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Cognitive precursors of the developmental relation between lexical quality and reading comprehension in the intermediate elementary grades

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ABSTRACT

In a longitudinal study, we investigated how cognitive precursors (short-term memory, working memory, and nonverbal reasoning) influence the developmental relation between lexical quality (decoding and vocabulary) and reading comprehension skill in 282 Dutch students in the intermediate elementary grades (mean age at start Grade 4 was 9; 7 years) as these grades mark an important transition point in the development of reading comprehension skill. Analyses revealed strong autoregressive effects for the linguistic measures. Moreover, evidence was found for a reciprocal relation between vocabulary and reading comprehension. Direct concurrent relations were evidenced between short-term memory and decoding, and between working memory and reasoning, on the one hand, and reading comprehension and vocabulary, on the other hand. Finally, we found direct and indirect influences of nonverbal reasoning and working memory capacity on reading comprehension and vocabulary development. The results highlight the importance of both lexical and cognitive factors in reading comprehension development.

1. Introduction

Comprehending written text is a complex process, drawing on many different underlying skills. The Lexical Quality Hypothesis (Perfetti & Hart, 2002) states that reading comprehension development is highly determined by levels of word decoding and vocabulary (Perfetti, Landi, & Oakhill, 2005). Various studies indeed have evidenced longitudinal relations between decoding, vocabulary, and reading comprehension (De Jong & Van der Leij, 2002; Oakhill & Cain, 2012; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Verhoeven & Van Leeuwe, 2008; Verhoeven, Van Leeuwe, & Vermeer, 2011). Additional research has shown that cognitive skills, such as memory capacity and reasoning, also account for individual differences in reading comprehension skill (e.g., Fuchs et al., 2012; Nouwens, Groen, & Verhoeven, 2016). With respect to reading, the intermediate elementary grades mark a critical transition point: in contrast to the focus on learning to read, students now are required to extract knowledge from increasingly complex texts (McMaster, Espin, & Van den Broek, 2014). Longitudinal studies on the development of reading comprehension in this critical transition phase, including both lexical quality markers and cognitive factors, are warranted. Therefore, in the current study we examined (1) the developmental relations between markers of lexical quality (decoding and vocabulary) and reading comprehension skill in Dutch students in the intermediate elementary grades (mean age at start of grade 4: 9 years and 7 months) and (2) to what extent cognitive factors (memory and reasoning) influence these developmental relations.

1.1. Decoding and vocabulary as predictors of reading comprehension

Individual differences in reading comprehension have proven to be stable over time (De Jong & Van der Leij, 2002; Oakhill & Cain, 2012; Verhoeven & Van Leeuwe, 2008). Results from various longitudinal studies have shown that early levels are predictive of later levels of reading comprehension skill. Although the stability of reading comprehension development is high in elementary school (standardized path coefficients > 0.90 are not uncommon), additional factors affecting reading comprehension have been identified.

One of the most influential theories on reading comprehension is the Simple View of Reading (Hoover & Gough, 1990) which states that reading comprehension is the product of word decoding and linguistic comprehension. Word decoding refers to the ability to identify single

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words; linguistic comprehension refers to the ability to process and comprehend orally presented information. To be able to understand written text, both skills are necessary. Within the Simple View of Reading, the role of vocabulary has been underexposed: different studies have shown that vocabulary affects reading comprehension above and beyond the effect of other linguistic comprehension skills (e.g., Ouellette & Beers, 2010), especially when students become older. A theory that places more emphasis on word knowledge is the Lexical Quality Hypothesis (Perfetti & Hart, 2002), which assumes, more specifically, that decoding and vocabulary are two critical determinants of reading comprehension. When children start to learn to read, decoding is a cognitively effortful and time-consuming process in which each grapheme has to be translated to its corresponding phoneme and these phonemes have to be blended into (meaningful) words. The attainment of fluent reading skills has been characterized as essential in developing reading comprehension skills (e.g., Perfetti, 1992). As children become more experienced, decoding becomes less cognitively effortful and more automated, freeing mental resources which then can be used for other processes, such as text comprehension (e.g., National Reading Panel, 2000; Perfetti, 1998). Various cross-sectional studies have shown that individual differences in decoding skill accounted for individual differences in reading comprehension skill (e.g., Cutting & Scarborough, 2006; Ouellette, 2006; Swart et al., 2017). Longitudinal studies, in addition, have shown that, although students showed development in decoding skills, individual differences, both in accuracy and speed, remained stable over time (e.g., De Jong & Van der Leij, 2002; Oakhill & Cain, 2012; Torgesen et al., 1997; Verhoeven & Van Leeuwe, 2008; Wagner et al., 1997) and that early decoding skills predict later reading comprehension ability (e.g., Fuchs et al., 2012). However, without taking autoregressive effects into account in longitudinal studies, it is possible that observed relations between word decoding and reading comprehension at a later time point can be attributed to the relation between word decoding and reading comprehension at an earlier time point. Only few studies examining the relation between decoding and reading comprehension included these autoregressive effects. In their longitudinal study, De Jong and Van der Leij (2002) examined how linguistic abilities affect decoding and reading comprehension in Dutch children in the early elementary grades. They concluded that word decoding speed measured in first grade influenced the development of reading comprehension skills from first through third grade, after controlling for the autoregressive effect of reading comprehension from first to third grade. Additionally, Verhoeven and Van Leeuwe (2008) concluded that, after controlling for autoregressive effects, first grade decoding skills substantially influenced second grade reading comprehension skills and that, in addition, there was also a small positive influence of fifth grade decoding skill on sixth grade reading comprehension. Taking together, these studies suggested that there is an association between decoding and reading comprehension and that decoding skills influence reading comprehension development.

Although automated decoding skills are clearly crucial, they are by no means sufficient to arrive at comprehending written text. According to the Lexical Quality Hypothesis, word knowledge, or in other words, vocabulary, is a second crucial determinant of reading comprehension (Perfetti & Hart, 2002). Quality of word representations is based on the precision and extensiveness of orthographic, phonological, and semantic knowledge and it has been argued that individual differences in reading comprehension can be brought back to individual differences in the quantity and quality of these lexical representations (Perfetti, 2007). Cross-sectional studies have shown that individual differences in reading comprehension ability can be predicted by both the number of available representations (e.g., Ouellette, 2006; Ouellette & Beers, 2010) and the quality of these representations (Brinchmann, Hjetland, & Lyster, 2015; Perfetti & Hart, 2002; Richter, Isberner, Naumann, & Neeb, 2013; Verhoeven & Van Leeuwe, 2008). As with the development of reading comprehension and decoding skill, longitudinal studies have shown that individual differences in vocabulary are stable over time and that, after controlling for autoregressive effects, vocabulary influences reading comprehension development (e.g., De Jong & Van der Leij, 2002; Oakhill & Cain, 2012; Torgesen et al., 1997). In contrast to the unidirectional relation between decoding and reading comprehension, however, Verhoeven et al. (2011) have shown that the relation between vocabulary and reading comprehension is reciprocal. In other words, in addition to the influence of vocabulary on reading comprehension development, results showed that reading comprehension skill also influenced vocabulary development.

