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A Retrospective Longitudinal Study of Cognitive and Language Skills in Poor Reading Comprehension

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Children who exhibit low levels of reading comprehension, despite having age-appropriate word decoding, have received considerable attention during the last 20 years (for a review see Hulme & Snowling, 2011). Unlike typically developing children, these children's reading comprehension does not develop in parallel with their word decoding skills during the first years of school. We will label these children as "Specific Poor Reading Comprehenders" (and use the acronym SPRC) because they show depressed reading comprehension skills that are unexpected based on their more adequate levels of word decoding. In other words, their difficulties are specific to comprehension processes, not associated with decoding. This profile has sometimes been referred to as late emerging reading disability because it becomes most evident around the fourth grade (Catts, Compton, Tomblin, & Bridges, 2012; Leach, Scarborough, & Rescorla, 2003).

Although an important aim of reading research has been early identification of children who may be at risk for reading disabilities, the bulk of this research has focused on those who struggle with decoding rather than comprehension. Most studies examining SPRC have been cross sectional and the range of skills that have been assessed within the same study has been limited. The present study extends prior research by taking a longitudinal perspective on language and cognitive skills that may be associated with SPRC. We determined not only how SPRC children differed from their peers on language and cognitive skills when they were identified, but also whether there were differences earlier in the development. We used a retrospective longitudinal approach, such that children were identified as SPRC based on their reading profile in Grade 4. In Grade 4 comprehension skill can more easily be separated from decoding skill compared to earlier grades. We also examined the cognitive and language skills of the SPRC at four earlier time points; preschool, kindergarten, Grade 1 and Grade 2. This wide age assessment allowed us to see if difficulties associated with SPRC were present when the children were preliterate (preschool). Also, it could be determined how reading instruction influenced their language skills. With this broader

developmental perspective our aim was to better understand the characteristics and developmental aetiology of SPRC.

Previous Studies of SPRC

Previous studies of SPRC have typically selected children at 8–9 years of age and have reported differences from typical readers on vocabulary (Cain, Oakhill, & Elbro, 2003; Nation, Cocksey, Taylor, & Bishop, 2010; Nation, Clarke, Marshall & Durand, 2004; Nation & Snowling, 1998), grammar (Catts, Adolf, & Weismer, 2006; Nation et al., 2010; Tong, Deacon, Kirby, Cain, & Parrila, 2011), verbal memory (Nation, Adams, Bowyer-Crane, & Snowling, 1999; Swanson, Howard, & Sáez, 2007), as well as inference making and comprehension monitoring skills (Cain & Oakhill, 1999; Oakhill, Hartt, & Samols, 2005). In line with the age-appropriate decoding skills used to select them, SPRC typically have not been found to differ from adequate readers in tasks assessing phonological awareness (PA) (Cain, Oakhill, & Bryant, 2000; Nation et al., 2004) or rapid automatized naming (RAN).

A few retrospective longitudinal studies have examined SPRC prior to any reading instruction (Justice, Mashburn, and Petscher, 2013; Torppa et al., 2007) or as the children are just beginning their reading development (Catts et al., 2006; Nation et al., 2010). The studies examining prospective SPRC aged 1–5 have suggested subtle differences in oral language skills between SPRC and typical readers at the beginning of language development. The differences have been found to be reliable at 4–5 years of age (Justice et al., 2013; Torppa et al., 2007). Deficits in grammar, vocabulary and listening comprehension have been found in SPRC in 5–6 year-olds (Catts et al., 2006; Nation et al., 2010). Thus, these patterns suggest that the oral language deficits exhibited by SPRC are longitudinally stable. A more unexpected result is that deficits in some aspects of PA have been found in kindergarten in groups of SPRC (Catts, Hogan, & Fey, 2003; Elwér, Keenan, Olson, Byrne, & Samuelsson, 2013; Nation et al., 2010). This is surprising given the close relationship between decoding and PA and the normal decoding development in word reading exhibited by the SPRC.

The cognitive profile of the SPRC differ between studies, and recent results suggest that this may be a consequence of differences in tests used for selection, age of the children, and the specific selection procedure (Keenan et al., in press). Because of the changing nature of reading comprehension over time, SPRC may not be reliably detected until children have had several years of reading instruction (Catts et al., 2012). When reading comprehension is primarily constrained by level of decoding skill, as is the case during the first years in school, SPRC will not show compromised results. Another important factor that influences the selection of SPRC is that reading comprehension tests differ in the underlying properties that they assess (Keenan, Betjemann & Olson, 2008). Thus, a child may be selected as a SPRC when assessed with one reading comprehension test but not another (Keenan & Meenan, 2014).

Variability in findings may also reflect the fact that there is heterogeneity within groups of SPRC such that not all SPRC show the same deficits (Cain & Oakhill, 2006; Cornoldi, De Beni & Pazzaglia, 1996; Nation et al., 2004). For instance, Cain and Oakhill (2006) found

that less than half of the children in their SPRC group showed vocabulary results below the mean of the entire sample. Also, Nation and colleagues (2004) reported that there was no single task where poor performance uniquely identified SPRC.

