How Fluency Informs Reading Comprehension Development

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The research presented in this dissertation was carried out at the Behavioural Science Institute of the Radboud University, Nijmegen, the Netherlands.

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General Introduction
General Introduction

The ultimate aim of reading instruction is to teach children how to comprehend written text. Reading comprehension is not only important for all aspects of the curriculum at primary school, it is also essential for a child's future school career and for their later social and professional life. The first prerequisite for reading comprehension is to be able to decode well. Decoding refers to the ability to connect the constituents of written words, in other words, coupling the graphemes—the written symbols—to the phonemes—the accompanying sounds. Developing text reading fluency has been proposed to be an essential shift from decoding to comprehension of text (Chall, 1983a; Pikulski & Chard, 2005). Text reading fluency has traditionally been defined as the ability to read a text quickly and accurately (e.g., Fuchs, Fuchs, Hosp, & Jenkins, 2001). More recent definitions, however, have added ‘reading with appropriate expression’, or text reading prosody, to the construct of text reading fluency (Kuhn, Schwanenflugel, & Meslinger, 2010; National Reading Panel, 2000).

Prosody can be defined as ‘suprasegmental phonology’ because it is part of the sound system of language but not bound to any particular segments of spoken language or written text. Text reading prosody is characterized by the use of pitch, phrasing, rhythm and pauses in reading a text aloud. Studies that incorporated text reading prosody as a component of text reading fluency (e.g., Benjamin & Schwanenflugel, 2010; Miller & Schwanenflugel, 2006, 2008; Rasinski, Rikli, & Johnston, 2009) have found that text reading prosody was associated with reading comprehension, often in addition to text reading rate and accuracy. However, most studies on text reading fluency are based on children learning to read English, and we currently know very little about its role in children learning to read a relatively transparent orthography, such as Dutch. Therefore, this dissertation examines the role of text reading fluency—reading a text aloud—in reading comprehension, in Dutch primary school children. The focus is on the ‘expression’ component of text reading fluency, in other words, text reading prosody.

Development of Reading

Reading comprehension is typically taught in the intermediate and upper grades of primary school. According to the stages of reading development by Chall (1983a), reading development progresses from the beginning stages of ‘learning to read’—being able to decode words and becoming a fluent reader—to the more advanced stages of ‘reading to learn’—where text becomes more complex and more cognitively and linguistically challenging. Children generally make this critical transition from ‘learning to read’ to ‘reading to learn’ in fourth grade (Chall, 1983a, 1983b). At this point, children are not only actively learning how to comprehend...
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Decoding efficiency is one of the predictors of reading comprehension; if a word cannot be deciphered, the meaning of the word cannot be extracted. Decoding is a base-level skill in reading development, and teaching children to decode efficiently is the main aim during the first few years of literacy education. For Dutch children—learning to read a language with a transparent orthography in which the relation between graphemes and phonemes is mostly consistent—this is an easier process than for children learning to read English. English is called an opaque language because the orthography does not always directly match the phonology. For example, the pronunciation of the English grapheme ‘i’, is very inconsistent, as illustrated by the following English words: win /wɪn/, wine /waɪn/, fir /fɜːr/, fire /ˈfaɪər/. In the Dutch language, the grapheme-phoneme coupling is more consistent, as the following Dutch words show: vis /vɪs/, kip /kɪp/, lippen /ˈlipən/, winnen /ˈvɪnən/. Although some graphemes show more variability in Dutch (for example bad /baːd/ versus baden /baːn/), statistics show that the pronunciation consistency in mono-syllabic words from a large database was 84.5% in Dutch and 69.3% in English (Bosman, Vonk, & van Zwam, 2006).

Dutch does not have an entirely transparent orthography, and in addition, Dutch also uses loanwords from other languages. It is estimated that approximately 15% of words in the Dutch language are loanwords (e.g., Bosman, de Graaff, & Gijsel, 2006; Nunn, 1998). These loanwords come from many different languages, among them English (computer, t-shirt), French, (horloge, douche) and Latin (alibi, agenda) (for a full overview see: Van der Sijs, 2009). Loanwords are often atypical or inconsistent compared to the usually transparent phoneme–grapheme coupling in Dutch (Bosman, van Hell, & Verhoeven, 2006). Children typically encounter more complex and more challenging material, such as loanwords, in the stages of ‘reading to learn’, from fourth to sixth grade (Chall, 1983a, 1983b). Therefore, although Dutch children generally read 90% of words correctly after the first year of reading instruction (Seymour, Aro, & Erskine, 2003), automaticity in decoding can still be challenging for some children in the intermediate and upper grades of primary school (e.g., Verhoeven & van Leeuwe, 2009).

In contrast to children learning to read Dutch, children learning to read English will have to learn most words by heart (e.g., sight word reading: Ehri, 2005, 1995). Dutch children can, to a large extent, read words by sounding them out and by blending graphemes into phonemes. The English language can be described as an ‘outlier language’, compared to most other European languages, because of the large inconsistency in the grapheme-phoneme relationship (Share, 2008).

Text Reading Fluency: Automaticity or Prosody?

Decoding efficiency is not only a predictor for reading comprehension, it is also an important foundation skill for text reading fluency (e.g., Pikulski & Chard, 2005; Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004). Decoding precedes text reading fluency because individual words need to be deciphered in order to read connected text. Text reading fluency has traditionally been defined as a combination of reading speed and reading accuracy (e.g., Adams, 1999; Fuchs & Deno, 1991; Fuchs et al., 2001; Logan, 1997). Text reading requires different skills than word reading and it has been shown that these skills relate to reading comprehension in different ways (Cutting, Materek, Cole, Levine, & Mahone, 2009; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003; Klauda & Guthrie, 2008). For example, studies have shown that text reading fluency explained additional variance in reading comprehension whereas word reading fluency did not (Jenkins et al., 2003).

Apart from reading speed and reading accuracy, which can be seen as the automaticity aspect of both word and text reading, text reading prosody has

Because of the opaque orthography, the English language literature on literacy puts great emphasis on the role of accuracy. In contrast, Dutch decoding development seems more a matter of increased speed than of increased accuracy (Verhoeven & van Leeuwe, 2009). It is therefore important to compare the results from English language studies to results from studies in other languages, such as Dutch, because language characteristics are likely to influence the developing relationship between text reading fluency and reading comprehension considerably.

In opaque and transparent orthographies alike, decoding forms an important foundation skill for reading comprehension (e.g., LaBerge & Samuels, 1974, Perfetti, 1985, Stanovich, 2000; Verhoeven & van Leeuwe, 2008). At the stage where words are automatically decoded, it is claimed that conscious attention is no longer needed for decoding purposes and cognitive resources can be utilized for comprehension processes (LaBerge & Samuels, 1974; Perfetti, 1985). According to the simple view of reading, decoding together with language comprehension (e.g., vocabulary and syntactic awareness) are the best predictors of reading comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). Nevertheless, decoding has been shown to exert particular influence on reading comprehension in young, beginning readers, whereas language comprehension becomes more influential in older, more proficient readers (e.g., Juel, 1988, Tunmer & Hoover, 1992; Bast & Reitsma, 1998). This transition is partly dependent on the characteristics of the language (e.g., opaque or transparent orthography) and may therefore happen at an earlier age for Dutch children (Verhoeven & van Leeuwe, 2008) compared to English children.
been added more recently to the construct of text reading fluency (National Reading Panel, 2000). Text reading prosody is considered a hallmark of proficiency in text reading fluency (Dowhower, 1991; Kuhn & Stahl, 2003; Schwanenflugel et al., 2004). Correct use of text reading prosody makes reading a text aloud sound more like natural speech, with appropriate phrasing, use of pauses, word and sentence boundaries and general expressiveness. Text reading prosody has been measured with spectrographic analyses (e.g., Benjamin & Schwanenflugel, 2010; Miller & Schwanenflugel, 2006, 2008; Schwanenflugel et al., 2004) and in a more holistic way, with rating scales (e.g., Calet, Defior, & Gutiérrez-Palma, 2015; Rasinski et al., 2009). Evidence has been found for a relation between text reading fluency and reading comprehension, both when text reading prosody was included (e.g., Benjamin & Schwanenflugel, 2010; Calet, Defior, & Gutiérrez-Palma, 2015; Miller & Schwanenflugel, 2006, 2008; Rasinski et al., 2009), and when text reading prosody was not included (e.g., Berninger et al., 2010; Kim & Wagner, 2015; Kim, Wagner, & Lopez, 2012). Furthermore, in the English language literature, a contribution of text reading prosody to reading comprehension has often been found in addition to a contribution of reading speed and accuracy (e.g., Miller & Schwanenflugel, 2006; Klauda & Guthrie, 2008).

