60	(3,1201) = 189.57***
	Grade 4	39.81[1]	7.79	23.67[2]	4.19	39.80[1]	5.97	21.38[2]	6.42	(3,1172) = 151.68***
Sentence reading fluency										
	Grade 1	21.63[1]	7.04	8.86[2]	3.53	16.13[3]	5.20	6.02[4]	5.81	(3,1182) = 133.90***
	Grade 2	33.73[1]	6.78	18.60[2]	4.44	28.98[3]	5.45	13.81[4]	5.17	(3,1188) = 214.41***
	Grade 3	41.88[1]	7.10	25.72[2]	4.86	38.44[3]	4.11	21.45[4]	5.83	(3,1198) = 216.79***
	Grade 4	49.70[1]	6.95	31.92[2]	5.54	45.51[3]	6.36	27.96[4]	7.80	(3,1172) = 242.84***
Spelling accuracy										
	Grade 1	6.53[1]	1.26	5.47[1]	1.28	2.58[2]	1.57	0.93[3]	1.28	(3,1183) = 463.90***
	Grade 2	7.38[1]	0.73	7.34[1]	0.77	4.58[2]	1.69	2.88[3]	1.95	(3,1192) = 600.88***
	Grade 3	7.03[1]	0.97	6.78[1]	1.02	3.93[2]	1.72	2.53[3]	1.92	(3,1201) = 425.70***
	Grade 4	7.26[1]	0.75	7.08[1]	0.81	4.37[2]	1.22	3.71[2]	1.98	(3,1172) = 421.95***

Note. Superscript numbers refer to pairwise comparisons (Dunnett T3). If two means have the same superscript number they do not differ significantly. For typical readers n= 1043-1067, for RD group n= 35-36, for SD group n=40-41, and for RSD group n=57-59

Table 2

Descriptive Statistics and Group Comparisons on the Kindergarten Measures

	Good readers / good spellers		RD group		SD group		RSD group		
	M	SD	M	SD	M	SD	M	SD	F
Cognitive skills									
Phoneme identification, fall	8.27[1]	2.01	7.10[1]	2.64	5.65[1,2]	2.24	4.86[2]	2.97	(3,1006)= 51.99***
Phoneme identification, spring	9.50[1]	1.12	8.81[1]	1.40	7.16[2]	1.66	6.27[2]	2.75	(3,1009)= 119.39***
Letter knowledge, fall	20.35[1]	7.88	14.00[2]	8.28	10.74[2,3]	7.88	7.12[3]	6.97	(3,1006)= 55.94***
Letter knowledge, spring	25.64[1]	4.53	21.39[2]	6.53	18.87[2]	6.78	12.52[3]	7.49	(3,1010)= 119.85***
Rapid naming, spring	66.10[1]	15.61	77.09[2,3]	13.01	73.62[1,2]	16.17	85.22[3]	15.41	(3,1009)= 25.75***
Task avoidance									
Teacher	10.61[1]	4.84	10.31[1,2]	4.91	13.37[2,3]	5.09	16.74[3]	5.35	(3,1183)= 22.71***
Tester	7.88[1]	4.27	8.87[1,2]	4.60	11.00[2,3]	4.77	13.62[3]	6.24	(3,1186)= 27.92***
Home literacy environment									
Teaching literacy, mother	2.62	0.92	2.79	0.83	2.52	0.64	2.42	0.84	(3,1015)= 0.90
Teaching literacy, father	2.46	0.83	2.25	0.82	2.18	0.61	2.25	0.98	(3,729)= 1.43
Shared reading, mother	2.97	1.13	2.69	1.35	2.54	1.24	3.10	1.21	(3,1010)= 1.81
Shared reading, father	2.39[1]	1.17	1.67[2]	0.82	2.68[1]	1.20	1.74[2]	0.87	(3,720)= 4.30**

Note. Superscript numbers refer to pairwise comparisons (Dunnett T3). If two means have the same superscript number they do not differ significantly. The ns in cognitive skills for typical readers were n= 1043-1067, for RD group n= 35-36, for SD group n=40-41, and for RSD group n=57-59, in task avoidance for typical readers n= 1072-1083, for RD group n= 29-31, for SD group n=30-31, and for RSD group n=39-42 and in home literacy environment for typical readers 932-936 (mothers) and 668-675(fathers), for RD group n= 26 (mothers) and 15-16 (fathers), for SD group n=26-27 (mothers) and 19 (fathers), and for RSD group n= 30 (mothers) and 19-20 (fathers).