The Present Study

The present retrospective study was designed to compare SPRC to good reading comprehenders individually matched with the SPRC on decoding skill. As reading comprehension assessments are mainly explained by decoding skill in the early grades, a group of 56 SPRC was selected at the end of Grade 4, relatively late compared to many previous studies. In the selection procedure, three criteria were used; compromised results on reading comprehension, adequate decoding, and a substantial discrepancy between the two z-scores. The SPRC group was compared retrospectively to good comprehenders at preschool, and subsequently at the end of kindergarten, Grade 1, and Grade 2. The assessments included a wide range of language skills in preschool, and most of these skills were assessed at later test occasions as well, along with tests of decoding, spelling and reading comprehension. This study allows for examination not only of the early SPRC language profile but also the degree of consistency in this profile relative to the classification in Grade 4.

The following main question was addressed: What characterized children in the SPRC group compared to children with good reading comprehension, from preschool to Grade 4? Based on previous research, we hypothesized that the groups would not differ on RAN, since RAN has been closely associated with individual differences and deficits in word recognition (Christopher et al., 2012; Elwér et al., 2013). PA has also been closely associated with word recognition in previous research (Scarborough, 1998), particularly when it is assessed while children are learning to read, due in part to the reciprocal relation between PA and learning to read (Nation & Hulme, 2011). However, there is evidence that PA measured in preschool may be relatively independent from later word recognition and more related to reading comprehension due to its association with broader memory and language skills (Byrne et al., 2009; Lepola, Lynch, Laakkonen, Silvén, & Niemi, 2012). We also hypothesized vocabulary deficits in the group of SPRC, as stable vocabulary deficits have been found in a previous study of poor *oral* comprehenders (Elwér et al., 2013). Foregoing further specific hypotheses, we will let the data speak to subgroup differences across other language skills, preschool print knowledge, and non-verbal IQ. We will also assess the effect of the emerging discrepancy between levels of reading comprehension and word decoding in the early school years in SPRC.

Methods

Participants

The participants in this study were engaged in the International Longitudinal Twin Study (ILTS) with the purpose of studying genetic and environmental influences on language and literacy skills in Australia, Scandinavia, and the US (Byrne et al., 2005; 2007; Olson et al., 2011; Samuelsson et al., 2005). For the present study, the twins were drawn from the American sample (772 twins, 400 girls) because it was the only sample large enough to

identify a group of SPRC of a sufficient size at the time when the analyses were conducted. The US sample consists of a population sample of twins ascertained through the Colorado Twin Registry. This registry contains records of all twin births in Colorado. In the first wave of testing, 86% of the families that were contacted agreed to participate. The number of children varied somewhat across tests and test occasions, but the dropout rate never exceeded 8%.

The twins were tested at preschool (mean age 59 months), and at the end of kindergarten (mean age 76 months), Grade 1 (mean age 89 months), Grade 2 (mean age 102 months) and Grade 4 (mean age 126 months). Children in the US attend preschool between the ages 3 and 5, and start kindergarten at age 5–6. Kindergarten is the first official school year, which means that kindergarten classrooms are located at the schools. The kindergarten curriculum is part of the public school curriculum. All of the twins in the present sample had English as their first language. Means and standard deviations obtained for most tests at all grades are close to norms available for the test batteries of mean 100 and standard deviation 15 (e.g., at Grade 4, TOWRE Sight Word $M = 101.80$, $SD = 12.39$; Woodcock Reading Comprehension $M = 97.78$, $SD = 13.98$, WRAT Spelling $M = 101.33$, $SD = 15.12$).

The main focus of our analyses was on matched samples of 56 SPRC and 56 good comprehenders who were selected from the population sample. Their selection and characteristics are described at the beginning of the Results section.

Procedure

Preschool testing was conducted in the twins' homes or preschools across five sessions lasting approximately one hour. The assessments were conducted within a two-week time span during the year prior to their enrolment in kindergarten. Testing following kindergarten and Grades 1, 2, and 4 was conducted in the twins' homes in single sessions of approximately 1 hour. At both preschool and follow-up, the twins in a pair were tested separately by two different testers.

Measures

The tests in preschool all showed Cronbach alpha above .70 (see Samuelsson et al., 2005). The follow-up tests across grades all showed Cronbach alpha above .80. All tests were standardized within the present sample based on raw scores. Composite scores were created by adding the standardized scores for each of their component measures and then re-standardizing the composite. For the measures of RAN, the z -scores were converted so that a high z -score represents better performance.

Preschool Assessment

A large battery of tests was used to assess pre-reading skills at preschool. These tests have been described in some detail in previous papers from the project (e.g., Byrne et al., 2002; Samuelsson et al., 2005). The tests were used to form six preschool composite scores which reflect a wide range of oral language skills as well as phonological processing skills. The composites used in the present study were formed based on prior factor analyses and theoretical consideration of these data (Samuelsson et al., 2005). A single test was used to

assess non-verbal IQ, the Block Design (Wechsler, 1989). All composites and individual tests are presented in Table 1, along with a short description of each test.

Follow-Up Testing

The follow-up testing took place during the children's summer vacation following kindergarten and Grades 1, 2 and 4. Most of the constructs assessed at preschool were assessed again at one or several of the test occasions. In addition, tests of decoding and spelling were introduced in kindergarten, reading comprehension in Grade 1, and listening comprehension in Grade 4.