There are currently, as far as we know, very few studies in languages other than English that have examined the association between text reading prosody and reading comprehension. An exception is a Spanish study by Calet et al. (2015) that examined text reading fluency performance, including text reading prosody, in children learning to read Spanish—a transparent orthography. It was found that automaticity in reading (correctly read number of words per minute) was the strongest predictor of reading comprehension in second grade children, but text reading prosody was the strongest predictor in fourth grade children (Calet et al., 2015). More studies from different languages are needed to determine whether the contribution of reading speed and accuracy versus the contribution of text reading prosody to comprehension may be language specific or perhaps reading level specific.

Why would Text Reading Prosody and Reading Comprehension be Related?

Because some studies showed that text reading prosody explained variation in reading comprehension scores above and beyond accuracy and rate of text reading (e.g., Klauda & Guthrie, 2008; Veenendaal, Groen, & Verhoeven, 2015), it has been suggested that text reading prosody makes an independent contribution to reading comprehension. The mechanism by which text reading prosody could be related to reading comprehension involves the binding problem of language. A passage of text can be divided into orthographic-phonological units, but also into syntactic or semantic units (Frazier, Carlson, & Clifton, 2006). A sentence such as “The old man the boat” illustrates this. ‘Man’ and ‘boat’ are both phonological units as well as nouns. Nevertheless, when ‘man’ is read as a noun, the sentence does not make much sense. Therefore, a different syntactic structure is needed in order to construct a semantically correct sentence. When it becomes clear that ‘man’ should be read as a verb, the meaning of this sentence, as well as the use of prosody, instantly changes. This example shows that the use of text reading prosody—in this case the use of pauses to group certain words together—is related to the meaning of ambiguous sentences.

In reading a text aloud, the use of text reading prosody often depends on the punctuation in sentences. An example of this is the title of the book ‘Eats, shoots and leaves: The zero tolerance approach to punctuation’ (Truss, 2003). When the reader knows that ‘eats shoots and leaves’ refers to the diet of giant pandas, the interpretation, and therefore the use of text reading prosody, is completely different than when the reader thinks this sentence refers to, for example, a cowboy in the Midwest of America. Punctuation is necessary to guide the reader, as the purposefully misplaced comma in the title of the book above illustrates. However, in written text, punctuation can only in some cases be used to signpost sentences, and prosodic patterns are therefore not always directly obvious (Schreiber, 1991). Schreiber (1991) stated that children must learn to recognize and interpret the syntactic structure of written text. An internal prosodic representation of a text (implicit prosody) may therefore facilitate the comprehension of written text. This is what Fodor (2002, 1998) proposed with the implicit prosody hypothesis. She stated that a default prosodic contour is projected onto a text, and that this prosodic contour helps in solving syntactic ambiguity when reading silently (Fodor, 2002, 1998). It could therefore be that the degree to which a child successfully manages to construct this internal representation relates to the level of reading comprehension.

The Role of Speech Prosody

In the literature, it is often assumed that an appropriate use of text reading prosody transfers from spontaneous speech abilities to text reading performance (Dowhower, 1991; Schwanenflugel, Westmoreland, & Benjamin, 2013). However, as far as we know, no studies have investigated this. Because speech production occurs well before reading ability in language development, it is conceivable that later reading skills are built upon a foundation of prosodic speech abilities. Speech prosody is part of the earliest experiences with spoken language. Studies have shown that infants are sensitive to aspects of speech prosody even before they are born (Granier-Deferre, Bassereau, Ribeiro, Jacquet, & DeCasper, 2011). Prosodic sensitivity continues to develop and becomes more refined during the
first year of life, which may provide children with a mechanism for linguistic processing throughout their life (Gordon, Jacobs, Schuele, & McAuley, 2015). Cutler and Mehler (1993) proposed that children are born with a ‘periodicity bias’ that makes them sensitive to the specific rhythmic properties of their native language. English and Dutch are both stress-timed languages in which strong syllables are alternated with weak syllables. Consider, for example, the alternating stress patterns in the words: /BIRTHday/ or /toMORrow/ or the stress pattern in a short phrase such as: /CATS chase MICE/. The periodicity bias—the awareness of stress patterns in their native language—can therefore assist young children in segmenting words from the speech stream (Cutler & Norris, 1988), which will aid their oral language comprehension.

It has been shown that early prosodic speech perception contributes to later morphological and phonological awareness (Zhang & McBride-Chang, 2010). In addition, in primary school children, prosodic perception skills have been related to word reading skills (e.g., Gutiérrez-Palma & Reyes, 2007; Holliman, Wood & Sheehy, 2010; Wade-Woolley, 2007; Wood & Terrell, 1998). A distinction that is made in this literature is between prosodic tasks at the word-level (e.g., Gutiérrez-Palma & Reyes, 2007; Holliman, Wood & Sheehy, 2008, 2010; McBride-Chang, Tong, Shu, Wong, Leung, & Tardif, 2008; Cheung, Chung, Wong, McBride-Chang, Penney, & Ho, 2008), at the phrase-level (Whalley & Hansen, 2006) and at the sentence-level (e.g., Wood & Terrell, 1998).

Holliman et al. (2008, 2010) used a word-level task, a metric stress task, to assess whether children were sensitive to stress manipulation in words (e.g., the word carROT instead of CARrot). Children who were better at this task performed better at word reading, even when age, vocabulary and phonological awareness were controlled for (Holliman et al., 2008, 2010). Whalley and Hansen (2006) used a word-level task as well as a phrase-level task and found that these tasks were differently related to reading outcomes. The compound noun, word-level task (ice, cream versus ice-cream) was found to be related to word reading outcomes whereas the phrase-level task (detection of stress and rhythm in short phrases) was related to reading comprehension outcomes (Whalley & Hansen, 2006). Performance on sentence-level tasks, such as the rhythmic matching task by Wood and Terrell (1998), was found to distinguish between typical and poor readers (children who were at least one year behind in word reading). Children heard a low-pass filtered sentence—all phonemic content was removed and only the prosodic contour remained—followed by two naturally spoken sentences. The child had to select the natural sentence that had the same rhythm and stress pattern as the low-pass filtered sentence. The poor readers performed considerably worse at this task than typical readers (Wood & Terrell, 1998).

The above mentioned studies were all performed in children learning to read English. Only a few studies examined the relation between speech prosody and reading ability in languages other than English. A Spanish study found that knowledge of stress rules in words, such as the difference between the non-words /Mipa/ and /mIPA/ predicted both word and non-word reading (Gutiérrez-Palma & Reyes, 2007). Prosodic word-level studies in Chinese children examined sensitivity to lexical tone identification. Lexical tone identification is an important skill for Chinese children as different tones can refer to different meanings. A study from Cantonese Chinese, a tonal language, showed that children with dyslexia performed less well than control children on a lexical tone identification task (Cheung et al, 2008). Sensitivity to lexical tones was also found to be associated with Chinese word reading abilities in typically developing children (McBride-Chang et al., 2008).

These studies show that different aspects of speech prosody may be important for the development of word reading. However, it also illustrates the importance of studies from different languages. Because each language has its own characteristics, for example in stress patterns or in use of lexical tone, this will ultimately affect outcomes.

Speech Prosody and Reading Comprehension

Only a few studies that examined the relation between speech prosody and reading ability included reading comprehension (Holliman, Williams, Mundy, Wood, Hart, & Waldron, 2014; Kent, 2013; Lochrin, Arciuli, & Sharma, 2015; Whalley & Hansen, 2006). Whalley and Hansen (2006), for example, showed that prosodic sensitivity at the phrase-level, assessed with a reiterative speech task (DEEdee task), explained 30% unique variance in reading comprehension, when phonological awareness and non-speech rhythm detection were controlled for. In this task, children had to match the rhythm and stress of a short naturally spoken phrase to the rhythm and stress of a DEEdee phrase, in which all words are replaced by the word ‘dee’. As an example, the phrase Humpty Dumpty would become DEEdee DEEdee. It is suggested by Whalley and Hansen (2006) that prosodic word-level and phrase-level tasks relate to different reading skills. Phrase-level prosody may rely more on aspects such as syntactic parsing (Kentner, 2012) and given versus new information (Bock & Mazzella, 1983). These are important aspects in reading comprehension. In contrast, word-level prosody relies more on aspects such as intonation and use of stress and pauses, which could be more suitable for word reading performance (Holliman, Wood, & Sheehy, 2008, 2012, Whalley & Hansen, 2006).