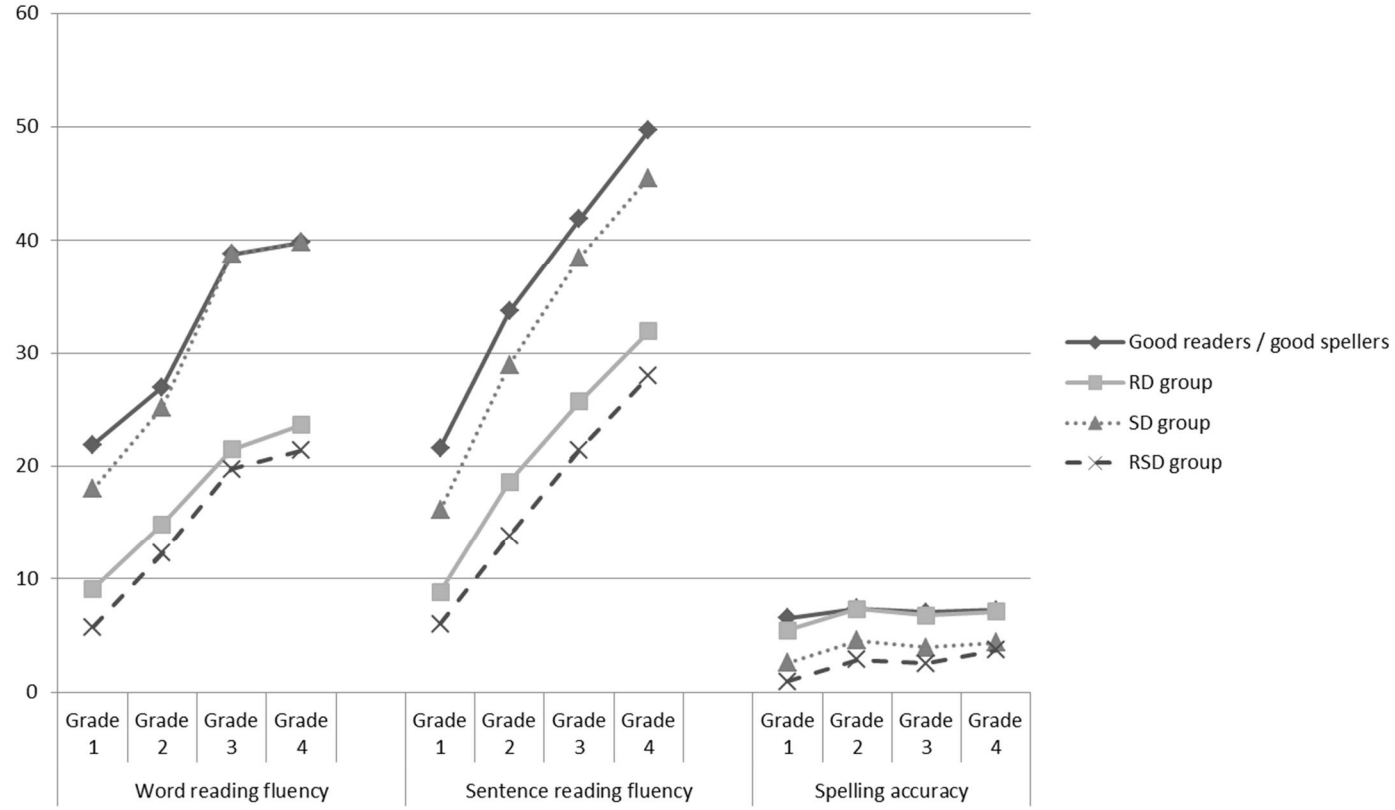

Figure 1

Reading and Spelling Skills across Grades 1-4 in Each Group

Appendix A

Effect Sizes for the Pairwise Group Comparisons in Reading and Spelling Skills

	Effect size[a]					
	Good readers/good spellers vs. RD group	Good readers/good spellers vs. SD group	Good readers/good spellers vs. RSD group	RD group vs. SD group	RD group vs. RSD group	SD group vs. RSD group
Word reading fluency						
Grade 1	**-2.04**	-0.53	**-2.54**	**1.76**	**-1.02**	**-2.37**
Grade 2	**-2.24**	-0.28	**-2.57**	**2.15**	-0.67	**-2.51**
Grade 3	**-2.68**	0.00	**-2.73**	**3.02**	-0.28	**-3.01**
Grade 4	**-2.58**	0.00	**-2.58**	**3.13**	-0.42	**-2.97**
Sentence reading fluency						
Grade 1	**-2.29**	**-0.89**	**-2.42**	**1.64**	-0.59	**-1.83**
Grade 2	**-2.64**	-0.77	**-3.30**	**2.09**	**-0.99**	**-2.86**
Grade 3	**-2.66**	-0.59	**-3.14**	**2.83**	**-0.80**	**-3.37**
Grade 4	**-2.83**	-0.63	**-2.94**	**2.28**	-0.59	**-2.47**
Spelling accuracy						
Grade 1	**-0.83**	-2.77	**-4.41**	**-2.02**	**-3.55**	**-1.15**

Grade 2	-0.05	**-2.15**	**-3.06**	**-2.10**	**-3.01**	**-0.93**
Grade 3	-0.25	**-2.22**	**-2.96**	**-2.01**	**-2.76**	-0.77
Grade 4	-0.23	**-2.85**	**-2.37**	**-2.62**	**-2.23**	-0.40

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

Appendix B

Effect Sizes for the Pairwise Group Comparisons in Kindergarten Measures

	Effect size[a]					
	Good readers/good spellers vs. RD group	Good readers/good spellers vs. SD group	Good readers/good spellers vs. RSD group	RD group vs. SD group	RD group vs. RSD group	SD group vs. RSD group
Cognitive skills						
Phoneme identification, fall	-0.50	**-1.23**	**-1.34**	-0.59	**-0.80**	-0.30
Phoneme identification, spring	-0.54	**-1.65**	**-1.54**	**-1.07**	**-1.16**	-0.39
Letter knowledge, fall	-0.79	**-1.22**	**-1.78**	-0.40	**-0.90**	-0.49
Letter knowledge, spring	-0.76	**-1.17**	**-2.12**	-0.38	**-1.26**	**-0.89**
Rapid naming, spring	0.76	0.47	**1.23**	-0.24	0.57	0.73
Task avoidance						
Teacher	-0.06	0.56	**1.20**	0.61	**1.25**	0.65
Tester	0.22	0.69	**1.07**	0.45	**0.87**	0.47
Home literacy environment						
Teaching literacy, mother	0.19	-0.13	-0.23	-0.36	-0.44	-0.13
Teaching literacy, father	-0.25	-0.38	-0.23	-0.10	0.00	0.09

Shared reading, mother	-0.22	-0.36	0.11	-0.12	0.32	0.46
Shared reading, father	-0.71	0.24	-0.63	**0.98**	0.08	**-0.90**

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