Phonological awareness (PA)—Tasks assessing PA were used at each test occasion; however fewer tasks were used across time. In kindergarten, the composite included syllable and phoneme blending and elision from the CTOPP along with a task assessing sound matching (Wagner et al., 1999). In Grades 1 and 2 the kindergarten composite was repeated excluding the sound matching task. In Grade 4 PA was assessed with a new measure assessing phoneme deletion skills. The children were required to repeat words and non-words verbally after deleting a sound (e.g., say prot. Now say prot without the /r/ sound: pot) (Olson, Forsberg, Wise, & Rack, 1994).

Rapid automatic naming (RAN)—In kindergarten, Grade 1, and Grade 4 the same RAN- composite was used. It consisted of rapid naming tasks using letters and numbers from the CTOPP battery (Wagner et al., 1999). Each task was assessed twice at each test occasion.

Vocabulary—The Boston Naming Test (Kaplan, Godglass, & Wintraub, 2001) was introduced in Grade 2 and repeated in Grade 4. In Grade 4, the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) was used as an additional vocabulary test.

Grammar—Grammatical knowledge was assessed in kindergarten using the Test for the Reception of Grammar (TROG; Bishop, 1989). The TROG applies a sentence – picture matching procedure to test knowledge of grammatical understanding.

Verbal memory—The sentence memory task used in preschool was repeated in Grade 1 (WPPSI; Weschsler, 1989).

Decoding—Decoding was assessed at each test occasion starting in kindergarten using the Test Of Word Reading Efficiency (TOWRE, Torgesen, Wagner, & Rashotte, 1999). In kindergarten, Grade 1 and Grade 2 two lists assessing sight word reading and two assessing phonemic decoding were included in the composite. In Grade 4, the TOWRE was used again, but only one list each of words and non-words was used. Two additional tests were included at Grade 4, the WORD ID and Word attack subtests form the Woodcock reading mastery test (Woodcock, McGrew, & Mather, 2001). These four tasks were included in the Grade 4 decoding composite.

Spelling—In kindergarten, a spelling task adapted from Lieberman, Rubin, Duquès and Carlisle (1985) was used. This task has been used and described by Byrne and Fielding-

Barnsley (1993). The spelling tasks included 10 words and 4 non-words with both phonological and orthographic accuracy contributing to the score. At the end of Grades 1, 2, and 4, spelling was assessed using the spelling subtest from The Wide Range Achievement Test (WRAT; Jastak & Wilkinson, 1984).

Reading comprehension—Reading comprehension was assessed in Grades 1, 2, and 4 with a cloze test, the Woodcock Passage Comprehension (Woodcock, 1987). In addition, another reading comprehension task was used in Grade 4, the Gates MacGinitie Reading Comprehension of Passages (MacGinitie & MacGinitie, 1989). In Grade 4, these two tasks were used to create a composite measure of reading comprehension.

Listening comprehension—Listening comprehension was assessed at Grade 4 using the Woodcock- Johnson Oral Comprehension Test (Woodcock et al., 2001).

Results

The results section is divided into four parts. First, we present correlational patterns across the full sample. Second, the procedure of selecting SPRC and good comprehenders (matched for word decoding) are described. Third, comparisons of the SPRC and good comprehenders' cognitive, oral language, and reading skills are presented across grades. Fourth, the distributions of the SPRC group's results are shown in four different performance categories to present patterns of strengths and weaknesses within the group.

Full Sample Correlations

The full sample correlations were used to provide a framework to better understand the SPRC profile in a developmental perspective. The correlations for the full sample at preschool and Grade 4 are presented in Table 2. Preschool correlations were quite high between all skills; however RAN and non-verbal IQ showed lower correlations with the other preschool composites. The two reading comprehension measures used in Grade 4 were highly correlated with each other ($r = .74$) and exhibited very similar correlations with decoding, listening comprehension and vocabulary respectively.

Selection of the SPRC and Good Comprehenders

The SPRC profile is conceptualized as adequate word reading accuracy and/or decoding and poor reading comprehension. In this study, composites of decoding and reading comprehension at the end of Grade 4 were used to select the group of SPRC. The decoding composite included results from four different tasks of single word reading including both words and non-words. Some studies have used non-word reading measures to select SPRC as those measures are more independent from vocabulary knowledge (Nation, Clarke, & Snowling, 2002). However, we found that word and non-word reading was highly correlated and therefore combined the two types of measures.

The SPRC group was selected from the full sample of 772 twins using three criteria, following the procedure used by Nation and colleagues (2010); low performance on reading comprehension (z -scores below $-.67$), adequate decoding (z -scores above $-.67$) and importantly, a discrepancy between the two z -scores (with comprehension being lower than

decoding) of at least .67 ($M = 1.26$, $SD = .41$, range = .68 – 2.18). With this procedure, 56 children were identified from the full sample, which corresponds to 7%. Of these 56 children, 59 percent were boys and the group had a mean age of 125 months ($SD = 3.63$). The comparison group of good comprehenders was selected among those children who showed reading comprehension results above the mean of the full sample ($z > 0$). In a second step the good comprehenders were selected as those 56 children who were the best individual matches on decoding ability to the SPRC. The group of good comprehenders had a larger percentage of girls (54%) and the group's mean age was 125 months ($SD = 3.72$).

