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

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