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Longitudinal Stability and Predictors of Poor Oral Comprehenders and Poor Decoders

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Abstract

Two groups of 4th grade children were selected from a population sample (*N*= 926) to either be Poor Oral Comprehenders (poor oral comprehension but normal word decoding), or Poor Decoders (poor decoding but normal oral comprehension). By examining both groups in the same study with varied cognitive and literacy predictors, and examining them both retrospectively and prospectively, we could assess how distinctive and stable the predictors of each deficit are. Predictors were assessed retrospectively at preschool, at the end of kindergarten, 1st, and 2nd grades. Group effects were significant at all test occasions, including those for preschool vocabulary (worse in poor oral comprehenders) and rapid naming (RAN) (worse in poor decoders). Preschool RAN and Vocabulary prospectively predicted grade 4 group membership (77–79% correct classification) within the selected samples. Reselection in preschool of at-risk poor decoder and poor oral comprehender subgroups based on these variables led to significant but relatively weak prediction of subtype membership at grade 4. Implications of the predictive stability of our results for identification and intervention of these important subgroups are discussed.

Keywords

Early identification; simple view of reading; poor decoders; poor oral comprehenders; reading disability

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Reading comprehension is the product of word decoding skills and oral comprehension skills (Gough & Tunmer, 1986). Although these skills are correlated (Gough, Hoover & Peterson, 1996; Nation & Snowling, 1997), what has captured the attention of researchers and educators is the independence these skills sometimes exhibit, as when poor readers exhibit excellent oral comprehension, or when readers with good word decoding show difficulties in comprehension. Partial independence of individual differences in word

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decoding and oral comprehension has even been established at a genetic level (Harlaar, et al., 2010; Keenan, Betjemann, Wadsworth, DeFries & Olson, 2006). As a result, the field now acknowledges two subtypes of poor readers – poor decoders and poor comprehenders. The question addressed by this paper is, given that we can define groups that are extreme on one dimension and not the other, how stable and specific are these deficits?

Poor Reader Subtypes

Poor decoders—Children with poor decoding skills, often defined as dyslexia, have been the focus of many studies since the beginning of the 1960s (e.g., Vellutino, Fletcher, Snowling, & Scanlon, 2004). The literature on its causes and consequences as well as remediation is extensive (Ehri, Nunes, Stahl & Willows, 2001; Stanovich, 1986; Stanovich & Siegel, 1994). There is strong evidence supporting poor phonological awareness as an underlying cause of dyslexia, a deficit manifested both prior to reading instruction and in children struggling to read fluently (Snowling, 2000; Vellutino et al., 2004;). Deficits in other phonologically related processing skills, such as rapid automatized naming (RAN) and verbal short-term memory, have also been found in dyslexia (Cardoso-Martins & Pennington, 2004; Lyytinen et al., 2006;; Swanson & Alexander, 1997; Swanson & Siegel, 2001). Early print knowledge also predicts poor decoding skill (e.g., Furnes and Samuelsson, 2010).

Poor comprehenders—Poor comprehenders have weaknesses in oral language that can impact both their listening comprehension and their reading comprehension (Gough & Tunmer, 1986). Research has tended to define poor comprehenders using reading comprehension tests. Often just a single test, like the Neale (Neale, 1989), is used to assess both word reading and comprehension, and poor comprehenders are defined as those having reading comprehension difficulties despite adequate decoding (Yuill & Oakhill, 1991). The nature of the problems exhibited by children with poor reading comprehension has been clarified by studies comparing these children with typical readers on various aspects of oral and written language (Cain & Oakhill, 1999; Cain, Oakhill & Bryant, 2004; Cain, Oakhill & Elbro 2003; Catts, Adlof & Weismer, 2006; Nation, Clarke, Marshall & Durand, 2004; Nation, Cocksey, Taylor & Bishop, 2010; Nation, Marshall & Snowling, 2001; Nation & Snowling, 1998;Yuill, Oakhill & Parkin, 1989). Deficits have been identified in receptive and expressive oral vocabulary (Nation & Snowling, 1998), ability to learn new word meanings (Cain, et al., 2003), semantic processing (Nation et al. 2004; Stothard & Hulme, 1992), grammatical skills (Catts, et al., 2006; Nation et al., 2004), inferencing (Cain & Oakhill, 1999; Cain, Oakhill & Bryant, 2000; Catts et al., 2006), monitoring skills (Cain & Oakhill, 2003), and in verbal working memory (Nation, Adams, Bowyer-Crane & Snowling, 1999; Swanson, Howard & Sáez, 2007).

Defining poor comprehenders is not straightforward (Keenan, Meenan, Hua, 2012), and how one addresses these definitional issues likely influences the results obtained for the poor comprehender profile. First, reading comprehension is a complex construct that entails coordination of many different skills, which are differentially assessed across different reading comprehension tests (Cutting & Scarborough, 2006; Keenan, Betjemann & Olson, 2008; Nation & Snowling, 1997). Some commonly used tests are heavily dependent on decoding whereas others require more oral language proficiency. In addition, Keenan and Meenan (in press) showed that being in the low-tail in one reading comprehension test does not necessarily mean that the child is in the low-tail of another.

The selection criteria used to define a group of poor comprehenders can also present challenges in separating the effects of poor oral language skills from those of poor decoding on comprehension. That is why a discrepancy definition is often applied; poor

comprehenders are selected to have a discrepancy between their reading comprehension and their decoding. However, using simple discrepancies can end up classifying children as poor comprehenders even when they are well above the low-tail in reading comprehension because their decoding is better than their comprehension. If one uses a low-tail cut-off on reading comprehension to avoid that problem, then the number of children who qualify as poor comprehenders can be quite small, depending on the age of the sample (Keenan, et al., 2012).

The age of the sample highlights another problem in using reading comprehension tests to define a comprehension deficit group: the pattern of influence from decoding and oral language on reading comprehension changes as a function of age (Gough, et al., 1996). As decoding becomes automatized, more variance in reading comprehension is accounted for by oral language skills, and reading comprehension problems in the absence of decoding problems can emerge in later grades (Catts, Compton, Tomblin & Bridges, 2012).

Given the complexities and ambiguities associated with defining poor comprehenders using reading comprehension tests, the present study used oral language to define comprehension skill. Thus, the present study defines deficit groups using the two components of the Simple View of Reading, decoding and oral language (Gough and Tunmer, 1986). We aimed to understand reading comprehension difficulties by contrasting groups with specific deficits in one of the two sub-skills that explain variance in reading comprehension. By using listening to define comprehension deficits, it allows more orthogonally independent subgroups of poor readers because tests of oral language comprehension are more independent of decoding skills than reading comprehension (Gough et al., 1996; Keenan et al., 2006; Nation & Snowling, 1997).

Longitudinal Studies of Poor Decoders and Poor Comprehenders

A number of studies have used longitudinal designs to study individual differences in reading, and they have taught us much about what predicts word decoding and reading comprehension skill (e.g., Catts, Hogan & Fey, 2003, Catts et al., 2006; Kendeou, White, van den Broek, & Lynch, 2009; Muter, Hulme, Snowling & Stevenson, 2004; Nation et al., 2010; Oakhill & Cain, 2007; Olson et al., 2011; Scarborough, 1998; Storch & Whitehurst, 2002). Most of these studies have focused on the stability of predictor variables. Only a few have examined the longitudinal stability of deficit-specific subgroups, separating decoding from comprehension. Of those, two used a retrospective approach (Catts et al., 2003; 2006; Nation et al., 2010), looking back in time to determine how the deficit groups compared across previous grades, and one (Cain & Oakhill 2006; Oakhill & Cain, 2012) used a prospective approach, defining the deficit group at a young age and then doing follow-up testing in subsequent years.