The results of twins within a pair are typically more similar to each other when compared to individuals randomly selected from a population. This pattern could influence the statistical significance due to non-independence. Even though both twins were used in the selection procedure, it was relatively rare that both twins in a pair were selected in our subgroups. For those pairs, one of the twins within the pair was selected at random and deleted from the group so that there were no twin pairs where both twins were included in the same group.

Comparisons between the SPRC and Good Comprehenders

Mixed design analyses of variance (ANOVAs) comparing the two groups (between participants) across test occasions (within participants) were used to analyze longitudinal patterns for the two groups for all skills that were repeated over time. Significant interactions were examined with simple main effects analyses. *T*-tests for independent samples were used to test for significant differences between groups on tasks that were only included once (print knowledge, non-verbal IQ in preschool and listening comprehension in Grade 4). Group means on all included measures across time are presented in Table 3. First, we consider the analyses of decoding, spelling, and reading comprehension and then we turn to cognitive and language skills.

Decoding and spelling—The SPRC and the good comprehenders were individually matched on decoding ability at the end of Grade 4. The match at Grade 4 showed developmental stability as the ANOVA revealed no main effect of group. However, a significant effect of time was found ($F(3,312) = 12.29$, $p < .01$, $\eta_p^2 = .11$) as both groups exhibited slightly lower results compared to the mean of the entire sample in kindergarten. The interaction group by time was not significant. Analysis of spelling results over time revealed no significant effects. These results indicate that adequate decoding and spelling were developmentally consistent for children in the SPRC group.

Reading comprehension—The mixed design ANOVA for reading comprehension comparing the two groups on Woodcock Passage Comprehension across time showed significant effects of group ($F(1,107) = 62.07$, $p < .01$, $\eta_p^2 = .38$) and time ($F(2,214) = 8.42$, $p < .01$, $\eta_p^2 = .07$) and a significant interaction of group by time ($F(2,214) = 23.04$, $p < .01$, $\eta_p^2 = .18$). Simple effects revealed significant differences between the two groups in Grade 1 ($F(1,321) = 10.88$, $p < .01$, Cohen's $d = .55$), Grade 2 ($F(1,321) = 20.53$, $p < .01$, Cohen's $d = .86$) and at Grade 4 when the groups were selected ($F(1,321) = 113.86$, $p < .01$, Cohen's $d = 2.25$). Further analysis showed a significant simple effect of time for the SPRC ($F(2, 214) = 30.29$, $p < .01$); this effect was not found for the good comprehenders. As can be seen in

Table 3, the SPRC exhibited results in reading comprehension that were marginally behind the mean of the entire sample in Grade 1 and 2 ($M = -.09$ and $M = -.18$ respectively), consistent with their near-normal levels of word decoding at Grade 1 ($M = -.06$) and 2 ($M = .04$). At the time of selection in Grade 4, the reading comprehension of the SPRC group was much more compromised. In the Discussion we will consider possible reasons for the lack of developmental consistency for reading comprehension deficits in the SPRC group.

Cognitive and language skills—Tests of print knowledge and non-verbal IQ were performed at preschool age 5 only. These tests revealed significant differences between groups for non-verbal IQ ($t(110) = 4.40, p < .01$) and for print knowledge ($t(110) = 5.18, p < .01$) with large differences in favor of the good comprehenders (Cohen's $d = .84$ and $.98$ respectively).

No significant effects were found for the ANOVA comparing the groups on RAN. The two groups were at similar levels close to the mean of the full sample at each test occasion (z -score of 0). For PA however, we found a significant main effect of group ($F(1,105) = 18.77, p < .01, \eta_p^2 = .15$) and a significant interaction group by time ($F(4,420) = 3.08, p < .05, \eta_p^2 = .03$). The good comprehenders exhibited higher results on PA across time. The interaction can be explained by relatively low results in the group of SPRC in preschool compared to later assessments. Simple effects analyses revealed a significant effect of time in the SPRC ($F(4, 420) = 4.79, p < .01$) but not in the good comprehenders. The good comprehenders outperformed SPRC on phonological awareness tasks in preschool ($F(1, 525) = 26.79, p < .01$, Cohen's $d = 1.02$), kindergarten ($F(1, 525) = 12.87, p < .01$, Cohen's $d = .70$) and Grade 2 ($F(1, 525) = 14.0, p < .01$, Cohen's $d = .52$), but not in Grade 1 or 4.