Magnitude of the impact and influence of decoding and vocabulary on reading comprehension and its development is dependent on age and language. Ouellette and Beers (2010) in a cross-sectional study, have shown that the predictive power of decoding decreases as children become older, suggesting that the impact of decoding on reading comprehension becomes smaller. In addition, Verhoeven and Van Leeuwe (2008) have shown that the influence of decoding on reading comprehension development decreases when children become older. In the early grades (grade 1) decoding exerted a substantial influence on reading comprehension development (path coefficient was 0.44). Later in development (grade 5), this influence became much smaller (path coefficient of 0.04). With respect to vocabulary, Ouellette and Beers (2010) have shown that it did not explain any variance in reading comprehension in grade 1, but that it did in grade 6. Verhoeven and Van Leeuwe (2008) have shown that the influence of vocabulary on reading comprehension development remained relatively stable over time and that, as compared to decoding, it influenced reading comprehension development (path coefficients between 0.33 and 0.57). So, as children become older, the impact and influence of decoding seems to decrease, while the impact and influence of vocabulary remains stable or even increases. With respect to language, transparent languages have the benefit of having consistent grapheme to phoneme correspondences. In these languages (e.g., Dutch) most graphemes correspond to only one phoneme, making it easier to acquire automatized decoding skills as compared to more opaque languages (e.g., English) in which graphemes can correspond with different phonemes. It can be argued that in transparent language the impact and influence of decoding skills becomes smaller at an earlier age, since decoding skills become automated faster as compared to opaque languages.

1.2. Cognitive precursors of reading development

Not all variation in reading comprehension development can be explained by individual differences in lexical quality. In addition to linguistic skills, cognitive factors, such as short-term memory, working memory, and reasoning skills, have been shown to predict reading comprehension skill (e.g., Cain, 2006; Fuchs et al., 2012).

Short-term memory has been referred to as the ability to maintain information active for a short period of time. Associations between short-term memory, on the one hand, and decoding (e.g., De Jonge & De Jong, 1996; Van den Boer, Van Bergen, & De Jong, 2014, but Georgiou, Parrila, & Papadopoulos, 2008) and vocabulary (e.g., Gathercole & Baddeley, 1989, 1990, 1993; Leclercq & Majerus, 2010; Majerus, Poncelet, Greffe, & Van der Linden, 2006), on the other hand, have often been evidenced. Word representations, according to the Lexical Quality Hypothesis, consist of three chunks of information: orthographic, phonological, and semantic. Decoding requires both orthographic and phonological information, while word meanings are stored in the semantic chunk. In order to store word representations in long-term memory, these representations first have to go through short-term memory. The better the quality of these representations in short-term memory the more likely it is that stable representations are formed in long-term memory (Baddeley, 2003).

Where short-term memory refers to the ability to maintain information active, working memory has been defined as the ability to store information, while other processes are carried out. Carretti, Borella, Cornoldi, and De Beni (2009) showed with their meta-analyses that complex span tasks (used to measure working memory) are better predictors of reading comprehension skill as compared to simple span tasks (used to measure short-term memory). They concluded that deficits in reading comprehension can be partly attributed to inefficiencies in working memory control mechanisms. Previous research, indeed, has shown that individual variation in reading comprehension (and vocabulary) can be predicted by individual differences in working memory (Cain, 2006; Cain, Oakhill, & Bryant, 2003; Daneman & Carpenter, 1980; De Jonge & De Jong, 1996; Gathercole & Baddeley, 1993, 2014 Nouwens et al., 2016). Cain (2006) has argued that different skills important for vocabulary development and understanding written text – such as linking individual sentences to create a coherent representation of the text, integrating relevant background knowledge, inference making, and comprehension monitoring – are dependent on working memory, since they all require the simultaneous storing and processing of information.

A third cognitive factor involved in reading comprehension is reasoning. It has been suggested that these skills might be used to "analyze relations among and draw inferences about characters or actions in narrative text and to decipher challenging expository material" (Fuchs et al., 2012, pp. 218). Although measures of (nonverbal) reasoning are often administered in studies examining decoding, vocabulary, and reading comprehension, results of these tests are mostly used as control variables (e.g., Fuchs et al., 2012; McBride-Chang et al., 2008; Ricketts, Nation, & Bishop, 2007; Swart et al., 2017). Few studies, however, have examined the role of reasoning skills in decoding, vocabulary, and reading comprehension more extensively. For example, De Jonge and De Jong (1996) examined the relation between reasoning, on the one hand, and reading speed and reading comprehension, on the other hand, and concluded that reasoning skills were strongly related to reading comprehension skill, but less so to reading speed. In a similar vein, Segers and Verhoeven (2016) concluded that reasoning was uniquely related to reading comprehension skill, after lexical quality was controlled for. To gain more insight in the role of reasoning skills in reading comprehension development, students completed a test to measure nonverbal reasoning. We deliberately chose for a nonverbal task, to be as independent of language/reading skills as possible (but see Lohman, Korb, and Lakin (2008) for evidence that the Raven might not be independent of verbal skills).

1.3. Present study

During the intermediate elementary grades, reading comprehension skills become increasingly important because children are more and more required to extract knowledge from gradually more difficult texts. Previous studies have evidenced a developmental relation between lexical quality and reading comprehension skill. In addition, it has been shown that short-term memory predicts individual variation in decoding and vocabulary and that working memory and nonverbal reasoning predict individual variation in vocabulary and reading comprehension. However, research on how these cognitive factors might influence decoding, vocabulary, and reading comprehension development (both directly and indirectly through linguistic factors) is lacking. From both a theoretical and practical viewpoint, it is crucial to understand these relations in this critical transition point. Therefore, with the longitudinal study presented in the current paper, we aimed at answering the following two research questions:

1. How are lexical quality (decoding and vocabulary) and reading comprehension skill developmentally related in Dutch students in the intermediate elementary grades?
2. To what extent do cognitive factors (memory and reasoning) measured at the start of Grade 4 (Time 1) influence lexical quality (decoding and vocabulary) and reading comprehension skills of Dutch students in the intermediate elementary grades?

With respect to the first question, we controlled for strong hypothesized autoregressive effects for decoding, vocabulary, and reading comprehension. Secondly, we hypothesized that, in line with the Lexical Quality Hypothesis, both decoding and vocabulary influenced reading comprehension development. Due to the fact that Dutch is a transparent orthography and students in the intermediate grades usually have already acquired automatized decoding skills, we expected that the influence of vocabulary on the development of reading comprehension skill would be larger as compared to the influence of decoding skill. Thirdly, based on previous longitudinal studies involving Dutch students, we also expected reading comprehension skill to influence vocabulary development (Verhoeven & Van Leeuwe, 2008).

Regarding the second research question, both direct and indirect effects were hypothesized between the cognitive factors on the one hand and lexical quality and reading comprehension on the other hand. More specifically, we expected direct concurrent effects of short-term memory on decoding and vocabulary, and direct concurrent effects of working memory and nonverbal reasoning on vocabulary and reading comprehension. Due to the expected reciprocal relation between vocabulary and reading comprehension, we also expected that the cognitive factors would have an effect on reading comprehension development though vocabulary and decoding and that vocabulary development would be influenced by the cognitive factors through reading comprehension. Fig. 1 shows the hypothesized model.