Catts and colleagues (Catts et al., 2003; 2006) defined groups of poor comprehenders, poor decoders and typical readers by their performance on composites of listening and/or reading comprehension and decoding skill at either grade 2 or grade 8. Poor reading comprehenders were found to have performed significantly more poorly than typical readers even when they were in kindergarten on a composite of vocabulary, grammar and story comprehension, and this held across all grades.

Similar stability was reported by Nation et al. (2010); they identified children as having specific comprehension deficits based on their reading comprehension performance at age 8 and then retrospectively examined their oral language skills beginning at age 5. They found that poor reading comprehenders showed difficulties with oral language skills as far back as kindergarten, which predicted their subsequent specific reading comprehension problems.

Cain and Oakhill (2006; Oakhill & Cain, 2012) used a prospective longitudinal design, where specific poor comprehenders were selected using a discrepancy definition, and reading comprehension performance was tracked across time. Their results show remarkable stability in the deficit; with only a single exception, all 23 poor reading comprehenders they followed over a period of 3 years starting at age 8 were still classified as poor reading comprehenders at age 11, even though they never fell behind typical readers in decoding skills.

The Present Study

The present longitudinal study extends previous research on children at risk for reading problems in several ways. First, we search for precursors of both deficits in decoding and deficits in comprehension in the same study. By comparing poor decoders and poor oral comprehenders, the study allows us to draw conclusions regarding the distinctiveness of these subgroups and more importantly their early development in reading comprehension.

Another way we extend previous work is by including both retrospective and prospective analyses in the same study. Previous studies have used either a prospective approach or a retrospective approach, but not both. Like previous retrospective studies, we first identify children at the end of grade 4 as having either poor decoding skills or poor oral comprehension. We examine the stability of the two groups' specific deficits by examining their performance in earlier grades and attempt to determine if there are cognitive precursors of poor decoding and poor oral comprehension that are evident as early as preschool. However, we also take the additional step of confirming that these skills are indeed predictive by using those variables to identify preschoolers who are on the low end of the distribution of these skills and following them prospectively to determine whether they do in fact develop specific decoding or specific oral comprehension deficits.

The present study also extends previous research by searching for precursors of specific deficits in preschool before reading itself reciprocally influences cognitive and language skills that contribute to the course of reading development. We examine quite a broad range of cognitive skills starting in preschool, before children have been exposed to reading instruction, and follow those skills together with assessing their literacy development in decoding, spelling, and reading comprehension.

Method

Participants

The participants are all engaged in an international longitudinal twin study (ILTS) with the overall purpose of studying genetic and environmental influences on individual differences in language and literacy skills (see Byrne et al., 2005; 2007; Olson et al., 2011; Samuelsson et al., 2005). For the present study, 926 children from the U.S (464 girls) were included (i.e., 463 same sex twin pairs). They were tested at preschool (mean age 59 months), and at the end of kindergarten (mean age 75 months), grade 1 (mean age 89 months), grade 2 (mean age 101 months) and grade 4 (mean age 125 months). The sample was ascertained from the Colorado Twin Registry, which includes 90% of twins born in Colorado. All of the twins in the present sample had English as their first language. Their standard-score means and standard deviations on our standardized reading tests were similar to those of the tests' norming samples. (e.g., at grade 4, TOWRE Sight Word = 102.39, SD = 12.16; Woodcock Reading Comprehension = 98.52, SD = 14.98, WRAT Spelling = 100.69, SD = 13.80).

Measures

The goal was to measure all constructs over time, but time limitations did not allow us to test every construct at every test occasion. To avoid ceiling and floor effects we had to change measures across time. Cronbach α estimates of reliability were all above .70 for the tests at preschool (see Samuelsson et al., 2005) and test-retest reliabilities were well above . 80 for all tests measuring reading and spelling from kindergarten to grade 4.

Preschool assessment—In preschool, six composites were used assessing phonological awareness, RAN, verbal memory, grammar/morphology, vocabulary and print knowledge. The tests included in each composite were determined by the factor structure of the preschool measures and theoretical considerations (see Samuelsson et al., 2005). Composites were created by first standardizing raw scores of individual tests of each skill separately. The sum of these standardized scores was then re-standardized to form the composite.

Phonological awareness: Six different tasks varying in linguistic complexity and in cognitive demands were used to create a composite measure of preschool phonological awareness (PA). The tests were designed to assess skills in word, syllable and phoneme elision as well as phoneme blending (tasks were made available by C.J. Lonigan, personal communication, 2000). A phoneme identity training test was also included in the composite; it assessed the child's ability to learn initial and final phonemes (Byrne et al., 2002). Finally, the ability to match words that share initial and final sounds was tested using two different tasks addressing sound matching (Wagner, Torgesen & Rashotte, 1999) and the identification of rhyme and final sounds.

Rapid automatic naming (RAN): A preschool composite of rapid naming was created by using the subtests of object and color naming from the Comprehensive Test of Phonological Processing (CTOPP: Wagner et al., 1999). In these tasks the children were asked to name six objects and six colours presented randomly as quickly as possible. Each test included a total of 72 objects and colours. Response times from the RAN tasks were inverted in the analyses so that shorter times indicate better performance.

Print knowledge: Four different tasks formed a preschool composite of print knowledge. In the two tasks measuring letter recognition from names or sounds, the children were instructed to point to one out of four letters as the experimenter read the name or the sound of the letter aloud. A third test, concepts about print (Clay,1975), measured print knowledge by having children answer 24 questions about conventions of written language while listening to a story read by the experimenter. In the fourth task, the children read six logographs (e.g., an exit sign) as a measure of print recognition in an environmental context.

Verbal memory: Three different memory tasks were used to create a preschool composite of verbal memory. In the non-word repetition task (Gathercole, Willis, Baddeley & Emslie, 1994) children were asked to verbally repeat non-words varying in length from 2 to 5 syllables. The second task was the sentence memory subtest from the WPPSI (WPPSI-Revised; Wechsler, 1989), and the third test was the story memory subtest from WRAML (Adams & Sheslow, 1990).

Vocabulary: The composite of preschool vocabulary included the vocabulary subtest from the WPPSI (WPPSI-Revised; Wechsler, 1989) that asked children to define words spoken by the experimenter, and the Hundred Pictures naming test (Fisher & Glenister, 1992) that asked children to provide the names for pictures.

Grammar and morphology: A test of productive morphology designed after Berko (1958) and the subtest of grammatic closure from the Illinois Test of Psycholinguistic abilities (ITPA; McCarthy & Kirk, 1961) formed a preschool composite of grammar and morphology.

Kindergarten assessment—At the kindergarten assessment, composite scores of phonological awareness and RAN were created using the same procedure as for the preschool composites.

Phonological awareness: The kindergarten composite of phonological awareness was composed of three tests from the CTOPP measuring syllable and phoneme elision and blending as well as a test of sound matching (Wagner et al., 1999).