The SPRC group performed generally very poorly on all other measures of oral language skills across time. Robust main effects of group were found in the ANOVAs for grammar and verbal memory ($F(1,109) = 63.66, p < .01, \eta_p^2 = .37$; $F(1,108) = 36.59, p < .01, \eta_p^2 = .25$ respectively), such that the SPRC performed more poorly than the good comprehenders. No significant effects of time or interactions of group by time were found in these analyses. The mixed ANOVA for vocabulary showed significant effects of group ($F(1,108) = 70.37, p < .01, \eta_p^2 = .36$) and a significant interaction of group by time ($F(2,216) = 3.64, p < .05, \eta_p^2 = .03$). The simple effects analysis showed a significant effect of time for the group of good comprehenders ($F(2,216) = 3.21, p < .05$), which can be explained by results closer to the mean of the entire sample in preschool compared to later grades. The same pattern was not found for the SPRC. The single measurement of listening comprehension in Grade 4 revealed a large difference between the two groups in favor of the good comprehenders ($t(110) = 8.12$, Cohen's $d = 1.53$).

Performance Levels of SPRC

To examine severity of deficits within the SPRC group, the distribution of scores in four performance-level categories for each of the tests, from preschool to Grade 4, were examined (Table 4). The performance categories are: z -scores below -1 , between -1 and 0 , between 0 and 1 and finally above 1 .

At the time of selection in Grade 4, SPRC and good comprehenders differed in reading comprehension, listening comprehension and vocabulary. Many of the SPRC showed listening comprehension skills that were seriously depressed compared to the full sample. Seventy-nine percent of the group had listening comprehension results below average and 45% showed deficits below -1 *SD*. The vast majority showed compromised results on vocabulary, with 86% performing below the mean of the full sample.

Preschool—The SPRC group's results at preschool were generally low across tests, although variations in severity were present. In all skills, with the exception of RAN, more than 64% of the SPRC group showed results below the mean, and more than 30% of the SPRC group showed a severe deficit, (z -scores below -1). The most severe deficit was found in grammar/morphology, where 41% of the SPRC showed z -scores below -1 .

Kindergarten and Grades 1 and 2—At the test occasions in kindergarten, Grade 1 and Grade 2, the SPRC and good comprehender groups differed in all measures of oral language, PA and reading comprehension. Between 70 and 80% showed below average performance on these skills and more than 30% exhibited a severe deficit, with the exception of Grade 2 vocabulary. For PA, the results show a surprisingly persistent deficit in the SPRC group, more than 30% showed a deficit in Grade 2. However, in Grade 2, only one measure of PA was used, which influences reliability. This assessment interrupts an otherwise positive development for the SPRC group in PA from preschool through Grade 4.

As can be seen in Table 4, more than 48% of the SPRC group showed reading comprehension results above the mean of the full sample in Grade 1, and 38% showed this pattern in Grade 2. These results suggest that the reading comprehension deficits identified at the end of Grade 4 were “late emerging”.

Discussion

The present retrospective study was designed to compare SPRC with a group of good comprehenders on a variety of language and cognitive skills between the ages 5 and 10. The groups were selected in Grade 4 and compared at previous test occasions in preschool, kindergarten, Grade 1 and Grade 2. We begin with a discussion of the developmental consistency for the decoding, spelling, and reading comprehension measures across time. Then we turn to the cognitive and language profiles that characterized the SPRC, beginning in preschool.

The SPRC and good comprehender groups were matched on decoding at the end of Grade 4, and this match was remarkably consistent across time in the retrospective perspective for decoding, and the highly correlated but un-matched spelling variable. The group differences in reading comprehension established by selection at the end of Grade 4 were statistically significant across the grades. However, the differences between groups were much smaller at the end of Grade 1 and 2. In these grades the SPRC group's mean level of performance was close to the population mean, consistent with their mean levels of decoding and spelling. This pattern may be explained by the changing nature of reading comprehension (Florit & Cain, 2011; Gough, Hoover & Peterson, 1996). In this study, vocabulary showed

higher correlations with reading comprehension in Grade 4, compared to Grade 2 ($r = .55$ and $r = .42$ respectively, both $p < .01$). Similar results have been presented by de Jong and van der Leij (2002) and Torgesen, Wagner, Rashotte, Burgess and Hecht (1997). Apparently, for some children, reading comprehension will not be impaired until vocabulary is more closely related to reading comprehension. This can lead to so-called late emerging reading comprehension deficits (Catts et al., 2012; Elwér et al., 2013; Leach et al., 2003). But as we have seen from our analyses of other cognitive and oral language skills, deficits found in the SPRC group at the end of Grade 4 were quite evident even in preschool.

We found a developmentally consistent compromised oral language profile for the SPRC manifested as deficits in grammar, vocabulary, and verbal memory. For these three oral language measures (with the exception of Grade 2 vocabulary), more than 30% of the sample showed severe deficits ($< -1 SD$) and more than 70% showed performance below the mean of the full sample. The present study is consistent with the Catts et al. study (2006) as they also found mean performances in vocabulary and grammar around the 25th percentile in kindergarten. Also, it is consistent with a previous study of poor oral comprehenders drawn from the ILTS US sample (Elwér et al., 2013). In the Elwér et al. study (2013) poor oral comprehenders with adequate decoding in Grade 4 showed similar stability in oral language deficits when examined retrospectively back to preschool. The results of the present study showed low levels of verbal memory skills in the SPRC. Verbal memory deficits could potentially explain a variety of problems found in groups of SPRC. However, in a study examining several aspects of verbal memory in SPRC, Nation and colleagues (1999) suggested that poor performance in verbal memory tasks exhibited by the SPRC group were caused by oral language deficits, rather than the other way around.