2. Method

2.1. Participants

Participants in the current study were recruited from twelve schools located throughout the Netherlands, in both urban and rural parts of the country. Upon initial measurement, the sample consisted of 312 students (156 girls and 156 boys) between the ages of 8 years and 4 months and 10 years and 10 months (M_{age} start grade four = 9 years and 7 months, SD = 5.61 months) starting grade four. However, because of dropout throughout grade four and five (e.g., due to movement

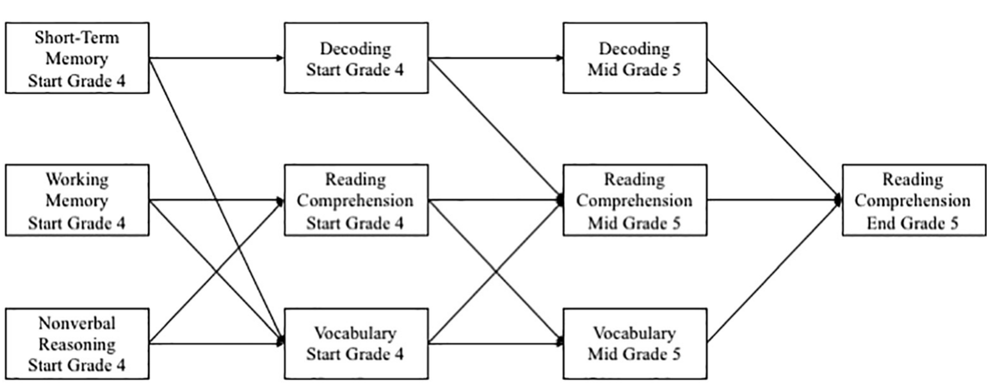

Fig. 1. Conceptual model of the hypothesized developmental relations between lexical quality and reading comprehension in children in the intermediate elementary grades and the influence of the cognitive factors on these relations.

or repeating a class), the sample used to conduct the analyses consisted of 282 students (140 girls and 142 boys) between the ages of 8 years and 4 months and 10 years and 10 months (M_{age} start grade four = 9 years and 7 months, SD = 5.48 months). With respect to language background, only 5% of the students were born outside the Netherlands and 98% of the students spoke Dutch at home with one or both parents. Students were tested three times: start grade 4 (Time 1), mid grade 5 (Time 2), and end grade 5 (Time 3). Prior to testing and in accordance with institutional guidelines, informed consent was obtained from the parents of the participating students. The present study was part of a larger project on the development of reading comprehension skill.

2.2. Materials

2.2.1. Reading comprehension

To fully capture the complex nature of reading comprehension, multiple tests were used to measure reading comprehension skill. At Time 1, Time 2, and Time 3, students completed a test assessing narrative reading comprehension skill, a test assessing expository reading comprehension skill, and a standardized test with short narrative and expository texts

For narrative and expository reading comprehension, different subtests of the Progress in International Reading Literacy Studies (PIRLS) Reading Literacy Test-2011 (International Association for the Evaluation of Educational Achievement (IEA), 2011) were used. Each test consisted of one text, with both open-ended questions (worth either one, two or three points depending on the difficulty of the answer and complexity of the question) and multiple choice questions (worth one point). Questions were literal (to assess understanding of information explicitly stated in the text), inferential (to assess inference skills), or evaluative (to examine how well students were able to evaluate information stated in the text). Existing guidelines were used by trained research-assistants for Time 1 and Time 2 and by the first and second author for Time 3 to score the open-ended questions. Interrater reliability for subtests of the PIRLS at all three measurement occasions was good (Cronbach's alpha > 0.90). To measure expository reading comprehension at Time 1 and Time 3, students read the text ‘The mystery of the giant tooth’ (text length: 884 words, sample-based test reliability: Cronbach's alpha = 0.77) and answered ten open-ended and seven multiple choice questions. The maximum score of this subtest was 18. At Time 2, students read the text ‘Antarctica: The land of ice’ (text length: 530 words, sample-based test reliability: Cronbach's alpha = 0.64) and completed 11 open-ended and four multiple choice items. Maximum score of this subtest was 16. To measure narrative text comprehension, students completed ‘The enemy pie’ (text length: 832 words, sample-based test reliability: Cronbach's alpha = 0.76) at Time 1. This text was accompanied by nine open-ended and seven multiple choice items. Maximum score was 19. At Time 2 and Time 3, students read the text ‘The little lump of clay’ (text length: 798 words, sample-based test reliability: Cronbach's alpha = 0.78) and answered seven open-ended and six multiple choice items. Maximum score was 18.

As a standardized measure of reading comprehension, we used two subtests of a test battery developed to examine reading comprehension skills throughout primary school (*Begrijpend lezen 345,678* [Reading comprehension grade 1, 2, 3, 4, 5, 6], Aarnoutse & Kapinga, 2005). At Time 1 and Time 2, students completed the test suitable for students in grades 4, 5, and 6 (from now on RC456). The test consisted of three narrative and four expository passages, containing 123 to 288 words (mean text length: 192 words) and students were asked to answer six or seven multiple choice questions per text, with a total of 44 questions (22 true/false; 22 four options). At Time 3, students completed the test suitable for students in grades 5 and 6 (from now on RC56), consisting of two narrative and five expository texts, containing 146 to 257 words (mean text length: 184 words). Again, students were asked to complete six or seven questions per text, with a total of 40 questions (19 true/false; 21 four options). Questions for both subtests related to the meaning of single words, single sentences, complete passages, and relations between sentences. The number of correct answers equaled the test score. The Cronbach's alpha, as provided by the test-developers, was 0.86 for RC456 and 0.82 for RC56.

2.2.2. Vocabulary

Vocabulary was assessed using three standardized tests: A written receptive test, an oral receptive test, and an oral productive test. All three tests were administered at Time 1 and Time 2. To measure knowledge of written words, the reading vocabulary subtest from the Taaltoets Allochtone Kinderen [language test for foreign children] (Verhoeven & Vermeer, 1986) was used. For each item (50 in total) students were presented with a single sentence in which one word was underlined. Students were asked to select, out of four options, the correct meaning of that underlined word. Although the test-name implies differently, the test was used for all students. Test score was equal to the number of correct answers. The sample-based Cronbach's alpha was 0.82.

Oral receptive vocabulary was measured with the Dutch version of the Peabody Picture Vocabulary Test (PPVT-III NL; Dunn, Dunn, & Schlichting, 2005). We used an adapted version in which the four picture-alternatives were presented next to each other in a booklet and students were asked to underline the correct picture after the experimenter read out the target word. With this adaption of the original test, we were able to administer the test group-wise instead of individually. The items from sets eight until thirteen were used (72 items in total) and the test score was equal to the number of correct answers. The sample-based Cronbach's alpha was 0.79.

To measure productive vocabulary, the vocabulary subtest of the Dutch version of the Wechsler Intelligence Scale for Children, third edition (WISC-III NL; Kort et al., 2005) was administered. Students were asked to provide definitional information for single target words increasing in difficulty (with a maximum of 35 items). Testing and scoring occurred using the official guidelines; for each item a score of zero, one, or two could be awarded and testing was terminated after four consecutive item scores of zero.

2.2.3. Decoding

Decoding was measured at both Time 1 and Time 2 using two standardized tests: a word reading task (*Een Minuut Test* (EMT) [One Minute Test]; Brus & Voeten, 1999) and a non-word reading task (*Klepel*; Van den Bos, Lutje Spelberg, Scheepstra, & De Vries, 1994). Two lists were presented to the students, one with 116 words and one with 116 non-words. Students were instructed to read the words and non-word as quickly and accurately as possible. After 1 min for the word list and 2 min for the non-word list testing was terminated and test score was equal to the number of (non)words read correctly. Difficulty of the items on the word and non-word list gradually increased starting with simple CVC structured to more complex multi-syllable items. Cronbach's alpha, as established by the test developers, was respectively 0.89 for the word reading task and 0.93 for the non-word reading task.

2.2.4. Short-term memory

Two tasks were used to measure short-term memory capacity at Time 1: one using high frequency one-syllable words and one using digits. In both span tasks, students were orally presented with a sequence of units (either words or digits) and were asked to remember the sequence and reproduce it. The words and digits were read to the students with a pace of one unit per second and a pause of 1 s between each unit. Difficulty of both tasks increased gradually from only two units per sequence to nine units per sequence. For each difficulty level students received three attempts and testing was terminated when all three attempts of one difficulty level were incorrect. The number of correctly recalled sequences comprised the scores for both tasks. Cronbach's alpha was respectively 0.86 for the wordspan task and 0.74

for the digit span task, given that the missing scores were coded as incorrect.