RAN: The kindergarten composite of RAN consisted of two rapid naming tasks using letters and numbers. These tasks were also taken from the CTOPP test battery (Wagner et al., 1999).

Grammar: The only test of grammar in kindergarten was the test for reception of grammar (TROG; Bishop, 1989). It uses a sentence – picture matching procedure to assess knowledge of grammatical structures.

Decoding: A decoding composite at grade 1 was composed of all four subtests (two lists measuring sight word reading and two lists assessing phonemic decoding) from the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner & Rashotte, 1999).

Spelling: Spelling was measured by a test adapted from Lieberman, Rubin, Duquès and Carlisle (1985) and was used by Byrne and Fielding-Barnsley (1993). The spelling task included 10 simple words and 4 non-words with both phonological and orthographic accuracy contributing to the score.

Grade 1 assessment—In grade 1, the composite of phonological awareness was created using two of the three tasks used in kindergarten; the test of syllable and phoneme blending, and the test of elision. The composites of RAN and decoding used in grade 1were identical to the ones used in kindergarten. We also repeated the sentence memory task that was used in preschool (WPPSI; Wechsler, 1989).

Two new tests were included in grade 1. Spelling was assessed using the spelling subtest from the Wide Range Achievement Test (WRAT; Adams & Sheslow, 1990). The Woodcock Passage Comprehension (Woodcock, 1987) was used to assess reading comprehension. It is a “cloze test” that requires subjects to provide a missing word in a sentence.

Grade 2 assessment—The test of syllable and phoneme elision used in grade 1 was again used to assess phonological awareness in grade 2. The grade 1 tests of decoding, spelling and reading comprehension were also repeated at grade 2. The only new test introduced in grade 2 was the Boston Naming Test that assessed vocabulary by asking subjects to name a series of pictures (Kaplan, Goodglass, & Wintraub, 2001).

Grade 4 assessment—The tests of RAN (i.e., letters and digits), decoding (TOWRE), spelling (WRAT), reading comprehension (Woodcock passage comprehension) and vocabulary (Boston Naming) used at grade 4 were all the same as used in previous assessments. Note, only one list of words and one list of non-words from the TOWRE were

used. Two new tests of decoding were included in the grade 4 assessment, the Word ID and Word attack subtests from the Woodcock Reading Mastery Test (Woodcock, McGrew & Mather, 2001). The decoding composite used for group selection at grade 4 included these measures along with the TOWRE measures.

The Peabody picture vocabulary test (Dunn & Dunn, 1997) and the Woodcock-Johnson Oral Comprehension Test (Woodcock et al., 2001) were administered for the first time at grade 4. The Comprehension composite used for group selection at grade 4 included these two measures along with the Boston Naming test.

Phonological awareness was assessed with a new experimental measure of phoneme deletion that required subjects to pronounce words and non-words spoken by the experimenter, and then say what the resulting sound would be for the target word or non-word after deletion of a sound (i.e., say prot. Now say prot without the /r/ sound: pot) (Olson, Forsberg, Wise, & Rack, 1994).

Procedure

Two testers worked together administering all the tests to one of the children within each twin pair. The preschool assessments were conducted over five one-hour sessions across one or two weeks, typically in the children's homes, but sometimes in their preschools. The follow-up assessments were conducted in the children's homes in a one- to two-hour session during the summers following kindergarten, grade 1, grade 2, and grade 4.

Results

Three separate types of analyses were used to explore the longitudinal predictors of poor decoder and poor oral comprehender subtypes. First, using a retrospective approach, the subgroups were selected in grade 4 and compared on assessments conducted across the five test points from preschool to grade 4. Second, a prospective logistic regression analysis was performed to examine what preschool language and cognitive skills independently predict subgroups of poor decoders and poor oral comprehenders identified at grade 4. Third, a prospective analysis was performed by reselecting "at-risk" poor decoders and poor oral comprehenders based on their performance on the significant independent preschool predictors (RAN and vocabulary) that were identified in the prospective logistic regression analysis.

Because the twins in a pair are not fully independent observations, we compared these three separate types of analyses (using the cut-off criterion of −1 SD) with results when one twin was selected at random from each twin pair, and found that results were virtually identical. For this reason we decided to include the full sample of twins in all analyses.

4th Grade Group Selection

For the retrospective analysis, performance at grade 4 was used to define groups of poor decoders and poor oral comprehenders. Two composite measures were created using average z-scores across tests within each composite. The first composite, denoted *oral comprehension*, was based on two vocabulary tests, the Peabody Picture Vocabulary Test (PPVT) and the Boston Naming test, as well as a listening comprehension test, the Woodcock-Johnson Oral Comprehension test. The correlations between these tests were all above .59. The second composite, denoted decoding, was composed from 4 tests of decoding: TOWRE word reading efficiency, TOWRE phonemic decoding efficiency, Woodcock Word ID, and Woodcock Word Attack. The correlation of these tests exceeded . 68 for all pairs of tests.

Subgroups were identified using a cut-off criterion for poor performance in decoding or oral comprehension as a z-score of less than −1 SD (see Catts et al., 2003 for a similar procedure). This criterion corresponds to the 15th percentile. As can be seen in Figure 1, these cut offs defined four groups across our sample. The largest group (n=688) exhibited good or adequate decoding skill (mean .35) and oral comprehension (mean .35). This group is best characterized as *typical readers.* The smallest group (n=54) performed at least one standard deviation below average on both decoding (mean −1.83) and comprehension (mean −1.71). This group exhibited a mixed reading disability for both decoding and oral comprehension (Tunmer & Greaney, 2010), and has been referred to as *garden variety poor readers* (Stanovich, 1988). These two groups were not included in our analyses because our focus was to compare poor decoders to poor oral comprehenders. However, the entire sample of 926 children formed the baseline for computing *z*-scores for the analyses.

The target groups were *poor decoders* (n=85) and *poor oral comprehenders* (n= 99). The poor decoders show relative weaknesses in decoding (mean −1.59) and at least adequate performance (above −1 SD) in oral comprehension (mean −.04). In contrast, poor oral comprehenders exhibited relative weaknesses in oral comprehension (mean −1.52) and at least adequate performance (above −1 SD) in decoding (mean −.03).

Mean performance and standard deviations for all composites and single variables are presented in Table 1 for poor decoders and for poor oral comprehenders (defined by grade 4 performance on the decoding and oral comprehension composites). The table is organized by the cognitive variables, with the results presented for each of the testing periods from preschool to grade 4 below the label for each measure. Mixed design ANOVAs comparing the two subgroups (between subjects), and test occasions (within subjects) were run on each measure. The *F*-ratios for the comparison of poor decoders to poor comprehenders are shown in Table 1, along with effect sizes. Of central importance is whether these groups who were defined by their performance in grade 4 showed any differences in earlier test periods, and if so, on which variables, as those variables would then define the precursors of poor decoder or poor oral comprehender subtypes.

Retrospective Analysis

Phonological awareness, RAN, and print knowledge—As can be seen in Table 1, there were group differences in phonological awareness at each time point except the kindergarten assessment. It is important to note that the pattern of results is not consistently in favour of one group. In preschool, poor decoders performed better than poor oral comprehenders (an effect size of .55). However, starting at grade 1 poor oral comprehenders performed significantly better than poor decoders, with the difference gradually increasing from grade 1 (effect size .41) to grade 4 (effect size .99). Altogether, this pattern of group differences between poor decoders and poor oral comprehenders in phonological awareness accounts for the main effect of group, $F(1,177) = 13.08$, $p < .01$, $\eta_p^2 = .07$, as well as the interaction effect between time and group, $F(4, 708) = 20.33$, $p < .01$. $\eta_p^2 = .10$. The main effect of time was not significant.