Holliman et al. (2014) made an attempt to construct a comprehensive computer test of speech prosody, combining different levels and different aspects of prosody.
They constructed a multi-component test of speech prosody at the word, phrase and sentence-level and assessed perception of stress, pitch, and duration. To assess stress perception, children heard a spoken utterance (e.g., Aladdin = weak-strong-weak) which they had to match to a low-pass filtered utterance, based on the stress pattern. Pitch was assessed by asking children whether they heard a question or a statement, both in spoken utterances as well as in low-pass filtered speech. Lastly, children had to decide whether two low-pass filtered utterances were the same or different, in terms of duration (e.g., Spiderman/Spiiiiiderman). The results showed that the total score on this test was significantly associated with a number of language measures, including reading comprehension (Holliman et al., 2014).

Another comprehensive assessment of speech prosody is the PEPS-C computer test (Profiling Elements of Prosodic Systems–Children; Peppé & McCann, 2003) which measures perception and production of speech prosody. The PEPS-C test examines speech prosody skills with 6 different subtasks: Chunking (using word boundaries to distinguish the number of items: Chocolate, biscuits and jam versus chocolate-biscuits and jam), Contrastive stress (using stress placement to highlight information: I wanted green and BLUE socks), Affect (using intonation to convey like or dislike of an item: Carrots said with enthusiasm or reservation), Turn-end (using pitch to convey a question or a statement: Carrots? versus Carrots) and two speech rhythm tasks. The first of these is an imitation task, where children are asked to repeat a short phrase as precisely as possible, and the second is a Discrimination task, where children are asked to indicate whether two low-pass filtered sentences sound the same or different (Peppé & McCann, 2003). Performance on the subtasks of the PEPS-C test has been related to reading outcomes and among these, reading comprehension (e.g., Kent, 2013; Lochrin et al., 2015). Kent (2013) found that the perception of speech rhythm (Discrimination), word boundaries (Chunking) and stress placement (Contrastive stress) was associated with children’s reading comprehension and that the perception of word boundaries and stress placement explained unique variance in reading comprehension scores in fourth grade children (Kent, 2013). Lochrin et al. (2015) examined perception as well as production of speech prosody and related this to word reading and reading comprehension outcomes in children from 7 to 12 years of age. They found that the perception and production of word boundaries (Chunking), and the perception of speech rhythm (Discrimination) and stress placement (Contrastive stress) were associated with reading comprehension, but only the production of word boundaries explained unique variance in reading comprehension (Lochrin et al., 2015). These results show that speech prosody tasks have in some cases been related to reading comprehension outcomes, although the results differ slightly between studies.

To summarise, the predominantly English language literature has consistently shown that text reading prosody is associated with reading comprehension. Only a few studies have examined this relationship in languages other than English. Because the relation between prosody and reading comprehension has mostly been assessed with text reading prosody, we do not know how much of this association is due to reading-related abilities. Not many studies have examined the relation between speech prosody and reading comprehension. As far as we know, the role of text reading prosody has never been directly compared to the role of speech prosody in relation to reading comprehension.

**Longitudinal Studies**

Another problem with the current literature is that most studies that have examined text reading prosody and reading comprehension are cross-sectional in design. While cross-sectional studies can be very useful in providing information about reading outcomes at one specific moment in time, longitudinal studies can provide us with information about stability and change in these reading skills. Only a handful of studies on the relation between text reading fluency and reading comprehension have used a longitudinal design, but not all of these studies were well controlled. For example, it is important to determine the relation between text reading prosody and reading comprehension, above and beyond autoregressive effects, because the most important predictor for any skill is most likely the skill itself at a prior time (Gollob & Reichardt, 1987).

Autoregressive effect were, as far as we know, only included in one recent study that examined the direction of the relationship between text reading fluency, including text reading prosody, and reading comprehension at three times points in second-grade (Lai, Benjamin, Schwanenflugel, & Kuhn, 2014). It was found that the direction of the relation between reading fluency–a latent variable including accuracy, rate and prosody of text reading, as well as decoding–and reading comprehension, was unidirectional. The latent variable ‘reading fluency’ contributed to reading comprehension at all three time points. However, the influence of decoding in this latent variable could have biased the results in these young and beginning readers. Another longitudinal study examined the contribution of text reading prosody in first and second grade to reading comprehension outcomes in third grade (Miller & Schwanenflugel, 2008). It was found that text reading prosody contributed to later reading comprehension. However, this study did not control for autoregressive effects and therefore the contribution above and beyond the effect of reading comprehension itself, remains unclear.

The two above mentioned studies both examined reading skills in young, beginning readers. A longitudinal study in older children, in fourth grade, showed...
that the rate and accuracy of text reading fluency and reading comprehension were bi-directionally related (Klauda & Guthrie, 2008). Nevertheless, text reading prosody was shown to be related to reading comprehension and not vice versa (Klauda & Guthrie, 2008). Lastly, only one longitudinal study, as far as we know, took into account the influence of segmental phonology (phonological awareness) in examining the contribution of suprasegmental phonology (speech prosody) to reading comprehension. Holliman et al. (2010) showed that, after controlling for age, vocabulary and phonological awareness, a word-level prosodic speech task, which manipulated stress placement (CARot pronounced as carROT) was related to word reading, but not to reading comprehension, one year later (Holliman et al., 2010).

As most longitudinal studies did not include segmental phonology, we do not know how segmental and suprasegmental phonology relate to reading comprehension over an extended period. In addition, the results from longitudinal studies into text reading fluency and reading comprehension are hard to compare because of the lack of autoregressive controls and use of latent variables. Lastly, as far as we know, no longitudinal studies have been performed in older, more proficient readers who are learning to read a language with a transparent orthography.

This dissertation

To summarise, in the current literature on text reading fluency and reading comprehension there is still an ongoing debate on three related issues. First, text reading fluency has been associated with reading comprehension, but it is still contested which specific component of text reading fluency—automaticity or text reading prosody—contributes to reading comprehension. Some studies have found that rate and accuracy (automaticity) contribute to reading comprehension (Berninger et al., 2010; Kim & Wagner, 2015; Kim et al., 2012), but other studies showed that text reading prosody contributed to this, sometimes in addition to rate and accuracy (e.g., Miller & Schwanenflugel, 2006; Klauda & Guthrie, 2008). It seems that language characteristics as well as the reading level of children may play a part in this. Second, the role of text reading prosody—as a component of text reading fluency—in reading comprehension has received increased attention over the last decade (e.g., Klauda & Guthrie, 2008; Miller & Schwanenflugel, 2006, 2008; Rainski et al., 2009; Schwanenflugel et al., 2004), but it is not very clear what exactly constitutes text reading prosody. Is it a representation of being able to decode efficiently, being able to comprehend written text well, or does text reading prosody in itself make a unique and independent contribution to reading comprehension? Is speech prosody, for example, also related to reading comprehension, or is it merely the reading-related aspect that causes the association? Third, most studies that examined the relation between text reading prosody and reading comprehension are cross-sectional and the relation has mostly been examined in young, beginning readers. Little is currently known about the relation between text reading prosody and reading comprehension over an extended period and in older, skilled readers, who are learning to read a transparent orthography.

This dissertation examined how text reading fluency informs reading comprehension in Dutch children in the intermediate and upper primary grades. In line with the issues discussed here, the following three research questions were addressed:

1. What constitutes text reading fluency and how are its constituents related to reading comprehension in proficient readers of a transparent orthography?
2. To what extent is the prosody aspect of text reading fluency independent of the automaticity aspect of text reading fluency, in its relation to reading comprehension?
3. How are text reading prosody and reading comprehension related during development over an extended period, from intermediate to upper grades of primary school?