2.2.5. Working memory

Working memory was assessed at Time 1 using two subtests: A listening span task and a reading span task. The span tasks used in the present study were developed by the second author and were also used in other studies (e.g., Muijselaar et al., 2017a, 2017b). The tasks were an adaptation of the procedure proposed by Daneman and Carpenter (1980). For the listening task, series of simple semantically unrelated sentence were orally presented to students and for each series, students were asked to (1) semantically judge each sentence by, directly after reading or hearing the sentence, indicating whether it was true or false (example true: A car has a steering wheel; example false: you drive with a pen) and (2) remember the last word of each sentence. After the final sentence of each series, students were asked to repeat the remembered words in the correct order (e.g., wheel, pen). Testing started out relatively easy with only two sentences per series, but gradually increased to five sentences per series. For each level of difficulty, students received four attempts and testing was terminated after an incorrect response to all four attempts of one difficulty level. Test score was equal to the number of correctly recalled word-series. Cronbach's alpha was 0.76, given that the missing scores were coded as incorrect

The procedure of the reading span task was equal to that of the listening span task, with the difference that sentences were not orally presented to the students, but students had a booklet with written sentences in it and were asked to read those sentences aloud. After reading each sentence students again were asked to semantically judge it, remember the final word of each sentence, and recall these final words in the correct order after judging the final sentence of each series. During the semantic judgement, the sentence was visible for the participants, but during the recall of the words, the sentences were not visible anymore. Difficulty again increased from only two sentences to five sentences per series and again students received four attempts for each difficulty level. Testing was terminated after an incorrect response to all attempts of one difficulty level and test score was equal to the number of correctly recalled word-series. Cronbach's alpha was 0.74, given that the missing scores were coded as incorrect.

2.2.6. Nonverbal reasoning

To measure nonverbal reasoning, students completed the Raven Standard Progressive Matrices (SPM; Raven, 1960) at Time 1. The SPM is a test in which incomplete visual patterns have to be completed by selecting the correct missing piece out of six or eight options. In total, the test consists of 60 visual patterns divided over five sets of increasing difficulty. Test score was equal to the number of correct answers. Cronbach's alpha was 0.83.

2.3. Procedure

At Time 1 (start of grade 4) tests (reading comprehension, vocabulary, decoding, short-term memory, working memory, and nonverbal reasoning) were divided over three group-wise and two individual sessions. At Time 2 (mid grade 5), tests (reading comprehension, vocabulary, and decoding) were administered during two group-wise and one individual session. Finally, at Time 3 (end grade 5), tests (reading comprehension) were divided over two group-wise sessions. Each test administered during the group-wise sessions took between 30 and 40 min, with a short break between each test administered during the same session. Tests were administered by the first and second author and by trained research assistants. Group-wise sessions took place in the students' own classrooms; individual testing was carried out in a quite separate room in the school.

2.4. Data analysis

All analyses reported in the current study were performed using the open source statistical program R (R Core Team, 2016). To answer the research question, three steps were undertaken. First two Confirmatory Factor Analyses (CFA's), using the *lavaan* function of the *lavaan* package (Rosseel, 2012), were performed to confirm the measurement model for Time 1 and Time 2. Results of these CFAs are presented in the results-section. Secondly, to examine to what extent lexical quality (decoding and vocabulary) influenced reading comprehension development, a structural path analysis was conducted using the *lavaan* function of the *lavaan* package (Rosseel, 2012). Finally, to examine to what extent cognitive factors influence reading comprehension development above and beyond the linguistic determinants, a second path analysis was performed including the lexical quality measures and measures of short-term memory, working memory, and nonverbal reasoning.

Prior to the analyses, a missing data analysis was performed. Only 0.8% of the data (55 out of the total 6713 test scores) was missing. Visual inspection of the missing value patterns indicated that data are missing completely at random. Results of Little's MCAR test (performed using the *LittleMCAR* function from the *BaylorEdPsych* package; Beaujean, 2012) support this claim: χ^2 (286) = 310.77, $p = 0.15$. By default, missing data are deleted listwise when using the *lavaan* function, however, since data are missing at random we used case-wise (i.e. full information) maximum likelihood estimation. In addition, a robust estimator (maximum likelihood estimation with standard errors based on the first-order derivatives, and a conventional test statistic) was used. Model fit of the CFA's and the path models was evaluated using the following fit indices: χ^2 (non-significant values indicate satisfactory fit), RMSEA (< 0.06 indicates satisfactory fit), GFI (> 0.90 indicates satisfactory fit), NFI (> 0.90 indicates satisfactory fit), CFI (> 0.90 indicates satisfactory fit), AGFI (> 0.90 indicates satisfactory fit) (Hu & Bentler, 1999).

3. Results

Descriptive statistics on the linguistic and cognitive measures assessed at Time 1, Time 2, and Time 3 are presented in Table 1. Multiple paired *t*-tests with Holm-Bonferroni correction showed that between Time 1 and Time 2 students' decoding abilities (respectively $t(281) = 20.04$, $p < 0.001$ for words and $t(281) = 15.93$, $p < 0.001$ for non-words), written receptive vocabulary ($t(278) = 26.08$, $p < 0.001$), oral receptive vocabulary ($t(273) = 23.32$, $p < 0.001$), oral productive vocabulary ($t(275) = 16.87$, $p < 0.001$), and reading comprehension as measured with a standardized test ($t(278) = 15.22$, $p < 0.001$) significantly improved. Due to the fact that tests used to assess expository and narrative reading comprehension only partly overlapped for each measurement occasion, it can only be concluded that, with respect to expository reading comprehension students showed a significant growth between Time 1 and Time 3 ($t(272) = 12.83$, $p < 0.001$) and that with respect to narrative reading comprehension, no significant growth was evidenced between Time 2 and Time 3 ($t(274) = -0.58$, $p = 0.57$).

3.1. Correlations and CFA's

Table 2 presents correlations between all linguistics and cognitive measures administered at Time 1, Time 2, and Time 3. Correlation coefficients indicated moderate to strong correlations between the reading comprehension measures (r's > 0.41), strong correlations between the vocabulary measures (r's > 0.51), strong correlations between the decoding measures (r's > 0.63), a strong correlation between the two short-term memory measures ($r = 0.55$), and a moderate correlation between the two working-memory measures ($r = 0.42$).

First step in answering the research questions was to confirm the factor structure at Time 1 and Time 2. Therefore, two CFA's were

Table 1
Descriptive statistics for all measures administered at Time 1, Time 2 and Time 3.

		N	Mean (*SD*)	Skewness	Kurtosis
Expository reading comprehension	Time 1 (GT)	280	8.14 (3.50)	− 0.05	− 0.71
	Time 2 (AA)	280	26.22 (2.37)	0.00	− 0.55
	Time 3 (GT)	282	34.71 (3.71)	− 0.08	− 0.23
Narrative reading comprehension	Time 1 (EP)	282	11.08 (3.99)	− 0.48	− 0.44
	Time 2 (LC)	280	12.00 (3.27)	− 0.05	− 0.71
	Time 3 (LC)	280	11.93 (3.21)	0.00	− 0.55
Standardized reading comprehension	Time 1 (456)	280	26.22 (6.14)	0.00	− 0.55
	Time 2 (456)	282	34.71 (6.66)	− 0.08	− 0.23
	Time 3 (56)	280	26.92 (6.63)	− 0.15	− 0.32
Written receptive vocabulary	Time 1	280	26.92 (7.01)	− 0.15	− 0.32
	Time 2	281	41.91 (7.62)	− 1.32	4.37
Oral receptive vocabulary	Time 1	282	34.71 (6.02)	− 0.08	− 0.23
	Time 2	280	26.92 (6.51)	− 0.15	− 0.32
Oral productive vocabulary	Time 1	278	31.38 (5.83)	− 0.48	1.43
	Time 2	282	4.90 (6.39)	0.34	0.17
Word decoding	Time 1	282	61.23 (13.13)	0.03	− 0.27
	Time 2	282	52.48 (15.62)	0.28	− 0.38
Non-word decoding	Time 1	282	52.48 (16.30)	0.28	− 0.38
	Time 2	278	31.38 (18.07)	− 0.48	1.43
Working memory: listening	Time1	282	4.90 (2.25)	0.34	0.17
Working memory: reading	Time 1	278	6.62 (2.08)	− 0.23	0.19
Short-term memory: words	Time 1	282	9.75 (1.64)	0.53	0.40
Short-term memory: digits	Time 1	278	11.09 (2.06)	0.41	− 0.28
Nonverbal reasoning	Time 1	280	42.05 (6.13)	− 0.82	1.35