RAN was measured at four test occasions. Table 1 shows that poor oral comprehenders performed close to an average level relative to the entire sample of 926 children; they also performed significantly better than poor decoders at each test occasion. Note also that there was a substantial increase in the group differences with the introduction of alphanumeric versions of RAN beginning in kindergarten (i.e., effect sizes changed from .37 in preschool to .93 on average on the remaining three test occasions). Consequently, the repeated measure ANOVA revealed a main effect of group, $F(1,176) = 50.86$, $p < .01$, $\eta_p^2 = .22$, and a significant interaction between time and group, $F(3, 528) = 8.70$, $p < .01$, $\eta_p^2 = .04$. The main effect of time was not significant.

The group difference in preschool print knowledge was significant and in favor of the poor decoders with an effect size of .34.

Oral language: vocabulary, grammar, and verbal memory—Poor oral comprehenders exhibited relative weaknesses compared to poor decoders in preschool assessments of vocabulary (effect size 1.07). This finding was convincingly replicated at grade 2 using the Boston naming test (effect size 1.50); and again at grade 4 (effect size 2.21), which would be expected given that the vocabulary tests had been part of the composite used to select groups. Main effects of time were significant $F(2, 362) = 4.79$, $p<.01$, $\eta_p^2=.03$ as was the group effect, $F(1, 181) = 180.70$ $p<.01$, $\eta_p^2=.50$. Consequently the interaction of group by time was significant, $F(2, 362) = 11.31$ $p<.01$, $\eta_p^2=.06$. The pattern of differences between groups across time was stable in the assessments of grammar at both preschool and kindergarten with effect sizes of .82 and .77, respectively. As a result the group effect was significant, $F(1, 181) = 46.54$, $p<.01$, $\eta_p^2=.21$, whereas the time effect and interaction effect failed to reach significance.

A significant group effect was found in the assessments of verbal memory across time, $F(1, 177) = 20.18$, $p<.01$, $\eta_p^2=.10$. However, no significant time- or interaction effects were found for verbal memory in the repeated measures ANOVA. Thus, poor oral comprehenders scored significantly lower than poor decoders on oral language measures at every time point assessed, showing that oral comprehension deficits manifest early and are stable.

Reading and spelling—Table 1 also summarizes the performances of poor decoders and poor oral comprehenders in decoding and spelling from kindergarten through grade 4, and reading comprehension from grade 1 to grade 4. For decoding and spelling the results across time were straightforward. Poor oral comprehenders outperformed poor decoders in both decoding and spelling at each time point. Effect sizes for these differences exceeded .85 except kindergarten (.31). As a result the ANOVAs show significant group effects, $F(1,176) = 189.35$, $p<.01$, $\eta_p^2=.52$ for decoding and, $F(1,177) = 78.35$, $p<.01$, $\eta_p^2=.31$ for spelling. The effects of time across groups were also significant for both decoding $F(3,528) = 22.74$, $p<.01$, $\eta_p^2=.12$ and for spelling $F(3,531) = 5.29$, $p<.01$, $\eta_p^2=.03$. The differences between groups gradually increased across time for both decoding and spelling such that poor decoders lagged behind poor oral comprehenders. At grade 4 when the selection of groups was made, effect sizes of group differences exceeded 1.75 for both measures. These results receive further support from the ANOVAs indicating significant interactions between time and group for both decoding, $F(3,528) = 97.18$, $p<.01$, $\eta_p^2=.36$ and for spelling, $F(3, 531) = 20.07$, $p<.01$, $\eta_p^2=.10$.

Reading comprehension was assessed at three test occasions (grades 1, 2 and 4). The main effect of time was not significant. However, the analysis showed a significant effect of group, $F(1,178) = 61.73$, $p<.01$, $\eta_p^2=.26$), with poor oral comprehenders performing at higher levels compared to poor decoders in reading comprehension at each test occasion. Better performance by poor oral comprehenders on reading comprehension may seem surprising, but it reflects the fact that reading comprehension is more constrained by word decoding skill than oral language skill in the early grades, when decoding skills are developing, and for poor decoders whose decoding skills are very low. Interestingly, there was also a significant interaction between time and group indicating that mean differences in reading comprehension between groups decreased with increasing age, $F(2,356)= 16.73$, $p<.01$, $\eta_p^2=.09$). The effect sizes for the differences in reading comprehension changed from 1.04 in grade 2 to .48 in grade 4.

If our interpretation is correct that poor oral language affects reading comprehension more in the later grades when it is less constrained by low levels of decoding, then if we remove the

effects of decoding, we should see the expected pattern where poor oral comprehenders are performing worse than poor decoders. We therefore did an analysis of covariance controlling for decoding on the reading comprehension measures across time. The results showed that the covariate, decoding, was significant across time, $F(1,402.32) = 216.34$, $p<.01$; the main effects of time and group were not significant, but the interaction of group by time was, $F(2,376.50) = 43.89$, $p<.01$. Ancovas at each test occasion revealed the predicted pattern. Namely, poor oral comprehenders and poor decoders perform similarly in reading comprehension in grades 1 and 2 when the effect of decoding is taken into account; however, in grade 4, poor oral comprehenders perform significantly worse than poor decoders, as one might expect. Adjusted means, group effect, effect of the covariate and effect sizes of these analyses are presented in Table 2.

Retrospective Analysis with Stricter Exclusion Criteria

In order to check the reliability of our findings from the first retrospective analysis, we examined whether they replicated using a more strict exclusion criterion in selecting subgroups. To accomplish this, poor oral comprehenders were required to have both poor oral comprehension (z scores of less than −1) and at least age appropriate skills in decoding (z scores above 0). Thus, children in this poor oral comprehender group had a specific deficit only in comprehension. Similarly, poor decoders were now defined as those children with poor performance only in decoding because they were required to have above average performance in oral comprehension. By using this procedure, two new groups of 36 poor decoders and 43 poor oral comprehenders were identified.

The results using these stricter exclusion criteria are strikingly similar to those previously reported (see Table 3). This was true for the mean comparisons performed at each time point, for group effects collapsed across time, as well as for the interaction effects between time and group. Only two exceptions were found. The preschool assessment of print knowledge was not significantly different between subgroups when using the more strict exclusion criteria for group selection. In addition, spelling in kindergarten failed to reach significance; however, group differences were significant across grades starting at grade 1 with large effect sizes. These two exceptions may reflect the loss of power from having a sample size now that is less than half the size in the previous analyses. Thus, the findings from the first set of retrospective analyses were replicated generally when applying a stricter criterion for group selection.

Prospective Prediction from Preschool

Logistic regression—A logistic regression analysis was used to predict group membership of poor oral comprehenders and poor decoders identified at grade 4 by using all six preschool composites of cognitive and language skills as predictors (i.e., phonological awareness, RAN, verbal memory, vocabulary, grammar/morphology and print knowledge). All 184 children classified as either poor oral comprehenders or poor decoders in our first retrospective analysis of group differences were included in the logistic regression analysis. In this analysis the predictor model was significantly better compared to the baseline model ($\chi^2 = 68.18^{**}$, $df = 6$). The model explained 42 % of the variance (Nagelkerke R^2), and 77 % of the poor decoders and 79 % of the poor oral comprehenders were correctly classified using the preschool skills as predictors. The contribution of each preschool composite is shown in Table 4.