In order to answer the first research question, Chapter 2 of this dissertation addressed the contribution of the independent components of text reading fluency—reading rate (correctly read number of words per minute) and text reading prosody—to reading comprehension, when controlling for decoding, vocabulary and syntactic awareness.

To answer the second research question, the construct of text reading prosody was explored in more depth in two subsequent studies. In Chapter 3, the contribution of speech prosody to reading comprehension was compared to the contribution of text reading prosody, when accounting for the influence of decoding and language comprehension. In addition, in Chapter 4, the contribution of decoding was further disentangled from the association between prosody skills and reading comprehension. In this particular chapter, the performance on text reading prosody, as well as speech prosody, of children with weak reading comprehension but age-adequate decoding efficiency (poor comprehenders) was compared to that of typical readers.

To address the third research question, two longitudinal studies investigated the long-term relation between text reading prosody and reading comprehension. The study in Chapter 5 examined the unique contribution of suprasegmental phonology (text reading prosody) versus segmental phonology (phonological awareness) to reading comprehension, over a period of three years. The study in Chapter 6 investigated the direction of the relation between text reading prosody and reading comprehension. This study addressed the question whether text reading prosody is a reflection of the level of reading comprehension, or whether text
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References


reading prosody makes an independent contribution to reading comprehension, or perhaps both. In Chapter 7, the results of the five empirical studies are discussed. In this concluding chapter, a summary of the main results will be provided, and theoretical and practical implications will be outlined.
Chapter 1 General Introduction


What Text Reading Fluency can Reveal about Reading Comprehension

Based on:
Abstract
Text reading fluency—the ability to read a connected text quickly, accurately and with a natural intonation—has been proposed to be a predictor of reading comprehension. In the current study we examined the unique variance that the components of text reading fluency, text reading rate and text reading prosody, explained in reading comprehension scores, in addition to decoding efficiency and language comprehension. One hundred-and-six Dutch primary school children from fourth grade participated in this study and were assessed on decoding efficiency, language comprehension (vocabulary and syntactic awareness), text reading fluency and reading comprehension. Regression analysis showed that text reading prosody, not text reading rate, explained additional variance in reading comprehension scores when decoding efficiency and language comprehension were controlled for. This result suggests that the inclusion of text reading prosody as an aspect of text reading fluency is justified and that a natural intonation is associated with better comprehension of what is read.

What Text Reading Fluency can Reveal about Reading Comprehension

The National Curriculum for Primary English (Key stage 2) states that “To develop understanding and appreciation of literary texts, pupils should be taught to read stories, poems and plays aloud” (National Curriculum for England, 1999, pp. 25-26). In this study, we examined the importance of reading aloud, and what this can tell us about the level of reading comprehension. From the simple view of reading, it is proposed that decoding and language comprehension strongly predict reading comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). However, it is also claimed that text reading fluency, or the ability to read a text aloud quickly, accurately and with a natural intonation, contributes to successful reading comprehension. Two issues make it difficult to interpret research findings in this area. First, studies so far have used different definitions of the construct of ‘reading fluency’. Second, when evaluating the contribution of text reading fluency to reading comprehension performance, other predictors (e.g., decoding and language comprehension) have not always been taken into account. In the current study, we investigated whether text reading fluency—defined as text reading rate and text reading prosody—predicts reading comprehension performance over and above predictors specified by the simple view of reading.

When children first start to read, their reading will not be very fluent and smooth. The child first has to learn how to decode the written words, that is, to learn how to connect the appropriate sounds to letter combinations. Only when children become more proficient in decoding and learn how to quickly recognize words, their reading performance starts to become more fluent. The ultimate goal of reading development is reading comprehension. Decoding abilities form an important foundation skill for reading comprehension, according to some classic studies on literacy (LaBerge & Samuels, 1974; Perfetti, 1985). Gough and Tunmer (1986; Hoover & Gough, 1990) built on this and developed the simple view of reading. According to this framework, decoding together with language comprehension (e.g., vocabulary and syntactic awareness) are the best predictors of reading comprehension outcomes.

Text reading fluency, however, has been put forward as an additional important predictor of reading comprehension ability (e.g., Adams, 1990; Fuchs, Fuchs, Hosp, & Jenkins, 2001; Kuhn & Stahl, 2003). A considerable number of studies have investigated the role of reading fluency in children’s reading comprehension. A factor that complicates the interpretation and comparison of these results is the use of different definitions and assessments of the construct of ‘reading fluency’. Both the automaticity theory of LaBerge and Samuels (1974) and the verbal efficiency theory of Perfetti (1985, Perfetti & Hart, 2002) proposed that word
reading fluency (speed and automaticity) facilitate reading comprehension. As word reading processes become automatic, cognitive resources are proposed to become available for comprehension purposes (LaBerge & Samuels, 1974, Perfetti, 1985). More recent evidence confirms the contribution of automaticity in word reading, as well as in text reading, to reading comprehension. In a study including both word reading and text reading (Schwanenflugel et al., 2006) it was found that automaticity in reading fluency—a latent factor, including rapid naming, pseudoword decoding, word reading fluency and text reading fluency—predicted reading comprehension in early primary school years (grade 1-3).

Even though word reading fluency and text reading fluency may be related, some studies found that their influence on reading comprehension differed. For instance, Cutting, Materek, Cole, Levine and Mahone (2009) showed that children with specific reading comprehension deficits matched control children on word reading fluency but performed more poorly than controls on text reading fluency. In another study it was shown that text reading fluency uniquely predicted reading comprehension whereas word reading fluency did not (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). The influence of text reading fluency on reading comprehension has also been shown by Klauda and Guthrie (2008). The authors showed that sentence and text reading fluency explained additional variance in reading comprehension when word reading fluency was controlled for, emphasizing the importance of contextual reading fluency in predicting reading comprehension (Klauda & Guthrie, 2008).

A few recent studies explored the influence of word and text reading fluency on reading comprehension in addition to the predictors proposed by the simple view of reading; decoding and language skills. One of these studies did not find any evidence for an additional role for word reading fluency and text reading fluency in reading comprehension above and beyond these predictors (Adlof, Catts, & Little, 2006), whereas two other studies did (Silverman, Speece, Harring, & Ritchey, 2012, Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009). Even though the latter two studies both claimed that reading fluency, as an additional component, should be added to the simple view of reading, their assessment of reading fluency differed quite strongly. For instance, the study by Silverman et al. (2012) measured reading fluency as connected text reading, where Tilstra et al. (2009) used a latent factor including word reading fluency, passage reading fluency, spelling and rapid naming.

None of the studies mentioned above investigated the influence of text reading prosody on reading comprehension, with exception of the study by Klauda and Guthrie (2008). Their study included a measure of expressiveness in reading. The authors found a significant contribution of expressive text reading to reading comprehension, in addition to a significant contribution of reading rate and accuracy (Klauda & Guthrie, 2008). Text reading prosody has been added more recently to the construct of text reading fluency and is considered to be a hallmark of proficiency in text reading fluency (Dowhower, 1991, Kuhn & Stahl, 2003, National Reading Panel, 2000; Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004). Kuhn, Schwanenflugel and Meisinger (2010) reviewed the theory and assessment of text reading fluency and proposed a new definition of the construct:

Fluency combines accuracy, automaticity, and oral reading prosody, which, taken together, facilitate the reader’s construction of meaning. It is demonstrated during oral reading through ease of word recognition, appropriate pacing, phrasing, and intonation. It is a factor in both oral and silent reading that can limit or support comprehension. (p. 240).

Text reading prosody makes reading aloud sound more similar to spoken language by appropriate phrasing, use of pauses, word and sentence boundaries and general expressiveness. The inclusion of text reading prosody as an aspect of reading fluency is therefore only possible when connected text is used for fluency assessment. Schwanenflugel et al. (2004) examined the relationship between decoding, prosodic aspects of text reading (pauses and fundamental frequency) and reading comprehension in second and third grade children. Their results showed that decoding was related to both prosodic aspects of text reading and to reading comprehension, but the authors found little evidence for a relationship between these prosodic aspects of text reading and reading comprehension.

Other studies, however, did find an association between text reading prosody and reading comprehension. A study by Miller and Schwanenflugel (2006) showed that in third grade children, specific pitch features in text reading (large declinations at the end of declarative sentences and larger pitch rises following questions) accounted for variance in reading comprehension beyond reading skill—a factor score consisting of decoding efficiency (word and pseudoword), rate and accuracy of oral text reading. The pitch changes (changes in fundamental frequency) were measured by spectrographic analysis.