We also found large differences between SPRC and good comprehenders in PA and print knowledge in preschool. This is surprising given that PA has a strong association with decoding development (Scarborough, 1998) and previous studies of SPRC have found age-adequate levels of PA after a few years of school (Cain, Oakhill & Bryant, 2000; Nation et al., 2004). However, dissociations between compromised PA and poor decoding have been reported, especially when PA is assessed early in the development (Bishop, McDonald, Bird, & Hayou-Thomas, 2009). The same pattern is apparent in results showing depressed results on some aspects of PA in SPRC around age 6 (Catts et al., 2003; Nation et al., 2010). In addition, in a previous study examining poor oral comprehenders and poor decoders, PA did not separate children with adequate decoding skills from poor decoders at preschool, whereas RAN and vocabulary did (Elwér et al., 2013). Therefore, compromised PA can be seen as an aspect of a generally poor oral language profile, before the children have received formal reading instruction (see also Metsala & Walley, 1998; Torppa et al., 2007). The same was true for another important predictor of decoding, print knowledge, which was also highly correlated with the other preschool skills in this study. The SPRC's deficits in PA were surprisingly persistent. However, effect sizes of group differences gradually decreased, as decoding skills influenced PA. Recall that despite the low levels of PA, the decoding and spelling results of the SPRC group were not significantly different from the good comprehenders at any time.

One additional preschool skill where SPRC and good comprehenders exhibited different levels of results was non-verbal IQ. Non-verbal IQ was less correlated with the other preschool measures, yet its group effect size of $d = .84$ was not far below that of other preschool skills (except for RAN that we consider next). Non-verbal IQ deficits in SPRC groups have been reported by Nation et al. (2010) and Catts and al. (2006). Whether non-verbal IQ explains variance in reading comprehension beyond language skills in groups of SPRC is still unclear. However, previous studies have suggested that the contribution from non-verbal aspects of IQ in reading comprehension were modest (Catts et al., 2006; Nation et al., 2002).

Along with decoding and spelling, measurements of RAN did not separate the groups across time. This suggests that RAN performance may be more closely associated with the decoding variable on which the groups were matched than with the reading comprehension variable at the end of 4th grade. In fact, across the whole sample, RAN was correlated with decoding at $r = .58$, but only $r = .33$ and $r = .37$ with the two reading comprehension measures.

The few studies that have examined performance of SPRC on the individual level have suggested a heterogeneous profile and it has been difficult to find a core deficit which characterized most of the SPRC (Cain & Oakhill, 2006; Cornoldi et al., 1996; Nation et al., 2004). The findings of this study are not consistent with this research. Instead our results suggest a robust, stable and homogeneous oral language deficit in the SPRC expressed by compromised listening comprehension, vocabulary, verbal memory and grammar. The profile also includes early deficits of PA, print knowledge, and non-verbal IQ. Since deficits, at least mild ones, were found in a vast majority of the SPRC, these aspects qualify to be called “core deficits” of SPRC, and together they represent a general oral language deficit. However, as can be seen in our presentation of performance level categories, all children do not show this profile. The most surprising dissociation was found for listening comprehension, where 22% of the SPRC group showed performance above mean. The Simple View of Reading predicts that all individuals with SPRC should show listening comprehension deficits (Gough & Tunmer, 1986). However, dissociations of results in reading comprehension and listening comprehension are rather common in SPRC groups (see for example Cornoldi et al., 1996; Nation et al., 2004), an observation that has not been properly explained. There are important differences between comprehension in the two different modalities, such as attention- and working memory load, which may account for this discrepancy in the SPRC. Another possibility is that SPRC without listening comprehension problems are a consequence of statistical artefacts such as measurement error and/or the imposition of cut points on variables that have continuous properties, as suggested by Catts and colleagues (2003).

Limitations

Descriptions of early language profiles in subtypes of poor readers provide possible avenues to explore for early identification. However, in this study we have not controlled for false positives i.e., there may be children who exhibit compromised language skills in preschool

but do not end up as SPRC in Grade 4. The results of the present study need to be understood within that context.

The results of the present study suggest that reading comprehension deficits in SPRC may be more enhanced in Grade 4 compared to earlier grades. English is an opaque orthography, and learning to read English takes more time than learning more transparent orthographies such as Swedish, Norwegian and Finnish (e.g., Florit & Cain, 2011; Seymour, Aro, & Erskine, 2003). In transparent orthographies, reading comprehension tests may be more demanding in earlier grades because of the high levels of decoding skill in most readers. Therefore, our results regarding late emergent reading comprehension deficits in the SPRC may occur in the context of an opaque orthography only.

Finally, it should be noted that selection of extreme groups on some variable is often associated with regression-to-mean effects (Nesselroade, Stigler, & Baltes, 1980). Therefore, it is possible that some of the interactions of group by time and main effects of time may be partly a result of this phenomenon. However, because the group selection procedure included several assessments of each construct, hopefully strong regression to the mean effects were prevented.