Significant predictors of group membership, where 0 represented poor decoders and 1 represented poor oral comprehenders, were vocabulary and RAN. For vocabulary the b-value was negative and the odds ratio was below 1, which indicates that poor results in preschool vocabulary classify the child as a poor oral comprehender rather than a poor

decoder. The opposite pattern was found for RAN indicating that poor results were associated with the subgroup of poor decoders. The remaining composite measures of phonological awareness, verbal memory, grammar/morphology and print knowledge did not contribute to significant independent prediction of group membership after controlling for prediction from RAN and vocabulary.

Prospective prediction from subtypes re-selected at preschool—Subgroups of children from the full population sample who might be at-risk for subsequent poor decoder or poor oral comprehender subtypes were selected based on their preschool performance. Those in the low-tail of the distribution on their preschool performances in RAN or vocabulary (i.e., the significant predictors from the logistic regression analysis) were selected and followed across grades. Using a −1 SD cut-off criterion, there were 85 preschoolers (out of the entire sample of 926 children) who exhibited poor performance on the RAN composite (mean −1.74) and adequate (above −1 SD) vocabulary (mean .07). This subgroup is denoted “at-risk poor decoders”. A second subgroup of 86 pre-schoolers with an average score of −1.62 in vocabularies and .12 on the RAN composite was selected and denoted “at-risk poor oral comprehenders”. These two groups were followed prospectively on measures of literacy from grade 1 to 4. In addition, we compared them on their oral comprehension measured at grade 4. Table 5 reports means, standard deviations, and F-ratios as well as effect sizes for both groups on literacy and listening comprehension.

Assessments of decoding showed significant effects of group in favour of the at-risk poor oral comprehenders at each test occasion starting at grade 1 with moderate effect sizes. Consequently, the group effect of the repeated measures ANOVA was significant for decoding, $F(1,164) = 6.37$, $p<.05$, $\eta_p^2=.04$. The main effect of time was not significant for decoding; however, an interaction effect $F(3, 492) = 5.67$, $p<.01$, $\eta_p^2=.03$ was found, indicating different developmental patterns for the two groups. When comparing the at-risk groups in spelling, no significant group effects were found in the repeated measurements. However, a significant interaction indicated different developmental patterns over time in the two groups’ spelling, $F(3, 495) = 4.47$, $p<.01$, $\eta_p^2=.03$, with the at-risk poor oral comprehenders showing significantly better spelling by grade 4.

The differences between the at risk groups at grade 4 were most evident in RAN (effect size .70), listening comprehension (effect size .72) and vocabulary (effect size .73). These variables are very similar to the subtype selection variables at preschool (RAN pictures and colours, oral vocabulary). Children defined as at risk for oral comprehension deficits in preschool were significantly poorer on vocabulary and listening comprehension than the at-risk poor decoder group. However, the oral comprehension deficit for at-risk poor oral comprehenders was not associated with greater deficits in reading comprehension when compared to the deficit for poor decoders at any of the grade levels. As previously noted, because reading comprehension tests at this age assess both decoding and comprehension skills, it is not surprising that children with deficits in one or the other skill would not differ. However, the interaction between time and group was again significant for reading comprehension, $F(2,330) = 7.08$, $p<.01$, $\eta_p^2=.04$), showing that poor decoders catch up and poor oral comprehenders fall back as they get older. This result is consistent with a previously noted decrease in the importance of decoding and increase in the importance of oral comprehension variance for predicting reading comprehension with increasing age (Keenan et al., 2008).

By using the preschool variables of RAN and vocabulary to select at-risk groups, we were able to capture some, but not all, of the developmental patterns found to identify the subtypes selected in grade 4. It is also worth noting that the overlap between individuals selected in preschool as at-risk poor decoders or at-risk poor oral comprehenders and grade

4 subtypes was 27 % for the poor decoders and 37 % for the poor oral comprehenders, which is rather low considering the classification percentages of 77–79 % obtained in the logistic regression. However, accurate preschool prediction of extreme subtype performance differences in grade 4 may not be a reasonable criterion for the value of preschool prediction. The significant group effects in Table 5 following preschool indicate that the majority of those selected as at-risk for poor decoding at preschool do have relatively lower decoding across the grades, and most at-risk poor oral comprehenders do have relatively lower oral language skills across the grades.

Discussion

To better understand the prediction of literacy deficits, we examined the cognitive and language skills that predict poor decoding and poor comprehension. By examining both deficits in the same study, we were able to determine that there are distinctive predictors of each. We used both retrospective analyses of poor decoders and poor oral comprehenders defined in 4th grade and prospective analyses of pre-schoolers identified as “at risk poor decoders” and “at risk poor oral comprehenders”. Considerable developmental stability was found in the poor decoder and poor oral comprehender subtypes. We first review the main results and implications from the retrospective analysis, then the prospective findings, and then compare the similarity of findings across the two analyses to get a deeper understanding of the predictors of different reading profiles.

Retrospective Results

The overall pattern of differences between poor decoders and poor oral comprehenders selected in grade 4 was consistent from kindergarten through grade 4. The poor decoders showed lower performance on phonological awareness, RAN, decoding and spelling. These results are consistent with the vast literature that has identified these skills as most highly correlated with decoding performance when children are learning to read (c.f., Denkla & Rudel, 1976; Vellutino et al., 2004; Wolf, 1999). The poor oral comprehenders, on the other hand, exhibited relative weaknesses in vocabulary, grammar/morphology and verbal memory, also consistent with previous research on children with reading comprehension impairments (c.f., Catts, et al., 2006; Nation, et al., 2010). Basically, this pattern was replicated when using a stricter exclusion criterion where adequate skill in decoding (in the poor oral comprehenders) and oral comprehension (in the poor decoders) was defined as being above the population mean.

In addition to the findings that mesh well with the current literature, there were two noteworthy results that may seem at first glance to be inconsistent with previous findings. One is the strong main effect of better reading comprehension in the poor oral comprehender group that we observed in first, second and fourth grades. If they are poor oral comprehenders, why are they performing better on reading comprehension? As we learned from our analyses controlling for decoding skill, the answer lies in their good decoding skills. In order to meet criteria for having a specific deficit only in comprehension, poor comprehenders had to be typically performing on word decoding skill; thus, they had much better decoding compared to the very poor decoding of the poor decoders. Because decoding skill accounts for nearly all of the variance in reading comprehension in the early grades (Byrne et al., 2007; Keenan, et al., 2008), poor decoders perform more poorly on reading comprehension; but as decoding skill improves and vocabulary accounts for more variance than decoding (Olson et al., 2011), then poor performance on reading comprehension reflects poor oral language comprehension. When we controlled for decoding skill by using it as a covariate, then there was no longer a difference in reading comprehension between poor decoders and poor oral comprehenders in grades 1 and 2. In grade 4, however, there was.