Another study by Miller and Schwanenflugel (2008) found a similar effect in first and second grade children. By using spectrographic analysis they measured pausal intrusion duration (in milliseconds) as an indicator of the presence of inappropriate pauses within words or syntactical units (pause > 100 ms). Further, intonation contour was determined by isolating each word in the target sentence and measuring the $F_5$ at the vocalic nucleus. This prosodic profile was then correlated with a mean prosodic profile from an adult sample, and the resulting
correlation was used as the adult-like intonation contour. It was found that a lack of inappropriate pauses in first and second grade and an early adult-like intonation contour predicted reading comprehension in third grade, over and above word reading fluency. Rasinski, Rikli and Johnston (2009) found evidence for a relationship between text reading prosody (measured with a rating scale) and reading comprehension in third, fifth and seventh grade school children. At each grade level, text reading prosody was significantly correlated with reading comprehension.

Even though the role of text reading prosody in reading comprehension has received increased attention over the last decade, little is known yet about the exact function of text reading prosody. One of the proposed functions of prosody in speech is the attribution of syntactic roles to words within sentences (Chafe, 1988; Koriat, Greenberg, & Kreiner, 2002). Related to this, it has been proposed that speech prosody may assist in parsing processes, in segmenting a sentence into syntactically and semantically correct chunks (Kintsch, 1998; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). These aspects will also be important for an appropriate use of prosody in reading aloud. In addition, one could say that text reading prosody facilitates in solving the ‘binding’ problem of language. Readers have to combine many different cues when reading aloud (for example; morphemic, pragmatic, syntactic and semantic cues) and the prosodic representation of a sentence may provide the backbone on which the unification of a sentence depends (Frazier, Carlton & Clifton, 2006). It is proposed that these unification processes are required for reading comprehension (Snijders, Vosse, Kempen, van Berkum, Peterson, & Hagoort, 2009).

Intuitively, text reading prosody could also reflect the level of reading comprehension and therefore be an epiphenomenon of comprehension. Or, as Hudson, Lane and Pullen (2005) put it: “the amount of correct expression indicates to a trained ear how much the reader comprehended the text.” (p.705). There is little research, to our knowledge, supporting this reversed unidirectional view. However, there are some studies that found a bidirectional relationship between text reading prosody and reading comprehension. Ravid and Mashraki (2007) showed that in Hebrew-speaking children from fourth grade, text reading prosody, next to morphology, contributed to reading comprehension, whereas the reversed relation was also found. Other researchers such as Klauda and Guthrie (2008) found a bidirectional relation between text reading fluency and comprehension (see also: Stecker, Roser, & Martinez, 1998), although rate and accuracy were the most important components in this. It is proposed by Klauda and Guthrie (2008) that understanding the macrostructure of a text—for example a problem-solution structure—would enable the reader to use correct prosodic features, such as emphasis and pitch.

To conclude, the existing studies point towards a likely relationship between text reading prosody and reading comprehension, even though these finding are not entirely conclusive.

Rationale of the Present Study

Two observations can be made regarding existing research on the relation between reading fluency and reading comprehension. 1) Different conceptualizations of the construct of reading fluency (word reading, sentence reading, connected text reading or latent factors combining these skills) have been used. This makes interpretation and comparison of results difficult. 2) Studies that included text reading prosody in their definition of text reading fluency, and focused on its relationship with reading comprehension, are rare and often did not include other relevant predictors suggested by the simple view of reading, such as language comprehension. As such, it is at present unclear whether text reading fluency, including text reading prosody, still predicts reading comprehension if broader language comprehension skills are taken into account.

In the present study we have used text reading fluency in our assessments, in order to clearly distinguish between connected text reading fluency and word reading fluency, and to be able to include the component of text reading prosody, as specified by recent definitions of text reading fluency (Kuhn et al., 2010, National Reading Panel, 2000). When we use the term “text reading fluency”, we thus refer to reading a connected text aloud. Text reading prosody was assessed by means of the Multidimensional Fluency Scale (Rasinski, 2004), which has been used successfully in other studies (e.g., Holliman, Wood, & Sheehy, 2010; Rasinski, Rikli, & Johnston, 2009). Furthermore, we have investigated the contribution of text reading fluency to reading comprehension, in addition to the predictors suggested by the simple view of reading: decoding and language comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). Because word reading accuracy quickly reaches ceiling in a transparent orthography such as Dutch (Landerl & Wimmer, 2008), a pseudoword decoding test was used to measure decoding efficiency. In their discussion of the simple view of reading, Gough, Hoover and Peterson (1996) described how success in reading depends on finding the appropriate meaning for each word from the mental lexicon and on determining the syntactic function of each word in relation to other words. We therefore assessed language comprehension by means of a vocabulary test and a syntactic awareness test.

The performance on decoding efficiency and language comprehension as well as on text reading fluency (reading rate and text reading prosody) and reading comprehension were assessed in a sample of 106 Dutch primary school children from fourth grade, where basic reading skills should be stably developed. The present study addressed the following research question regarding the relationship between
text reading fluency and reading comprehension: Do the different components of text reading fluency (reading rate and text reading prosody) explain additional variance in reading comprehension scores when decoding efficiency and language comprehension are accounted for?

Method

Participants

Participants were recruited from four primary schools, located in the East of the Netherlands. The schools were comparable in terms of the total number of pupils, the number of pupils in each class and locality (all schools were based in the Eastern part of the Netherlands). One-hundred-and-six children from fourth grade; 61 girls and 45 boys, mean age 9 years, 9 months, SD = 7.6 months participated in this study. The primary language of all participating children was Dutch and they predominantly came from middle-class families. All parents gave their written consent for participation of their child in the study. Two children, who were diagnosed with dyslexia and whose results on the decoding task were more than 2 SD’s below the mean, were excluded from the study.

Materials

Decoding efficiency. Due to the characteristics of the Dutch language it was decided to use the number of correctly read pseudowords per minute (efficiency) rather than accuracy of decoding, which is also sometimes used as measure of decoding. Seymour, Aro and Erskine (2003) showed that pseudoword reading was more accurate in languages with shallow orthographies, such as Dutch, compared to deep orthographies such as English (e.g., monosyllabic pseudoword reading in children from first grade: 90% versus 41% correct). We used a standardized pseudoword reading test to assess decoding efficiency (Verhoeven, in press). Pseudowords are non-existing, but legal words (in terms of phonotactics) which can be compared to new words that the child has never encountered before. Four lists with pseudowords were presented to the child. The wordlists consisted of four categories of pseudowords; consonant-vowel-consonant (CVC) words (e.g., laas), double consonant (CC) words (e.g., stoef), two-syllable words (e.g., gluifel) and multi-syllable words (e.g., waagdoller). The pseudowords were presented in five (CVC and CC words) or four columns (two- and multi-syllable words) with 30 pseudowords in each column. For each list, children had exactly one minute to read aloud the pseudowords as quickly and accurately as possible. The variable decoding efficiency represents the average number of correctly read pseudowords in one minute over all four lists. Cronbach’s alpha reliability coefficient has been reported to be greater than .85 for this task (Verhoeven, in press).

Vocabulary. Children performed a standardized vocabulary test in writing. They were asked for the definitions of 50 words that were presented to the child in a written sentence (Verhoeven & Vermeer, 1993). The child had to select the correct answer by choosing one of four definitions, presented in a multiple choice format. An example of an item is: The children are enthusiastic, A) concentrating, B) funny, C) absent-minded, D) eager; of which answer D is the correct one. A maximum score of 40 was possible for the variable called vocabulary. Cronbach’s alpha reliability coefficient was .82.

Syntactic awareness. Syntactic awareness was also assessed by means of a standardized written test (Verhoeven & Vermeer, 1993). A total of 40 items were presented. In each item, four sentences were presented to the child in a multiple choice format. In one of these sentences a syntactic mistake could be identified, this included incorrect conjugations of verbs, or mistakes in word order. The child was asked to indicate which of the four sentences was incorrect by marking the sentence. Cronbach’s alpha reliability coefficient was α = .79.