Note. GT = The Mystery of The Giant Tooth, AA = Antarctica: The Land of Ice, EP = The Enemy Pie, LC = The Little Lump of Clay, 456 = standardized reading test for students in grade 4, 5, and 6, 56 = standardized test for students in grade 5 and 6.

performed (Fig. 2). Results indicated that the Time 1 model – with the three Time 1 measures of reading comprehension comprising the reading comprehension factor, the three Time 1 measures of vocabulary comprising the vocabulary factor, the two Time 1 decoding measures comprising the decoding factor, the two short-term memory measures comprising the short-term memory factor, the two working memory measures comprising the working memory factor, and correlations between all factors – fitted the data very well ($\chi^2(45) = 57.77$, $p = 0.10$, RMSEA = 0.03, GFI = 0.97, NFI = 0.97, CFI = 0.99, AGFI = 0.93). The correlation between the reading comprehension and the vocabulary factors and the correlation between the short-term memory and working memory factors was very high (respectively 0.88 and 0.90). The model with the three Time 2 measures of reading comprehension comprising the reading comprehension factor, the three Time 2 measures of vocabulary comprising the vocabulary factor, the two Time 2 decoding measures comprising the decoding factor, and correlations between all factors also fitted the data very well ($\chi^2(17) = 30.26$, $p = 0.03$, RMSEA = 0.05, GFI = 0.97, NFI = 0.97, CFI = 0.99, AGFI = 0.93). Again, correlation between the reading comprehension and vocabulary factor was high (0.94).

3.2. Developmental relation between lexical quality and reading comprehension

Structural path modeling, using factor scores, was used to examine the extent to which lexical quality influences reading comprehension development. The initial model included (1) autoregressive and cross-lagged paths between decoding, vocabulary, and reading comprehension Time 1 and Time 2; (2) paths from decoding, vocabulary, and reading comprehension Time 2 to reading comprehension Time 3; and (3) (residual) covariances between the factors at Time 1 and Time 2. Results indicated that this initial model did not adequately fit the data ($\chi^2(3) = 31.28$, $p < 0.001$, RMSEA = 0.18, GFI = 0.96, NFI = 0.98, CFI = 0.98, AGFI = 0.51). To improve the model, a direct path from reading comprehension Time 1 to reading comprehension Time 3 was added. Adding this path was a significant improvement ($\Delta\chi^2(1) = 30.67$, $p < 0.001$) and this model adequately fitted the data ($\chi^2(2) = 0.607$, $p = 0.74$, RMSEA = 0.00, GFI = 0.99, NFI = 1.00, CFI = 1.00, AGFI = 0.90). See Fig. 3 (panel a) for the final model.

The autoregressive paths for decoding, vocabulary, and reading comprehension were all significant, and the large path coefficients all indicated that individual differences at the start of fourth grade prevailed throughout fourth and fifth grade. The direct path from reading comprehension Time 1 to reading comprehension Time 3, in addition to the path from Time 1 to Time 2 and the path from Time 2 to Time 3, indicated that reading comprehension skill measured at times 1 influences performance on reading comprehension Time 3. The cross-lagged paths between vocabulary and reading comprehension were all significant, indicating that the relation between vocabulary and reading comprehension is reciprocal. In other words, vocabulary influences reading comprehension development and reading comprehension influences vocabulary development. The cross-lagged paths to and from decoding were not significant, indicating that decoding skills did not influence vocabulary and reading comprehension development and that vocabulary and reading comprehension did not influence decoding development. Covariances between the factors at Time 1 were all significant. In addition, the residual covariance between vocabulary and reading comprehension at Time 2 was also significant.

3.3. Cognitive precursors

A second path model was fitted to examine to which the extent the cognitive factors influence the development of the lexical quality markers (decoding and vocabulary) and reading comprehension skill. The model included: (1) autoregressive and cross-lagged paths between decoding, vocabulary, and reading comprehension Time 1 and Time 2; (2) paths from decoding, vocabulary, and reading comprehension Time 2 to reading comprehension Time 3; (3) path from reading comprehension Time 1 to reading comprehension Time 2; (4) paths from short-term memory, working memory, and nonverbal reasoning to decoding, vocabulary, and reading comprehension at Time 1; (5) paths from working memory and nonverbal reasoning to vocabulary and reading comprehension Time 2; and (6) (residual) covariances between the factors at Time 1 and Time 2. Results indicated that this model adequately fitted the data ($\chi^2(11) = 7.18$, $p = 0.52$, RMSEA = 0.00, GFI = 0.99, NFI = 1.00, CFI = 1.00, AGFI = 0.92). See Fig. 3 (panel

Table 2
Summary of the correlations for all measures.

	1. eRC1	2. eRC2	3. eRC3	4. nRC1	5. nRC2	6. nRC3	7. sRC1	8. sRC2	9. sRC3	10. wrVoc1	11. wrVoc2	12. orVoc1
1. ExpRC1	–	0.41***	0.62***	0.69***	0.54***	0.51***	0.65***	0.68***	0.62***	0.60***	0.57***	0.46***
2. ExpRC2		–	0.50***	0.47***	0.51***	0.50***	0.42***	0.53***	0.50***	0.44***	0.52***	0.30***
3. ExpRC3			–	0.65***	0.63***	0.62***	0.61***	0.69***	1.00***	0.56***	0.62***	0.41***
4. NarRC1				–	0.64***	0.61***	0.64***	0.71***	0.65***	0.64***	0.66***	0.46***
5. NarRC2					–	0.72***	0.57***	0.63***	0.63***	0.56***	0.62***	0.41***
6. NarRC3						–	0.53***	0.59***	0.62***	0.53***	0.61***	0.44***
7. sRC1							–	0.72***	0.61***	0.66***	0.64***	0.49***
8. sRC2								–	0.69***	0.64***	0.72***	0.47***
9. sRC3									–	0.56***	0.62***	0.41***
10. wrVoc1										–	0.77***	0.59***
11. wrVoc2											–	0.52***
12. orVoc1												–
13. orVoc2												
14. opVoc1												
15. opVoc2												
16. WD1												
17. WD2												
18. NWD1												
19. NWD2												
20. STMw												
21. STMd												
22. WMl												
23. WMr												
24. NVR												