The other result worth noting because it seems inconsistent with previous findings is that phonological awareness was highest in the subgroup of poor decoders at preschool. Most studies on poor reading comprehenders show adequate phonological skills after a couple of years in school. However, two studies suggest that phonological awareness may be impaired in poor reading comprehenders early in their literacy development at age 6 (Catts et al. 2003; Nation et al. 2010). In addition, Bishop, McDonald, Bird, & Hayiou-Thomas, (2009) examined language impaired children with and without dyslexia selected at age 9 and found no differences between these groups in phonological awareness at age 4 or 6. This shows that children with poor language can be compromised in phonological awareness early on in their literacy development and still manage to learn to read at appropriate levels. Taken together, these studies and our results suggest that deficits in phonological awareness in preschool may be a risk for either poor decoding or poor oral comprehension. The shift in the pattern of results in phonological awareness for both subtypes at the end of kindergarten, after having received some reading instruction, likely resulted from the close reciprocal relation between learning to decode and phonological awareness that derives from reading instruction (Perfetti, Beck, Bell, & Hughes, 1987). The task of learning to read thus leads to more distinct trajectories of phonological skills and other aspects of language.

Overall, the group main effects were remarkably consistent in direction from preschool, before children learn to read, through the end of grade 4. This essentially validates the poor decoder and poor oral comprehender subtypes from a developmental perspective. However, there were significant main effects for time and/or group by time interactions for most of the measures repeated across time. Some of these effects may reflect the ubiquitous phenomenon known as regression to the mean (Nesselroade, Stigler, & Baltes, 1980). In the present study, we expect the strongest regression to the population mean for variables used in or closely related to the extreme subtype selection composites at the end of 4^{th} grade. These are decoding and spelling for our poor decoders and vocabulary for our poor oral comprehenders. In fact, these variables showed the strongest regression to the population mean and this regression increased across measurement occasions.

The significant group by time interaction for RAN may have been largely due to differences in measurement between preschool and the later grades. The poor decoders were significantly lower on RAN when it was assessed with pictures and colors at preschool, but their RAN deficit increased substantially when we began assessing RAN with letters and numbers at the end of kindergarten.

Prospective Results

Our retrospective analyses provided an important developmental validation of the basic consistency of our subtypes from preschool through the end of grade 4. However, those analyses do not tell us how well we can predict 4^{th} grade subtype membership from preschool assessments or exactly which variables are most useful for this prediction. It is apparent from our discussion of the group by time interactions that prediction is likely to be better from assessments closer to 4^{th} grade when children are reading. But in the present study we were most interested in prediction from preschool.

The logistic regression analysis revealed that the preschool variables that independently contributed to the prediction of group membership were vocabulary and RAN, accounting for 42 % of the group variance. It may seem surprising that preschool phonological awareness together with print knowledge, commonly reported as core deficits underlying poor decoding, were not able to independently predict subtype membership at grade 4. Our result is directly related to the poor decoders' low decoding accompanied by adequate oral comprehension. The levels of phonological awareness and print knowledge in our group of poor decoders are likely higher than those of poor decoding groups used in other studies

because we selected only those poor decoders that show adequate oral language. In contrast, when predicting future individual differences or deficits in decoding regardless of oral comprehension in general population samples, there are significant independent contributions from preschool print knowledge, phonological awareness, and RAN, though RAN tends to be the strongest independent predictor (e.g., Furnes & Samuelsson, 2010; Keenan, Olson, Byrne, & Samuelsson, 2011).

In our final prospective analysis, we re-selected at-risk poor decoders and poor oral comprehenders from the full sample in preschool based on their pattern of results on preschool vocabulary and RAN. This analysis showed significant effects of group on decoding in favour of the at-risk poor oral comprehenders at each test occasion and this difference was stable across time. In addition, at-risk poor oral comprehenders exhibited deficits in listening comprehension and vocabulary skills at grade 4. Individual subjects' overlap between the at-risk subtypes in preschool and poor decoder or poor oral comprehender subtypes in grade 4 was rather small. This is not surprising. Although RAN and vocabulary explain some of the variance in the logistic regression model (42 %); the prediction is far from perfect. However, the significant effect sizes for decoding (.49) and oral comprehension (.72) for the at-risk group differences at grade 4 are impressive when considering the long time span, differences in tests, and the many educational and developmental changes that occur following preschool.

Implications for Identification and Intervention

Early identification and longitudinal stability of deficits characterizing subtypes of poor decoders and poor oral comprehenders are prerequisites for early and appropriate intervention. In this study we have focused on two different groups that show reading comprehension deficits in grade 4. The groups showed consistency in their cognitive profiles across grades and these different cognitive profiles both lead to compromised reading comprehension, but at different ages. The poor decoders showed compromised results in reading comprehension consistently, but the poor oral comprehenders' reading comprehension was not compromised until grade 4. That is because at grade 4, decoding and oral language are almost equally important in explaining variance in reading comprehension (as shown by confirmatory factor analysis on the data set by Keenan et al. 2011). When performance in reading comprehension is accounted for by oral language skills in addition to decoding skills, the group of poor oral comprehenders starts to fall behind the mean of the entire sample in reading comprehension. Thus, our evidence for the general consistency of children's reading profiles from preschool through the end of grade 4 suggests that a focus on the specific deficit (decoding or oral comprehension) should be considered for intervention.

Although RAN is consistently lower for the poor decoders beginning in preschool, it is not an appropriate target for remediation because training in rapid naming of letters or letter sounds and numbers does not significantly increase speed and does not improve reading (de Jong & Vrielink, 2004). On the other hand, poor decoders' deficit in phonological awareness while learning to read does present a useful target for intervention, particularly when it is combined with print, and when phonological awareness and decoding skills are very low (e.g., Hatcher, Hulme, & Ellis, 1994). At preschool, interventions for at-risk poor decoders that are focused on relations between phonemes and letters have shown significant benefits for decoding in the early grades (Byrne & Fielding-Barnsley, 1993; Hindson et al., 2005). Once phonological decoding and phonological awareness have reached approximately third-grade levels, a focus on decoding through accurate reading practice may be optimal (Wise, Ring, & Olson, 2000).

Deficits in oral comprehension and vocabulary are obvious targets for intervention. A recent study found that 30 hours of intensive oral language training distributed over 60 half-hour sessions had significant benefits for vocabulary growth and reading comprehension in 8- to 9-year-old children with specific reading comprehension deficits (Clarke, Snowling, Truelove, & Hulme, 2010). The continuity of vocabulary, grammar, and verbal memory deficits for many of our poor oral comprehenders from preschool through grade 4 suggests that interventions supporting these oral language skills prior to reading instruction would help reduce the expression of later oral language and reading comprehension deficits.

Limitations and Conclusion

Any longitudinal study that spans 5 years beginning in preschool necessarily must use different tests across grades to access the same construct in order to avoid floor and ceiling effects on the tests. But this raises the question whether differences in the specific tests used at different time points might have affected our results. This is an important methodological issue for longitudinal studies. However, it should be noted that even when one uses the exact same test at each time point, it does not guarantee that the same skill is being measured. Keenan et al. (2008) showed that for some tests of reading comprehension, the relative influence of decoding and oral language switches as a function of age. Changes also occur in the skills assessed in the TOWRE; decoding accuracy is the main constraint at kindergarten, but speed may be a greater constraint at grade 4. Fortunately, what we found was stability, not differences; evidence for stability suggests that our assessments of the variables were quite consistent across time.