Text reading fluency. Four short stories (approximately 100 words each) appropriate for fourth grade, were selected. Two of these stories were narratives and two were expository texts. The texts were adapted to ensure that each type of text (narrative and expository) had two levels of difficulty; one easy and one more difficult. These levels have been determined based on a selection of characteristics that have been shown to be important for text difficulty, such as number of sentences, average word and sentence length and frequency of words (Visser, 1997). Word frequency was based on a selection of wordlists naming the most frequent words for Dutch schoolchildren (Vermeer, 2000). Two scores were recorded during the text reading performance for each child; reading time (in seconds) and reading accuracy (number of errors made). These two scores were used to compute the correctly read words per minute over all four texts. This is the variable called text reading rate.

The text reading performance was recorded on an Olympus VN-5500PC digital recorder and was scored at a later time using the Multidimensional Fluency Scale (Rasinski, 2004). This scale consists of the following four sections; performance on each section was marked on a scale from 1 - 4. Expression and volume (1 = little sense of making text sound like natural language and 4 = varies expression and volume to match interpretation of the passage), phrasing (1 = shows little awareness of word boundaries and of the syntactic structure of the text and 4 = generally reads with good phrasing), smoothness (1 = makes frequent pauses and hesitations and 4 = generally reads smoothly) and pace (1 = reads slowly and laboriously and 4 = consistently reads at conversational pace). The total score on the variable text reading prosody could thus range from 4 - 16. Ten percent of the reading samples were double-scored by a fourth grade teacher who neither knew...
any of the children participating, nor received any additional information about them. An intraclass correlation coefficient (ICC) has been performed, using absolute agreement and single measures. The ICC on the average score for all four stories (as used for analysis) was high: ICC = .887, *F*(9) = 21.78, *p* < .001.

### Reading comprehension

The children were presented with two standardized reading comprehension tests (Verhoeven & Vermeer, 1993). In the first test, two short stories were presented in writing (one story about the making of bread and one about big felines). Children were instructed to choose the correct connective word or conjunction, such as ‘and’, ‘although’, ‘that’, ‘however’, for gaps within the text (cloze format). An example taken from the story about big felines is: “When a house cat is being teased, he often licks his shoulder excessively. A young lion can respond just like that… a stronger lion steals his prey!” A) when, B) therefore, C) until; of which option A is the correct answer. A total of 40 responses were required from each child. In the second comprehension test, children were asked to choose the correct content words (nouns, verbs and adjectives) for gaps in two written stories (one story about wild animals and one about the making of paper). An example from the story about making paper is: “They say that the Chinese invented paper. The Chinese kept their… hidden for a long time. Only after the Arabs imprisoned the Chinese craftsmen, they too learned how to make paper.” The answer options were: A) paper, B) reed, C) secret; of which answer C is the correct choice. This example shows that the missing content word had to be inferred by paying attention to the coherence of the paragraph. The score for the variable reading comprehension represents the average number of correct responses on these two comprehension tests (maximum score was 40). Cronbach’s alpha reliability coefficient for the reading comprehension tasks, as a whole, was .84.

### Procedure

All assessments were carried out during school hours. Apart from the syntactic awareness test, the vocabulary test and the two reading comprehension tests which were administered group-wise by the teacher, the testing was performed on an individual basis. The tests administered in class took approximately 15 minutes per test. Written instructions were provided on the tests so no further instruction by the teacher was necessary. Individual testing was carried out by the first author in a separate room provided by the schools. Text reading fluency and decoding efficiency were assessed in two separate sessions, together with three other tests not reported in this paper. The order of the tasks within each session was the same for each child. Each of the two sessions lasted approximately 40 minutes. The order of the four tests for the text reading fluency assessment and the four word lists for the decoding efficiency task was counterbalanced.

### Data Analysis

In order to assess the contribution of text reading fluency to reading comprehension, a multiple regression analysis was performed, adding text reading rate and text reading prosody to the model, after controlling for decoding efficiency and language comprehension (vocabulary and syntactic awareness). Before performing the regression analyses, the data were inspected to ensure that they met the required assumptions. Casewise diagnostics revealed that the standardized residuals of three cases were outside the accepted limit of two standard deviations and had undue influence on the regression parameters (Field, 2009). These particular cases have been excluded from further analysis. The results described below are from the remaining 101 participants.

### Results

### Descriptives

Table 1 shows means and standard deviations for decoding efficiency, language comprehension (vocabulary and syntactic awareness), text reading fluency (accuracy, rate and text reading prosody) and reading comprehension. The mean accuracy for text reading was high (average mean of 97%, SD = 2.26) indicating a ceiling effect. Therefore this variable was not included in any further analyses. According to national norms, children scored above average on the vocabulary task and the reading comprehension task, whereas on the syntactic awareness test they scored just below average. Relatively high mean scores were obtained for text reading prosody (13.76 from a maximum score of 16), and the variability in text reading prosody was quite low (SD = 1.47).

### Correlations

Table 2 shows bivariate correlations between all reading variables. As can be seen, there was a very weak and not significant correlation between decoding efficiency and reading comprehension (*r* = .08, *p* = .440). There were moderate correlations between reading comprehension and the two variables that represented language comprehension, syntactic awareness (*r* = .48, *p* = .001) and vocabulary (*r* = .61, *p* = .001). Lastly, the correlations between reading comprehension and the two components of text reading fluency differed; text reading rate was weakly and not significantly correlated (*r* = .14, *p* = .173) but text reading prosody was moderately correlated to reading comprehension outcomes (*r* = .29, *p* = .004).
Chapter 2 Reading fluency and reading comprehension

Contributors to Reading Comprehension Scores

A hierarchical regression analysis was performed to identify the unique variance in reading comprehension scores that text reading fluency explained. The components of the simple view of reading; decoding efficiency, vocabulary and syntactic awareness, were entered at step one. Text reading fluency; reading rate and text reading prosody, were added at step two.

Decoding efficiency, vocabulary and syntactic awareness explained 43% of the variance in reading comprehension scores, $R^2 = .429$, $F(3,97) = 24.32$. Of these, only vocabulary and syntactic awareness made significant contributions to reading comprehension. After decoding efficiency, vocabulary and syntactic awareness were accounted for, text reading prosody explained an additional 3% of variance in reading comprehension, $R^2 = .458$, $F(5,95) = 16.03$. Text reading rate did not add anything to the prediction of reading comprehension.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Means and Standard Deviations for Variables of Simple View of Reading, Text Reading Fluency and Reading Comprehension (N=101)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple View of Reading</td>
<td>M</td>
</tr>
<tr>
<td>Decoding efficiency $^a$</td>
<td>43.59</td>
</tr>
<tr>
<td>Vocabulary (max. 50) $^b$</td>
<td>34.29</td>
</tr>
<tr>
<td>Syntactic Awareness (max. 40) $^b$</td>
<td>21.84</td>
</tr>
<tr>
<td>Text Reading Fluency</td>
<td>M</td>
</tr>
<tr>
<td>Text Reading Accuracy $^c$</td>
<td>97.09</td>
</tr>
<tr>
<td>Text Reading Rate $^a$</td>
<td>146.33</td>
</tr>
<tr>
<td>Text Reading Prosody (max. 16) $^d$</td>
<td>13.76</td>
</tr>
<tr>
<td>Reading Comprehension (max. 40) $^b$</td>
<td>30.23</td>
</tr>
</tbody>
</table>

Note. $^a$ = correctly read words per minute, $b =$ average number of correct responses, $c = $ percentage of correctly read words, $d =$ score based on Multidimensional Fluency Scale (Rasinski, 2004).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Correlations between Variables Simple View of Reading, Text Reading Fluency and Reading Comprehension (N=101)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dec. eff.</td>
<td>.10</td>
</tr>
<tr>
<td>2. Voc.</td>
<td>-</td>
</tr>
<tr>
<td>3. Synt.</td>
<td>.17</td>
</tr>
<tr>
<td>4. Text rate</td>
<td>.67***</td>
</tr>
<tr>
<td>5. Text pros.</td>
<td>.60***</td>
</tr>
<tr>
<td>6. RC</td>
<td>.08</td>
</tr>
</tbody>
</table>

Note. Dec. eff. = decoding efficiency, Voc. = vocabulary, Synt. = syntactic awareness, Text rate= text reading rate (correctly read words per minute), Text pros. = text reading prosody, RC = reading comprehension, $^* p < .05$, $^** p < .01$, $^*** p < .001$.