Conclusions

Contrary to some previous studies examining within group variability of cognitive and language skills in SPRC, we found that a widespread oral language deficit characterized many of the SPRC. The profile included weaknesses in vocabulary, grammar and verbal memory. It was evident even before the children began reading instruction and persisted across time from preschool to Grade 4. In addition, weaknesses in PA and print knowledge at age 5 were found in many of the SPRC. Early, longitudinally stable, oral language weaknesses suggest that early identification of children at risk of becoming SPRC may be possible based on aspects of oral language such as vocabulary. These aspects of language could all be targets of intervention strategies, but vocabulary has shown the most robust influence on reading comprehension (Clarke, Snowling, Truelove & Hulme, 2010).

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Table 1

Pre-reading measures used at preschool

Measure	Description
<i>Phonological awareness composite</i>	
CTOPP sound matching ^a	Identify words that shares initial or final sound with target word.
Rhyme and final sounds ^b	Identify words that share final sounds or rhyme.
Syllable and phoneme blending ^c	Combine syllables and phonemes to form words.
Syllable and phoneme elision ^c	Delete a syllable or phonemes to form a different word.
Word elision ^c	Delete a word from a compound word to form a different word.
Phoneme identity training ^b	Dynamic measure of the ability to learn phonemes.
<i>Rapid naming composite</i>	
CTOPP rapid color naming ^a	Name series of 6 colors as quickly as possible.
CTOPP rapid object naming ^a	Name series of 6 objects as quickly as possible.
<i>Verbal memory composite</i>	
Nonword repetition ^d	Repeat nonsense words.
WPSSI – R sentence memory ^e	Repeated sentences provided by the tester.
WRAML story memory ^f	Listen to a story and repeat it from memory.
<i>Vocabulary composite</i>	
Hundred picture naming test ^g	Name series of pictures.
WPSSI- R vocabulary ^e	Define words that are described by the tester.
<i>Grammar/morphology</i>	
ITPA grammatical closure ^h	Measures generalizability of grammatical rules.
Productive morphology ⁱ	A test of morphological knowledge for example plural.
<i>Print knowledge composite</i>	
Concepts about print ^j	Test knowledge of conventions regarding print.
Environmental print ^b	Assesses knowledge of print in a context (eg. STOP sign).
Letter recognition from names ^b	Identify letter named by tester.
Letter recognition from sounds ^b	Identify letter whose sound is pronounced by the tester.
<i>Non- verbal IQ</i>	
Block design ^e	Match 2D patterns with cubes of two different colors.

Note.

^aComprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999)

^bByrne et al. (2002)

^cLonigan, personal communication, 2000.

^dGathercole, Willis, Baddeley, and Emslie (1994).

^eWechsler Preschool and Primary Scales of Intelligence, Revised (Wechsler, 1989)

^fWide Range Assessment of Memory and Learning (Adams & Sheslow, 1990)

^gFisher&Glennister (1992).

^hIllinois Test of Psycholinguistic Abilities (McCarthy & Kirk, 1961).

ⁱAdapted from Berko (1985)

^jClay (1985).

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Table 2

Full sample correlations for the composites and single tests at preschool and Grade 4

Preschool age 5							
	IQ	Pa	Print	RAN	Vocab	Gram	VM
N. verb. IQ	1						
PA	.44	1					
Print	.42	.64	1				
RAN	.25	.32	.35	1			
Vocab	.40	.59	.59	.29	1		
Gram	.39	.61	.54	.23	.65	1	
VM	.39	.57	.46	.30	.67	.54	1

Grade 4								
	Pa	RAN	Vocab	Word read	Spelling	Or-compr	R-compr (WP)	R-compr (GM)
PA	1							
RAN	.36	1						
Vocab	.31	.11	1					
Word read	.66	.58	.41	1				
Spelling	.58	.44	.40	.84	1			
L. compr	.34	.15	.69	.35	.33	1		
WP R-compr	.49	.33	.63	.67	.64	.59	1	
GM R-compr	.44	.37	.61	.65	.58	.58	.74	1

Note. PA= phonological awareness. RAN = rapid automatic naming. Print = print knowledge. Vocab= vocabulary. Gram= grammar/morphology. VM= verbal memory. WP R-compr = Woodcock passage comprehension. GM R-compr = Gates McGinitie reading comprehension of passages. L.compr =Listening comprehension. All $p < .01$.

Table 3

Mean z-scores and standard deviations of SPRC and good comprehenders on cognitive and language skills in preschool, kindergarten, Grade 1, 2 and 4. The table is organized by skill.