	13. orVoc2	14. opVoc1	15. opVoc2	16. WD1	17. WD2	18. NWD1	19. NWD2	20. STMw	21. STMd	22. WMl	23. WMr	24. NVR
1. ExpRC1	0.57***	0.43***	0.46***	0.32***	0.26***	0.31***	0.21***	0.24***	0.28***	0.29***	0.32***	0.47***
2. ExpRC2	0.36***	0.34***	0.36***	0.25***	0.27***	0.23***	0.15*	0.04	0.08	0.14*	0.15*	0.35***
3. ExpRC3	0.50***	0.41***	0.45***	0.34***	0.28***	0.31***	0.24***	0.16**	0.22***	0.27***	0.29***	0.43***
4. NarRC1	0.62***	0.56***	0.57***	0.30***	0.29***	0.26***	0.18**	0.22***	0.28***	0.24***	0.35***	0.41***
5. NarRC2	0.52***	0.45***	0.50***	0.28***	0.27***	0.23***	0.19**	0.21***	0.14*	0.19**	0.27***	0.37***
6. NarRC3	0.50***	0.46***	0.50***	0.24***	0.27***	0.20***	0.15*	0.17**	0.09	0.18**	0.23***	0.40***
7. sRC1	0.53***	0.52***	0.53***	0.30***	0.26***	0.29***	0.24***	0.19**	0.23***	0.25***	0.28***	0.41***
8. sRC2	0.61***	0.55***	0.56***	0.34***	0.35***	0.32***	0.29***	0.18**	0.20***	0.30***	0.28***	0.45***
9. sRC3	0.50***	0.41***	0.45***	0.34***	0.28***	0.31***	0.24***	0.16**	0.22***	0.27***	0.29***	0.43***
10. wrVoc1	0.60***	0.61***	0.66***	0.38***	0.29***	0.29***	0.28***	0.18**	0.22***	0.25***	0.24***	0.38***
11. wrVoc2	0.64***	0.60***	0.62***	0.43***	0.42***	0.33***	0.29***	0.18**	0.14*	0.24***	0.27***	0.38***
12. orVoc1	0.65***	0.51***	0.51***	0.26***	0.18**	0.20***	0.14*	0.09	0.09	0.14*	0.17**	0.29***
13. orVoc2	–	0.57***	0.58***	0.25***	0.22***	0.17**	0.12*	0.12*	0.12*	0.18**	0.23***	0.34***
14. opVoc1		–	0.60***	0.25***	0.28***	0.17**	0.20***	0.15*	0.13*	0.13*	0.21***	0.23***
15. opVoc2			–	0.30***	0.27***	0.18**	0.19**	0.19**	0.17**	0.16**	0.29***	0.30***
16. WD1				–	0.78***	0.85***	0.74***	0.21***	0.24***	0.16**	0.27***	0.12*
17. WD2					–	0.70***	0.63***	0.17**	0.16**	0.15*	0.25***	0.12
18. NWD1						–	0.77***	0.19**	0.27***	0.10	0.26***	0.13*
19. NWD2							–	0.22***	0.20***	0.05	0.22***	0.16**
20. STMw								–	0.55***	0.34***	0.54***	0.14*
21. STMd									–	0.33***	0.53***	0.19**

Table 2 (*continued*)

	13. orVoc2	14. opVoc1	15. opVoc2	16. WD1	17. WD2	18. NWD1	19. NWD2	20. STMw	21. STMd	22. WMl	23. WMr	24. NVR
22. WMl										–	0.42***	0.21***
23. WMr											–	0.25***
24. NVR												–

Note: eRC1 = Expository Reading Comprehension Time 1, eRC2 = Expository Reading Comprehension Time 2, eRC3 = Expository Reading Comprehension Time 3, nRC1 = Narrative Reading Comprehension Time 1, nRC2 = Narrative Reading Comprehension Time 2, nRC3 = Narrative Reading Comprehension Time 3, sRC1 = Standardized Reading Comprehension Time 1, sRC2 = Standardized Reading Comprehension Time 2, sRC3 = Standardized Reading Comprehension Time 3, wrVoc1 = Written Receptive Vocabulary Time 1, wrVoc2 = Written Receptive Vocabulary Time 2, orVoc1 = Oral Receptive Vocabulary Time 1, orVoc2 = Oral Receptive Vocabulary Time 2, opVoc1 = Oral Productive Vocabulary Time 1, opVoc2 = Oral Productive Vocabulary Time 2, WD1 = Word Decoding Time 1, WD2 = Word Decoding Time 2, NWD1 = Non-Word Decoding Time 1, NWD2 = Non-Word Decoding Time 2, STMw = Short-Term Memory: Words, STMd = Short-Term Memory: Digits, WMl = Working Memory: Listening task, WMr = Working Memory: Reading task, NVR = NonVerbal Reasoning.

*** = $p < 0.001$.

** = $p < 0.01$.

* = $p < 0.01$.

b) for the final model.

All paths significant in the first model, examining the influence of lexical quality on reading comprehension development, remained significant. In addition, results indicated that working memory capacity and nonverbal reasoning skills predicted vocabulary and reading comprehension skills at Time 1. In combination with the significant reciprocal relations between reading comprehension and vocabulary, it can be assumed that working memory and nonverbal reasoning skills indirectly affected reading comprehension through vocabulary and vice versa. In addition, a direct path from nonverbal reasoning to reading comprehension Time 2 was also significant, indicating that nonverbal reasoning skills influenced reading comprehension development directly. Short-term memory capacity did not predict vocabulary and reading comprehension at Time 1, but it did, however, predict decoding skills at Time 1. Other paths from the cognitive factors to Time 1 and Time 2 measures of lexical quality and reading comprehension were not significant.

4. Discussion

The aim of the present study was twofold. First, we were interested in the developmental relations between markers of lexical quality and reading comprehension skills of Dutch students in the intermediate elementary grades. Secondly, we were interested in the effects of cognitive factors (short-term memory, working memory, and nonverbal reasoning) on the development of lexical quality and reading comprehension. Results clearly indicate a reciprocal relation between reading comprehension and vocabulary development. In addition, direct effects of working memory and nonverbal reasoning on concurrent decoding, vocabulary and reading comprehension were evidenced and nonverbal reasoning directly influenced reading comprehension development. Finally, indirect effects of working memory and nonverbal reasoning on the development of reading comprehension and vocabulary were also present.

Consistent with previous studies (e.g., Verhoeven & Van Leeuwe, 2008; Verhoeven et al., 2011), we found that individual differences in decoding, vocabulary, and reading comprehension prevailed throughout fourth and fifth grade, demonstrating that, although students did show absolute growth, these skills remain relatively stable. For reading comprehension both the direct autoregressive effects (Time 1 to Time 2and Time 2 to Time 3) were significant, as well as the effect from Time 1 to Time 3, indicating that individual differences in reading comprehension skill had a high degree of stability over time. Significant covariations between decoding and reading comprehension and between vocabulary and reading comprehension at Time 1 support the Lexical Quality Hypothesis and demonstrate that reading comprehension skill is affected by both decoding and vocabulary skills for students in Grade 4. However, at Time 2 (halfway through Grade 5), reading comprehension was only affected by vocabulary skills; the covariance between decoding and reading comprehension was not significant. Both skills will be discussed in more detail below.