Table 3 Regression Results for Variables Contributing to Reading Comprehension Scores (N=101)

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Reading comprehension</th>
<th>$R^2$</th>
<th>$B$</th>
<th>SE $B$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoding efficiency</td>
<td>-0.005</td>
<td>.023</td>
<td>-.016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>0.319</td>
<td>.054</td>
<td>.494***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syntactic awareness</td>
<td>0.202</td>
<td>.062</td>
<td>.276**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2</th>
<th>Reading comprehension</th>
<th>$R^2$</th>
<th>$B$</th>
<th>SE $B$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoding efficiency</td>
<td>-0.046</td>
<td>.036</td>
<td>-.154</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>0.309</td>
<td>.055</td>
<td>.478***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syntactic awareness</td>
<td>0.177</td>
<td>.062</td>
<td>.242**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text reading rate</td>
<td>0.004</td>
<td>.019</td>
<td>.022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text reading prosody</td>
<td>0.610</td>
<td>.274</td>
<td>.217*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $^* p < .05$, $^** p < .01$, $^*** p < .001$.

Discussion

The question addressed in this paper was whether text reading fluency explained additional variance in reading comprehension scores when decoding efficiency and language comprehension were accounted for. We analysed the reading performance of 101 fourth grade Dutch primary school children by means of a regression analysis. The results showed that the two components of text reading fluency (text reading rate and text reading prosody) were differently associated with reading comprehension scores in this sample of children. Text reading prosody explained additional variance in reading comprehension scores, after decoding efficiency and language comprehension were accounted for, but text reading rate did not.

Regarding the two observations in the rationale section of the introduction, inclusion of text reading prosody means making use of connected text reading in reading fluency assessment, as the use of prosody cannot easily be measured.
using word lists. Regarding the association with reading comprehension, it could be concluded that the addition of text reading prosody to the construct of text reading fluency, results in text reading prosody being the key factor, even after controlling for decoding efficiency and language comprehension. This could have theoretical implications, for instance for the suggested addition of text reading fluency to the simple view of reading. Both Tilstra et al. (2009) and Silverman et al. (2012) found that text reading fluency (rate and accuracy) explained additional variance after decoding and listening/ language comprehension were accounted for. Tilstra et al. (2009) investigated the components of the simple view of reading across grade levels, and found that skills beyond decoding exerted more influence as children progressed through school. This partly concurs with the result from the current study, text reading fluency explained additional variance in reading comprehension, whereas decoding efficiency was no longer a significant factor in this age group. A large difference is, of course, which component of text reading fluency is the significant factor. When comparing the results from the current study with the two studies described above, the current study showed that text reading prosody contributed to reading comprehension scores. However, Tilstra et al. (2009) and Silverman et al. (2012) showed that text reading rate and accuracy contributed to this as these studies did not take text reading prosody into account.

There is some other evidence that text reading prosody predicts reading comprehension beyond the effects of decoding and text reading rate, but in those studies reading rate or decoding still partly explained variance in reading comprehension scores (Klauda & Guthrie, 2008; Miller & Schwanenflugel, 2006). We did not find this in the current sample of Dutch schoolchildren. The influence of text reading rate and/or text reading prosody on reading comprehension might differ as a result of the orthographic transparency of the language. The orthographic-phonological consistency is relatively high in Dutch and reading accuracy generally reaches ceiling quickly in children learning to read in Dutch (in the current sample, an average of 97% of words in four texts were read correctly). Therefore, in a language such as Dutch, the differential contribution of text reading rate and text reading prosody can be examined more directly, without interference from the inconsistencies of the writing system.

A related explanation is that the relationship between text reading prosody and reading comprehension becomes more prominent once decoding is well established and efficiency in reading is acquired. This is in line with the results of Miller and Schwanenflugel (2006). They found strong support for the emergence of adult-like text reading prosody, once automatic word- and text reading skills were mastered. This would suggest that, as a predictor to reading comprehension, text reading rate would be a more important aspect of text reading fluency in younger, beginning readers while text reading prosody could be a more important aspect in older, more advanced readers. For children learning to read in English, a mastery level in reading efficiency might occur at a later age than for children learning to read a more transparent orthography (Seymour, Aro, & Erskine, 2003).

To conclude, it has been shown that text reading prosody explained additional variance in reading comprehension scores of fourth grade children. The role of prosody in text reading fluency could therefore be more important than previously thought. Holliman et al. (2010) argued that prosodic sensitivity should be included in current models of children’s reading development. The results of the current study concur and suggest that text reading prosody is an important component
of text reading fluency. Therefore, we propose including text reading prosody when considering the addition of text reading fluency to theoretical frameworks, such as the simple view of reading.

References


Chapter 2 Reading fluency and reading comprehension


The Role of Speech Prosody and Text Reading Prosody in Children’s Reading Comprehension

Based on:
Abstract

Text reading prosody has been associated with reading comprehension. However, text reading prosody is a reading-dependent measure that relies heavily on decoding. Therefore, the investigation of the contribution of speech prosody—indeed from reading skills—to reading comprehension, in addition to text reading prosody, could provide more insight into the general role of prosody skills in reading comprehension. The current study investigated how much variance in reading comprehension scores was explained by speech prosody and by text reading prosody, after controlling for decoding, vocabulary and syntactic awareness. A battery of reading and language assessments was performed by 106 Dutch fourth grade primary schoolchildren. Speech prosody was assessed using a storytelling task and text reading prosody by letting children read a text aloud. We assessed enthusiasm, phrasing, smoothness and pace of their performances by means of a rating scale. Decoding, vocabulary, syntactic awareness and reading comprehension were assessed using standardized tests. Hierarchical regression analyses showed that text reading prosody explained 6% of the variance and that speech prosody explained 8% of the variance in reading comprehension scores, after controlling for decoding, vocabulary and syntactic awareness. Phrasing was the significant prosodic factor in both speech and text reading. When added in consecutive order, phrasing in speech added 5% variance to phrasing in text reading. In contrast, phrasing in text reading added only 3% variance to phrasing in speech. The variance that speech prosody explained in reading comprehension scores should not be neglected. It is proposed that speech prosody can facilitate the construction of meaning in written language.

The Role of Speech Prosody and Text Reading Prosody in Children’s Reading Comprehension

Prosody is the melodic intonation pattern of spoken language that modifies the meaning of utterances. Conveying meaning by the use of prosody is not only important in speech. When reading text aloud, a correct use of text reading prosody by the reader makes text sound more natural and more comprehensible to the listener (e.g., Kuhn & Stahl, 2003, Rasinski, 2004). Text reading prosody is the most recent addition to the components of text reading fluency, together with reading speed and reading accuracy (e.g., Dowhower, 1991; Kuhn & Stahl, 2003). There is a growing literature on the relationship between text reading fluency and reading comprehension that emphasizes the role of text reading prosody (e.g. Klauda & Guthrie, 2008; Miller & Schwanenflugel, 2006, 2008; Rasinski, Rikli, & Johnston, 2009). However, both text reading prosody and reading comprehension strongly rely on the ability to read well. After all, one of the proposed essential skills for text reading prosody is efficient and automatized decoding (Miller & Schwanenflugel, 2006, Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004). Once decoding efficiency is mastered, more adult-like text reading prosody starts to emerge (Miller & Schwanenflugel, 2006). In the literature, it is often assumed that an appropriate use of text reading prosody transfers from spontaneous speech to oral reading (Dowhower, 1991, Schwanenflugel, Westmoreland, & Benjamin, 2013). Although this reasoning seems logical, speech prosody is usually not measured in text reading fluency or reading comprehension assessment. We therefore do not know what the exact relations are between speech prosody, text reading fluency and reading comprehension. To shed more light on this, the current study focused on the unique contribution of both text reading prosody and speech prosody to children’s reading comprehension. By doing so, we take advantage of the fact that speech prosody can be measured independently from reading ability.