Another potentially limiting factor in longitudinal studies involving young children is reliability of measurement. The way we dealt with this issue is that most theoretical constructs were assessed using a multiple test approach. This was especially important in preschool; by using multiple tests of a construct we were able to reduce the risk of systematic measurement errors.

We used two tasks assessing preschool vocabulary; both were expressive vocabulary tasks. An interesting path for future research would be inclusion of even broader assessment of vocabulary. Ouellette (2006) and Nation and Cocksey (2009) have suggested that receptive and expressive aspects of vocabulary breadth and depth may play different roles in decoding and reading comprehension. This more nuanced view of vocabulary, may offer additional prediction.

In conclusion, the present study’s combination of retrospective and prospective analyses of poor decoder and poor oral comprehender subtypes from preschool through end of grade 4 has clarified their validity and their development. Prediction from preschool offers hope that appropriately targeted preschool interventions may help reduce the poor decoder and poor oral comprehender deficits that would otherwise emerge. Continued additional emphasis on remediating those deficits as needed in the early grades may ensure that fewer children will fall in the poor decoder or poor comprehender reading disability subtypes in the later grades. For children at risk for both poor decoding and poor oral comprehension, early intervention in both areas may help those children avoid later classification as “garden variety” poor readers (Stanovich, 1988).

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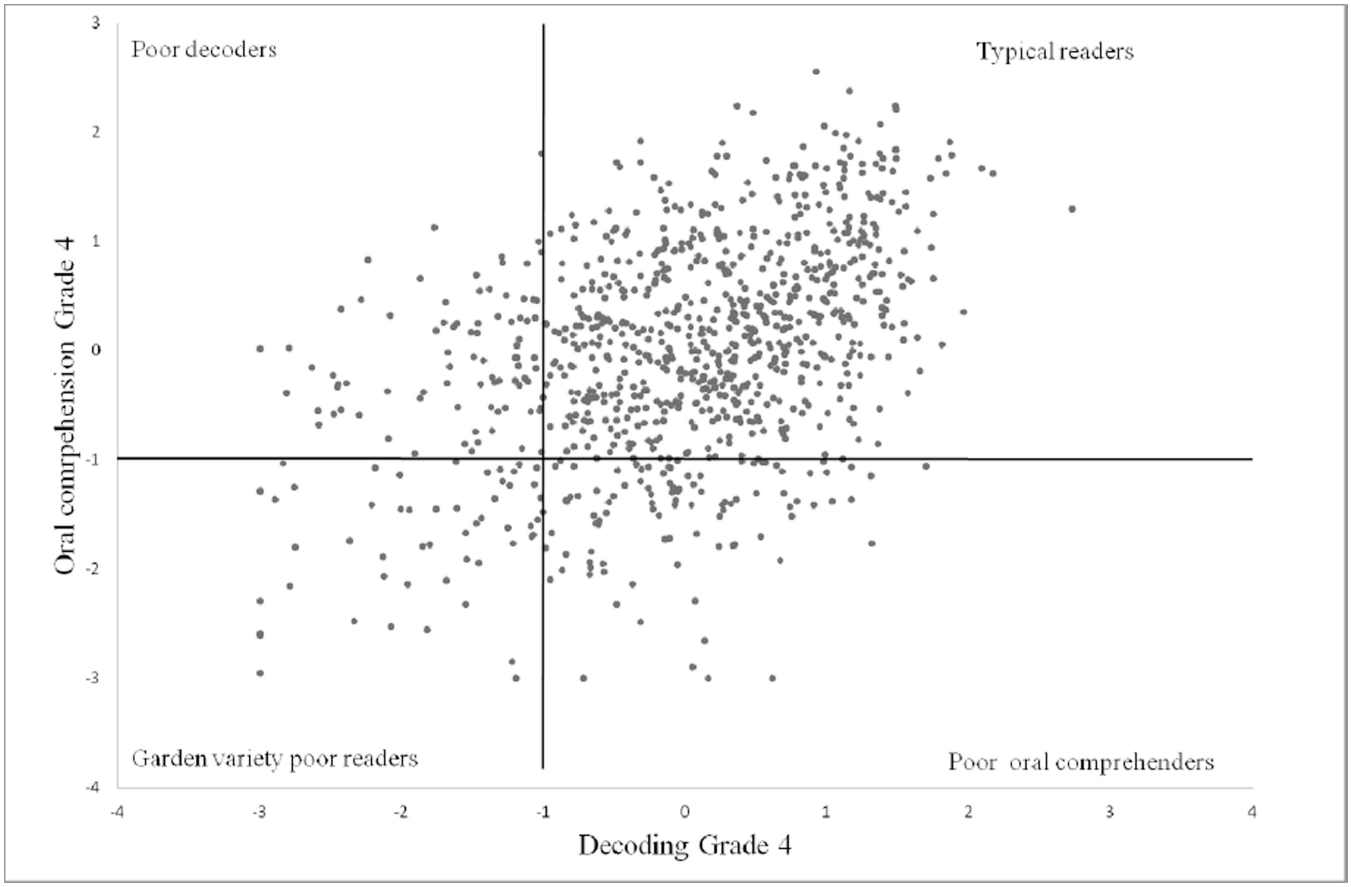

Fig 1.
Scatterplot Showing Group Selection in Grade 4 Based on Z-scored Composites of Decoding and Oral Comprehension

Table 1

Group Effect, Mean Z-scores and Standard Deviations of the Retrospective Analysis of Pre-literacy and Literacy Skills Comparing Poor Decoders and Poor Oral Comprehenders Identified by Their Deficits at Grade 4

	Poor decoders	Poor oral comprehenders		
Assessment	***M (SD)***	***M (SD)***	**F(1,182)**	**Cohen's D**
Phonological awareness				
Preschool	−.41 (.66)	−.78 (.67)	14.10**	.55
Kindergarten	−.73 (.72)	−.51(.86)	3.44	.26
1st grade	−.70(.73)	−.36(.82)	8.79**	.41
2nd grade	−.80(.70)	−.34(.86)	15.58**	.53
4th grade	−.91(.73)	−.14(.78)	47.15**	.99
Print knowledge				
Preschool	−.43(.73)	−.74(.81)	7.33**	.34
RAN				
Preschool	−.50 (.99)	−.12 (1.04)	6.54*	.37
Kindergarten	−.91(1.01)	−.01(.88)	42.01**	.89
1st grade	−.81(.99)	.13(.71)	54.41**	.95
4th grade	−.96(1.13)	.13(.88)	54.69**	.96
Grammar				
Preschool	−.22 (.84)	−.95(.89)	32.51**	.82
Kindergarten	−.22(.85)	−.96(.86)	33.94**	.77
Vocabulary				
Preschool	−.17 (.72)	−1.05 (.82)	58.87**	1.07
2nd grade	−.08(.78)	−1.21(.73)	100.12**	1.5
4th grade *gs*	−.07(.63)	−1.46(.54)	259.46**	2.21
Verbal memory				
Preschool	−.38 (.86)	−.83(.74)	14.43**	.52
1st grade	−.37(.91)	−.92(.94)	15.68**	.59
Decoding				
Kindergarten	−.61(.31)	−.37(.51)	13.66**	.47
1st grade	−1.12(.37)	−.22(.71)	105.60**	1.26
2nd grade	−1.44(.57)	−.10(.67)	204.73**	2
4th grade *gs*	−1.52(.58)	−.02(.66)	265.73**	2.27
Spelling				
Kindergarten	−.72(1.01)	−.40(.99)	4.56*	.31
1st grade	−.88(.58)	−.27(.71)	38.02**	.85

	Poor decoders	Poor oral comprehenders		
Assessment	***M (SD)***	***M (SD)***	**F(1,182)**	**Cohen's D**
2nd grade	−1.17(.59)	−.17(.70)	108.90**	1.42
4th grade	−1.31(.56)	−.21(.63)	153.61**	1.75
Reading comprehension				
1st grade	−1.12(.76)	−.31(.74)	52.52**	1.07
2nd grade	−1.24(.91)	−.29(.62)	69.31**	1.04
4th grade	−.91(.75)	−.55(.53)	14.40**	.48
Listening comprehension				
4th grade *gs*	.02(.68)	−1.28(.62)	185.29**	1.91

Note.

gs variables used for group selection.