In the current study, we provided evidence for a reciprocal relation between vocabulary and reading comprehension skill. These results are consistent with previous studies (e.g., Verhoeven & Van Leeuwe, 2008; Verhoeven et al., 2011) and demonstrate that, on the one hand, vocabulary influences reading comprehension development and that, on the other hand, reading comprehension also influences vocabulary development. Reading comprehension is facilitated by knowledge of words in the text (Perfetti & Hart, 2002). Understanding of a text improves as vocabulary size and quality of stored word representations increases (e.g., Brinchmann et al., 2015; Ouellette, 2006; Ouellette & Beers, 2010; Richter et al., 2013). With respect to vocabulary, Wagner, Muse, and Tannenbaum (2007) have suggested that, especially beyond the primary elementary grades, incidental word learning provides the primary means of vocabulary development. Incidental word learning refers to the process in which students learn new word meanings through the

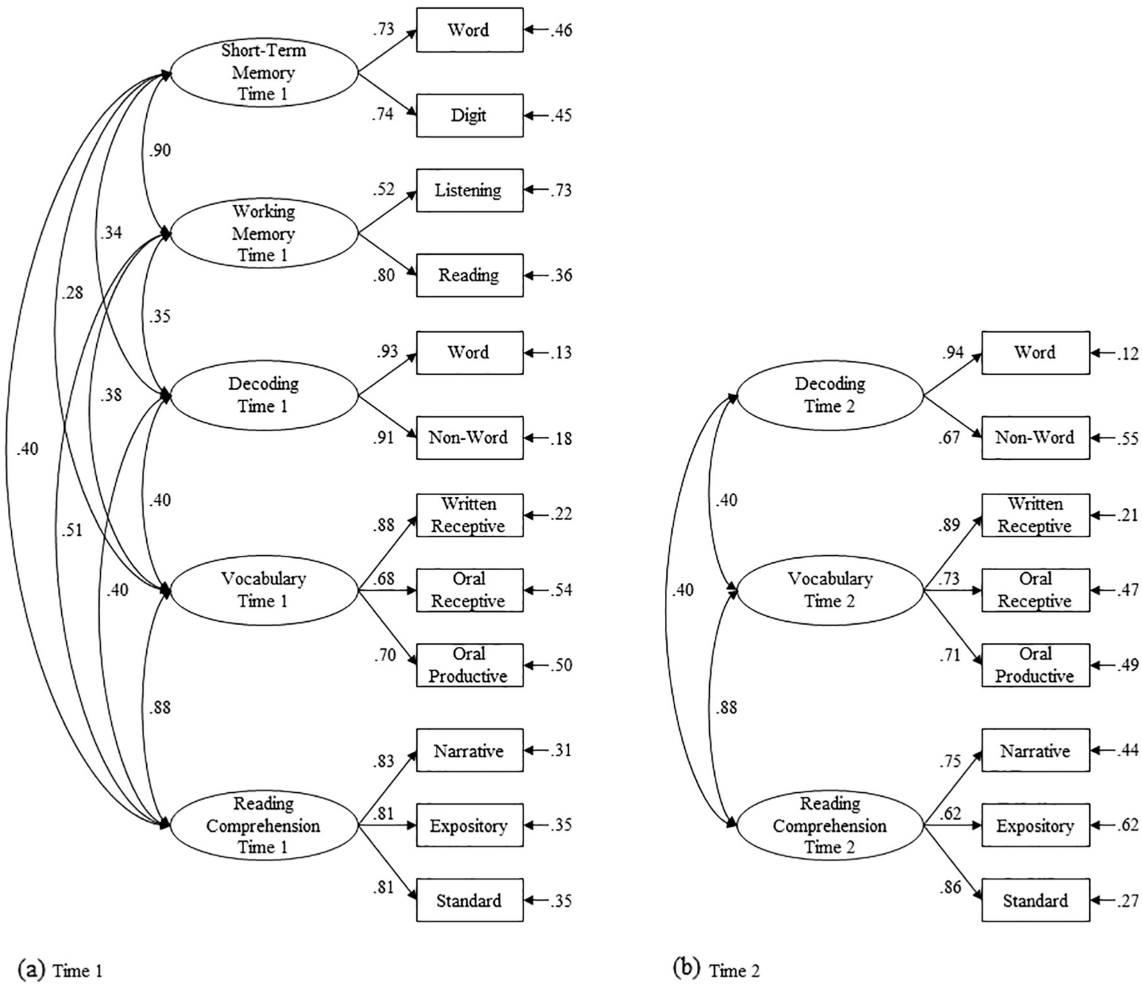

Fig. 2. Results of the CFA's performed to confirm the factor structure at the start grade 4 (Time 1; left panel) and mid through grade 5 (Time 2; right panel).

context in which a novel word is encountered. Well-developed reading comprehension skills therefore seem to be important in learning new words. In their study, Cain, Oakhill, and Lemmon (2004) have evidenced that poor comprehenders show more difficulties with inferring new word meanings from context as compared to readers with good reading comprehension skills.

We found that decoding, as a second critical determinant of reading comprehension according to the Lexical Quality Hypothesis, was related to reading comprehension skill, as evidenced by the significant residual covariance at the start of Grade 4. However, halfway through Grade 5, the covariance between decoding and reading comprehension did not longer reach significance, indicating that decoding did not longer affect reading comprehension skills. In contrast to what was predicted, results of the current study suggest that decoding does not influence reading comprehension development of Dutch children in the intermediate grades. Although these results contradict the Simple View of Reading (Hoover & Gough, 1990), which states that reading comprehension is the product of decoding and language comprehension, these results fit with the notion that as children develop better decoding skills, reading comprehension is more constrained by vocabulary skill (Verhoeven & Van Leeuwe, 2008), especially true for languages with a transparent orthography such as Dutch. More research is warranted to explore different theories on reading comprehension (development) (e.g., Simple View of Reading and Lexical Quality Hypothesis) and examine which factors affect reading comprehension at which stages in the development and what differences might be present for studies using transparent and opaque languages.

With respect to the cognitive factors, nonverbal reasoning and working memory directly predicted concurrent reading comprehension skill and vocabulary, indicating that children with more working memory capacity and better developed nonverbal reasoning skills are better able to comprehend written texts and have better developed vocabularies as compared to children with less working memory capacity and less developed nonverbal reasoning skills. These results are in line with results from previous studies (e.g., Cain, 2006; Fuchs et al., 2012). Short-term memory only predicted concurrent decoding skills (in line with e.g., Van den Boer et al., 2014), but not concurrent vocabulary as we had hypothesized. This second, not significant result, is in contrast with those of for instance Gathercole and Baddeley (1989, 1990, 1993). Future research should shed more light on these contrasting results and how short-term memory does (or does not) predict individual variation in reading comprehension skill. The observation that working memory did predict concurrent reading comprehension, but short-term memory did not is in line with the results of Carretti et al. (2009). They concluded, based on their meta-analyses, that complex span tasks were more strongly related to reading comprehension skill as compared to simple span tasks. More interesting, however, is the finding that nonverbal reasoning skills directly influence reading comprehension development. In addition, due to the reciprocal relation between vocabulary and reading comprehension, there was also evidence for indirect effects of working memory and nonverbal reasoning on reading comprehension and vocabulary development through respectively vocabulary and reading comprehension. These results indicate that the development of reading comprehension and vocabulary is indirectly influenced by working memory capacity and nonverbal reasoning. Fuchs et al. (2012) have suggested