	SPRC	Good comprehenders
Non-verbal IQ		
Preschool	-.58(.99)	.21(.90)
PA		
Preschool	-.53(.88)	.29(.71)
Kindergarten	-.34(.78)	.23(.84)
1 st Grade	-.18(.90)	.12(.91)
2 nd Grade	-.22(.98)	.29(1.0)
4 th Grade	.07(.74)	.23(.90)
Print knowledge		
Preschool	-.55(.84)	.32(.93)
RAN		
Preschool	-.07(1.23)	.02(1.09)
Kindergarten	-.06(1.02)	.05(.83)
1 st Grade	.10(.82)	.10(.89)
4 th Grade	.16(.95)	.13(.89)
Grammar		
Preschool	-.63(1.03)	.50(.70)
Kindergarten	-.72(.91)	.44(.70)
Vocabulary		
Preschool	-.64(.92)	.26(.78)
2 nd Grade	-.69(.98)	.49(.66)
4 th Grade	-.80(.84)	.43(.70)
Verbal memory		
Preschool	-.55(.83)	.31(.80)
1 st Grade	-.50(1.13)	.44(.75)
Decoding		
Kindergarten	-.30(.61)	-.08(.74)
1 st Grade	-.06(.63)	.07(.69)
2 nd Grade	.04(.63)	.10(.54)
4 th Grade ⁸⁵	.20(.48)	.20(.48)
Spelling		
Kindergarten	-.12(.90)	.21(.84)
1 st Grade	-.01(.70)	.00(.85)
2 nd Grade	.04(.69)	.04(.86)
4 th Grade	.06(.61)	.07(.65)
Reading comprehension		
1 st Grade Woodcock	-.09(.63)	.30(.76)

	SPRC	Good comprehenders
2 nd Grade Woodcock	-.18(.53)	.36(.70)
4 th Gradecomposite ^{gs}	-1.06(.29)	.63(.47)
Listening comprehension		
4 th Grade	-.75(.94)	.55(.75)

Note. PA= phonological awareness. RAN = rapid automatic naming.gs= group selection variable.

Table 4

Distribution of scores divided into four performance categories for the 56 SPRC on cognitive and language skills in preschool, kindergarten, Grade 1, 2 and 4. The table is organized by skill.

	z-score below -1	z-score between 0 & -1	z-score between 0 & 1	z-score above 1
Non-verbal IQ				
Preschool	22(39.3%)	14(25%)	19(33.9%)	1(1.8%)
PA				
Preschool	18(32.1%)	25(44.6%)	8(14.3%)	5(8.9%)
Kindergarten	10(17.9%)	26(46.4%)	18(32.4%)	2(3.6%)
1 st Grade	9(16.1%)	28(50%)	10(17.9%)	9(16.1%)
2 nd Grade	18(32.1%)	14(25%)	14(25%)	10(17.9%)
4 th Grade	5(8.9%)	17(30.4%)	33(58.9%)	1(1.8%)
Print				
Preschool	19(33.9%)	21(37.5%)	13(23.2%)	3(5.4%)
RAN				
Preschool	12(21.4%)	8(14.3%)	27(48.2%)	9(16.1%)
Kindergarten	12(21.4%)	11(19.6%)	27(48.2%)	6(10.7%)
1 st Grade	6(10.7%)	13(23.2%)	32(57.7%)	5(8.9%)
4 th Grade	6(10.7%)	15(26.8%)	26(46.4%)	9(16.1%)
Gram				
Preschool	23(41.1%)	18(32.1%)	11(19.6%)	4(7.1%)
Kindergarten	17(30.4%)	28(50%)	11(19.6%)	0(0%)
Vocab				
Preschool	21(37.5%)	19(33.9%)	14(25%)	2(3.6%)
2 nd Grade	13(23.2%)	30(53.6%)	11(19.6%)	2(3.6%)
4 th Grade	20(35.7%)	28(50%)	8(14.3%)	0(0%)
VM				
Preschool	17(30.6%)	26(46.4%)	10(17.9%)	3(5.4%)
1 st Grade	18(32.1%)	21(37.5%)	13(23.2%)	4(7.1%)
Decoding				
Kindergarten	0(0%)	40(71.4%)	15(26.8%)	1(1.8%)
1 st Grade	3(5.4%)	30(53.6%)	20(35.7%)	3(5.4%)
2 nd Grade	4(7.1%)	20(35.7%)	30(53.6%)	2(3.6%)
4 th Grade	0(0%)	19(33.9%)	35(62.5%)	2(3.6%)
Spelling				
Kindergarten	10(17.9%)	13(23.2%)	31(55.4%)	2(3.6%)
1 st Grade	3(5.4%)	22(39.3%)	29(51.8%)	2(3.6%)
2 nd Grade	3(5.4%)	26(46.4%)	21(37.5%)	6(10.7%)
4 th Grade	2(3.6%)	24(42.9%)	27(48.2%)	3(5.6%)
R. compr.				
1 st Grade WP	4(7.1%)	25(44.6%)	25(44.6%)	2(3.6%)

	z-score below -1	z-score between 0 & -1	z-score between 0 & 1	z-score above 1
2 nd Grade WP	3(5.4%)	32(57.1%)	21(37.5%)	0(0%)
4 th Grade WP	13(23.2%)	41(73.2%)	2(3.6%)	0(0%)
4 th Grade GM	40(71.4%)	15(26.8%)	1(1.8%)	0(0%)
4 th Gradecomp	30(53.6%)	26(46.4%)	0(0%)	0(0%)
L. compr.				
4 th Grade	25(44.6%)	19(33.9%)	9(16.1%)	3(5.4%)

Note. PA= phonological awareness. RAN = rapid automatic naming. Print = print knowledge. Vocab= vocabulary. Gram= grammar/morphology. VM= verbal memory. R.compr = Reading comprehension. WP = Woodcock passage comprehension. GM = Gates McGinitie reading comprehension of passages. L. compr = Listening comprehension.