* $p<.05$.

** $p<.01$

Table 2

Effects of the Ancova Analyses, Adjusted Means and Standard Errors for Reading Comprehension When Controlling for Decoding Results

Test Occasion	Poor Decoders	Poor oral comprehenders	Effect of group F(1,181)	η_p^2	Effect of covariate F(1,181)	η_p^2
Grade 1	−.66(.07)	−.68(.06)	.04		178.55**	.50
Grade 2	−.71(.08)	−.75(.08)	.12		106.63**	.37
Grade 4	−.46(.09)	−.93(.08)	11.22**	.06	53.94**	.23

Note.

*p<.05.

**p<.01.

Table 3

Group Effect, Mean Z-scores and Standard Deviations of the Retrospective Analysis of Preliteracy and Literacy Skills Comparing Poor Decoders and Poor Oral Comprehenders Identified in Grade 4 Using a More Strict Criteria for Group Selection

	Poor decoders	Poor oral comprehenders		
Assessment	***M (SD)***	***M (SD)***	**F(1,77)**	**Cohen's D**
Phonological Awareness				
Preschool	−.19(.67)	−.72(.68)	11.90**	.78
Kindergarten	−.55(.78)	−.39(.87)	.73	.18
1st grade	−.60(.75)	−.10(.91)	6.78*	.54
2nd grade	−.67(.70)	−.18(.94)	6.78*	.52
4th grade	−.74(.72)	.08(.83)	21.33**	.79
Print knowledge				
Preschool	−.35(.82)	−.68(1.02)	2.25	.32
RAN				
Preschool	−.32(.83)	.09(.90)	4.42*	.46
Kindergarten	−.64(.93)	−.09(.89)	12.36**	.59
1st grade	−.61(.92)	.44(.46)	41.57**	1.14
4th grade	−.78(1.05)	.54(.72)	43.83**	1.25
Grammar				
Preschool	.01(.91)	−.94(.92)	21.10**	1.03
Kindergarten	.18(.77)	−1.07(.92)	40.41**	1.36
Vocabulary				
Preschool	.11(.65)	−1.22(.94)	51.38**	1.41
2nd grade	.33(.66)	−1.27(.84)	84.89**	1.90
4th grade *gs*	.48(.45)	−1.42(.61)	240.61**	3.11
Verbal Memory.				
Preschool	−.35(.93)	−.80(.80)	5.40*	.48
1st grade	−.22(.98)	−.85(.80)	9.80**	.64
Decoding				
Kindergarten	−.53(.35)	−.24(.61)	6.29*	.48
1st grade	−1.09(.38)	.24(.74)	95.43**	1.80
2nd grade	−1.37(.54)	.31(1.02)	158.31**	1.65
4th grade*gs*	−1.40(.50)	.53(.47)	314.60**	3.86
Spelling				
Kindergarten	−.64(1.07)	−.30(1.10)	1.93	.31
1st grade	−.79(.53)	.03(.85)	25.52**	.96
2nd grade	−1.01(.57)	.22(.67)	76.29**	1.84

	Poor decoders	Poor oral comprehenders		
Assessment	***M (SD)***	***M (SD)***	**F(1,77)**	**Cohen's D**
4th grade	−1.25(.49)	.19(.56)	146.37**	2.57
Reading comprehension.				
1st grade	−1.02(.77)	−.05(.73)	32.05**	1.26
2nd grade	−1.06(.85)	−.11(.63)	31.80**	1.12
4th grade	−.79(.78)	−.36(.50)	8.53**	.55
Listening comprehension				
4th grade*gs*	.39(.61)	−1.34(.65)	145.85**	2.66

Note.

gs variables used for group selection.

* $p<.05$.

** $p<.01$.

Table 4

Results of Logistic Regression Analysis Predicting Group Membership in Grade 4 Based on Preschool Predictors

Variables	*B*	*SE*	*OR*	*CI*
Constant	−.67	.27		
PA	−.08	.34	.92	.48–1.78
RAN	.56	.19	1.75**	1.21–2.53
VM	.22	.29	1.24	.70–2.20
Vocab	−1.59	.36	.20**	.10−.41
Gram/Morph	−.54	.28	.59	.34–1.02
Print	.18	.28	1.20	.69–2.09

Note. OR= Odds Ratio. PA = phonological awareness. RAN = rapid automatized naming. VM = verbal memory. Vocab = Vocabulary. Gram/Morph = Grammar/Morphology. Print = print knowledge.

* $p<.05$.

** $p<.01$.

Table 5

Group effect, Mean Z-scores and Standard Deviations of the Prospective Analysis Comparing At-Risk Poor Decoders and At-Risk Poor Comprehenders Identified in Preschool

	At-risk poor decoders	At-risk poor oral comprehenders		
Assessment	***M (SD)***	***M (SD)***	**F(1,169)**	**Cohen's D**
RAN				
Preschool*gs*	−1.74(.62)	.12(60)	396.33**	3
Kindergarten	−.92(1.01)	−.04(.77)	41.2**	.87
1st grade	−.65(.99)	.00(.78)	22.66**	.66
4th grade	−.73(1.16)	.08(.88)	26.78**	.70
Vocabulary				
Preschool*gs*	.07(.61)	−1.62(.56)	352.03**	2.64
2nd grade	−.09(.86)	−.82(1.05)	24.89**	.70
4th grade	−.05(.84)	−.83(1.07)	28.86**	.73
Decoding				
Kindergarten	−.41(.57)	−.40(.65)	.01	.02
1st grade	−.54(.77)	−.24(.95)	5.11*	.32
2nd grade	−.59(.96)	−.19(.88)	8.28**	.42
4th grade	−.56(.95)	−.09(.93)	10.65**	.49
Spelling				
Kindergarten	−.35(1.05)	−.50(1.06)	.84	.14
1st grade	−.38(.89)	−.31(.89)	.25	.07
2nd grade	−.45(.90)	−.19(.96)	3.55	.27
4th grade	−.49(.99)	−.19(.92)	4.18*	.30
Reading comprehension				
1st grade	−.43(.98)	−.43(.98)	.00	0
2nd grade	−.41(1.06)	−.23(.92)	1.31	.17
4th grade	−.31(.96)	−.55(.87)	2.81	.25
Listening comprehension				
4th grade	−.06(.95)	−.78(.99)	23.70**	.72

Note.

gs variables used for group selection.

* $p<.05$.

** $p<.01$