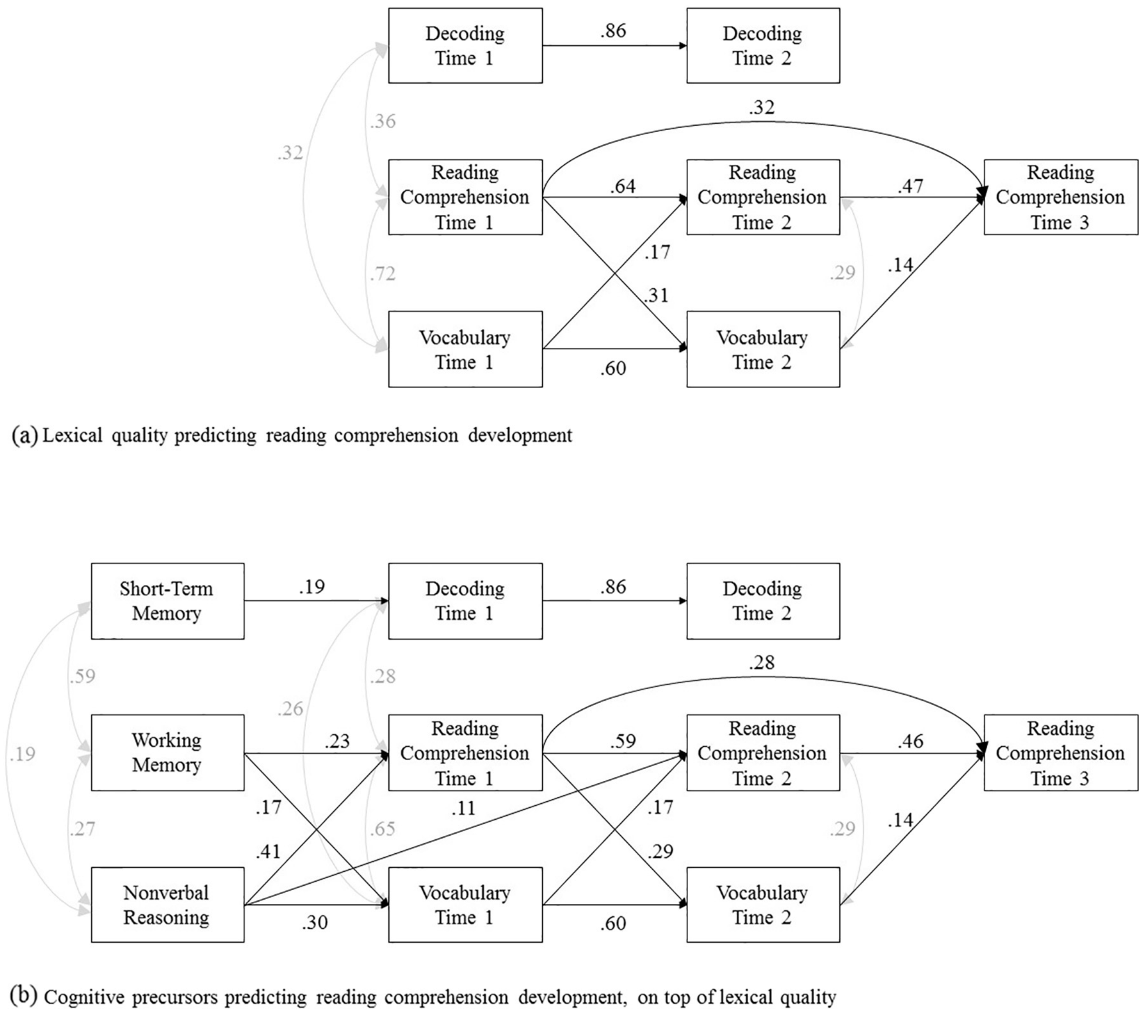

Fig. 3. Path models with standardized path coefficients. The top panel presents results of the first path analysis, examining the influence of lexical quality on reading comprehension development. The bottom panel presents results of the second path analysis, examining to what extent reading comprehension development can be predicted by cognitive factors, on top of lexical quality.

Note. Only significant paths and (residual) covariances between factors are presented.

that these skills might be involved in drawing inferences. Drawing accurate inferences is crucial for comprehension, since not all information needed to come to the true meaning can be explicitly stated in the text. Previous studies have shown that inference skills are positively related to reading comprehension (Oakhill et al., 2003) and that inference skills influence reading comprehension development and vice versa (Oakhill & Cain, 2012). More longitudinal research including measures of (nonverbal) reasoning (or deductive skills), inference generating, and lexical quality is warranted to examine their influence on reading comprehension development in more detail.

On a more theoretical note, research on different entities of reasoning in relation to reading comprehension would be insightful. Some indicate that reasoning is not a single entity and that distinctions can be made between sequential, quantitative, and indicative reasoning with joint variance between them (see Lohman & Lakin, 2011 for a summary). Raven typically has been considered as a test measuring inductive skills. However, it seems likely that sequential reasoning skill (the ability to mentally process and organize information usually measured using verbal tasks) might impact and influence reading comprehension as well. More research on the impact of both sequential and indicative reasoning and how they differ or overlap is warranted to better understand the relation between reasoning and reading skills.

The results of the current study have some theoretical and practical implications. Theoretically, we have shown that reading comprehension development does not only rely on lexical quality, but also on cognitive factors such as reasoning and working memory. Future research on the development of reading comprehension would benefit from including both lexical and cognitive measures. As to the question how reading comprehension difficulties develop, findings from the current study indicate that not only linguistic factors should be examined (as often is done now, both in research and practice), but that cognitive factors might also play a role in the development of these problems. More practically, the current study again shows the influence of lexical quality (especially vocabulary) on reading comprehension development. In classroom settings, children should be stimulated to improve their vocabulary knowledge in order to improve their reading comprehension skills and vice versa. Finally, results showed that reasoning skills both directly and indirectly (through vocabulary) influence reading comprehension development. Previous research has suggested that reasoning plays a role in generating inferences, which is important in reading comprehension, especially when texts become more complex. In the current study, we used a nonverbal task. Interventions stimulating deductive skills (both verbal and nonverbal), therefore, might improve reading comprehension skill. Studies examining how this can be accomplished are warranted. For educational purposes, poor comprehenders would benefit from situations in which the demand on deductive skills would be decreased. Using texts in which relations are stated more explicitly or the use of for example visual display of the content might benefit the poor comprehenders. Studies examining how this can be accomplished, again, are warranted.

The findings of this study must be placed in the context of some limitations and future research is necessary to gain more insight in how cognitive factors influence reading comprehension development. First, although we administered different tests to capture the complex nature of reading comprehension, we used component scores for the analyses. More fine-grained research is necessary to examine whether the same pattern of results holds for different types of reading comprehension. Expository and narrative texts, for instance, differ in information presented in the text (more daily life events in narrative and more information providing in expository), number of unknown words (larger in expository), and types if inferences that have to be generated to understand the text (Gardner, 2004; Graesser, McNamara, & Louwerse, 2003; Graesser, Singer, & Trabasso, 1994). Secondly, although we used a longitudinal design with three measurement occasions, the time between measurement 1 (start grade 4) and 2 (mid grade 5) was substantially longer as compared to the time between measurement occasion 2 (mid grade 5) and 3 (end grade 5). This difference might have influenced our results. A replication of the present study, with equal gaps between measurement occasions and preferably final measures in grade 6 (final grade of elementary school in the Netherlands), is warranted. Related, we have chosen to examine the development of reading comprehension of students in the intermediate elementary grades because this period marks a critical transition point. To gain more insights in how linguistic and cognitive factors influence reading comprehension development and how reading comprehension and the cognitive factors influence decoding and vocabulary development in different stages of development (before and after the transition point), longitudinal research following children from the start of elementary school all the way through sixth grade (or even longer) is warranted. Previous research has shown that in early years, reading comprehension is very constrained by decoding, but that later on vocabulary becomes the primary constraining factor, as decoding becomes an automated skill (e.g. Verhoeven & Van Leeuwe, 2008). Both from a theoretical and practical point of view, it would be helpful to know which factors influence each other in which stages of the development. Finally, previous research has shown that structural relations might differ between linguistically and culturally diverse groups (cf. Droop & Verhoeven, 2003). Research examining these differences in structural relations is warranted in order to improve our understanding of developmental differences and consequently improve education.

4.1. Conclusions

To conclude, the current study has shown that for Dutch children in the intermediate elementary grades, vocabulary, but not decoding, influences reading comprehension development. Additionally, it can also be concluded that reading comprehension skill influences vocabulary development. With respect to the cognitive factors, we argued that both working memory and nonverbal reasoning influence reading comprehension and vocabulary and the development of these skills, either directly or indirectly. Especially nonverbal reasoning plays an important role. These results highlight the importance of both lexical and cognitive factors in reading comprehension development.

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