Speech prosody may have multiple communicative functions. In general, a distinction can be made between paralinguistic and linguistic functions (Laver, 1994). A paralinguistic use of prosody in speech is the addition of circumstantial information, such as an indication of humour or irony by the rise-and-fall patterns of the speaker’s voice. Linguistic use of speech prosody affects the meaning of spoken information, such as the emphasis put on important words according to the speaker. An example of this would be someone saying “I wanted TEA, not coffee” after having been served a cup of coffee. Another linguistic prosodic feature is the use of pitch. When asking a question, our voice generally rises in pitch at the end of a sentence, whereas for statements the pitch usually lowers (Peppé et al., 2010). A third example of linguistic prosody in speech is the indication of word boundaries, for example, the difference between “chocolate,
cake and biscuits” and “chocolate-cake and biscuits” (Peppé & McCann, 2003). Correct use of word boundaries is closely related to syntactic phrasing, or ‘chunking’ skills (Peppé & McCann, 2003; Schreiber, 1991).

In language development, speech production skills develop well before reading skills, so it seems feasible that text reading prosody is built upon the pillars of prosodic speech abilities. Developmentally, speech prosody is one of the first experiences a child encounters in language. Babies between 3 and 10 months of age show sensitivity to prosodic features; in response to speech as well as in production of babbling (Crystal, 1986; Nelson, Hirsh-Pasek, Jusczyk, & Cassidy, 1989; Levitt, 1993). Dowhower (1991) remarked that prosodic patterns in speech facilitate speech processing and language comprehension in young infants. By the time children reach kindergarten age, they have usually mastered spoken language to a large extent, including a correct use of phonology and syntax (Gough, Hoover, & Peterson, 1996). Nevertheless, it has been shown that the use and understanding of speech prosody continues to develop during primary school years (e.g., Myers & Myers, 1983). There is some evidence that in the early years of primary school, a correct use of speech prosody by children precedes understanding of speech prosody in other speakers (Cutler & Swinney, 1987; Wells, Peppé, & Goulandris, 2004). It has been suggested that mastery of speech prosody, as a source for understanding intention and emotion in speech, emerges around the age of 9 (Friend, 2000; 2003; Friend & Bryant, 2000). Furthermore, the development of receptive and productive speech prosody in children from 5 to 13 years-of-age correlated significantly with the development of other language skills, such as grammatical comprehension and production (Wells, Peppé, & Goulandris, 2004).

Text reading prosody—the intonation, phrasing, stress patterns and pauses that children use when reading text aloud—has received increased interest over the last two decades, especially in relation to reading comprehension (e.g. Benjamin & Schwaneflugel, 2010; Klauda & Guthrie, 2008; Miller & Schwaneflugel, 2006, 2008; Rasinski et al., 2009; Veenendaal, Groen, & Verhoeven, 2015). Although text reading prosody has been assessed in different ways, a relation between text reading prosody and reading comprehension is usually found, even after controlling for general (word) reading. Text reading prosody has been analysed with spectrographic analyses and with rating scales, in which raters make an aural judgement of the text reading prosody performance. Studies using spectrographic analyses usually distinguish between different prosodic aspects, such as pitch, pauses or intonation contour. For instance, it was shown that an adult-like intonation contour in text reading was positively associated with reading comprehension (Schwanenflugel et al, 2004). Another study found that third grade children who used larger pitch changes and larger end-sentence declinations in reading, performed better on reading comprehension than children who used these prosodic features to a lesser extent (Miller & Schwaneflugel, 2006).

A number of studies have used rating scales to assess text reading prosody. A large study in fourth grade children for The National Assessment of Educational Progress (NAEP; Pinnell et al., 1995) used an oral reading scale with four levels, mostly related to phrasing aspects of text reading prosody. Pinnell et al. (1995) found a relation between text reading fluency (including prosodic phrasing) and reading comprehension. The NAEP scale of reading fluency has been used by other researchers and a relation between phrasing and reading comprehension was consistently found (e.g., Daane et al., 2005; Mokhtari & Thompson, 2006, Valencia et al., 2010). Klauda and Guthrie (2008) developed a 4-point oral reading scale with five subsections. It was found that expressive passage reading and phrasing contributed to reading comprehension (Klauda & Guthrie, 2008). A similar wide-ranging scale; the Multidimensional Fluency Scale (Rasinski, 2004), assesses four aspects of text reading prosody: expression, phrasing, smoothness and pace. Rasinski et al. (2009) found that text reading prosody and reading comprehension were significantly correlated in primary school children in third and fifth grade, and even beyond primary school in seventh grade. However, text reading prosody and reading comprehension both rely on the ability to read well. One way to disentangle the interrelationship between text reading fluency, reading comprehension and text reading prosody is to examine the role of speech prosody in reading comprehension.

To determine whether speech prosody plays a role in reading comprehension we first need to establish whether there are any genuine differences between reading a text aloud and spontaneous speech. Several studies examined this topic (e.g., Blaauw, 1994; Howell & Kadi-Hanifi, 1991; Laan, 1997). In these studies, differences were identified between spontaneous speech samples and transcribed versions of these speech samples read aloud. Consistent findings were that spontaneous speech differed from read speech in a higher occurrence of pauses (Blaauw, 1994; Howell & Kadi-Hanifi, 1991; Laan, 1997) and in simpler syntactic structures and more grammatical errors (Blaauw, 1994; Laan, 1997). Furthermore, it seems that pitch variation was greater in spoken speech compared to read speech (Batliner et al. 1994; Esser & Polomski, 1988). The above-mentioned studies provide some indication that speech prosody and text reading prosody differ substantially and that their role in reading comprehension might differ accordingly.

Even though the role of text reading prosody in reading comprehension has received increased attention over the last few decades, the theoretical mechanism linking text reading prosody to comprehension is not entirely clear. One of the proposed mechanisms is the facilitation of syntactic parsing or chunking (Frazier, Carlton & Clifton, 2006; Kintsch, 1998; Snedeker & Trueswell, 2003, Snedeker & Yuan, 2008). In spoken language, a lengthening of the final syllable, a change in
Rationale of the Present Study

Research has consistently shown that text reading prosody and reading comprehension are related (e.g., Benjamin & Schwanenflugel, 2010; Miller & Schwanenflugel, 2006, 2008; Rasinski et al., 2009; Veenendaal et al., 2015). However, text reading prosody and reading comprehension both rely on the ability to read well. By comparing the role of speech prosody to that of text reading prosody we separated prosodic abilities from general reading or decoding abilities. Although it is generally assumed that speech prosody skills transfer to text reading prosody (Dowhower, 1991; Schwanenflugel, Westmoreland, & Benjamin, 2013) spontaneous speech and oral text reading have been shown to differ in certain characteristics (e.g., Blauw, 1994; Howell & Kadi-Hanifi, 1991; Laan, 1997). Therefore, we do not know whether the role of speech prosody in reading comprehension would be similar to the role of text reading prosody.

To be able to determine the specific contribution of prosody skills to reading comprehension, we measured both speech prosody and text reading prosody. Speech prosody was assessed during a storytelling task by using a series of pictures that prompted children to tell two short stories. Text reading prosody was assessed during oral reading of four different texts, in order to obtain a representative sample. We used the Multidimensional Fluency Scale (Rasinski et al., 2009; Yildirim, Rasinski, Até, Zimmerman, & Yildiz, 2013; Yildiz, Yildirim, Ateq, & Çetinkaya, 2009). In order to distinguish which specific aspects of speech and text reading prosody were most important for reading comprehension we examined the four sections of the Multidimensional Fluency Scale (expression, phrasing, smoothness and pace) separately.

Furthermore, we controlled for some well-known predictors of reading comprehension. The first of these is decoding, or the fast and accurate retrieval of the phonological code for written words. Decoding is claimed to play a pivotal role in children’s reading comprehension (Perfetti, 1985; Verhoeven & van Leeuwe, 2008). Because the Dutch orthography is relatively transparent and word reading accuracy quickly reaches ceiling in Dutch children, we used the rate of pseudoword reading (efficiency) for assessment of decoding. Evidence for this comes from Seymour, Aro and Erskine (2003), who showed that pseudoword reading was far more accurate in languages with shallow orthographies, such as Dutch, compared to deep orthographies, such as English (e.g., monosyllabic pseudoword reading in children from first grade, 90% versus 41% correct). Two other important predictors of reading comprehension according to the literature are the size of children’s vocabulary (De Jong & van der Leij, 2002; Muter, Hulme, Snowling, & Stevenson, 2004) and syntactic awareness (Bowey, 1986; Cain, 2007; Mokhtari & Thomson, 2006; Tunmer, Nesdale, & Wright, 1987). Therefore, these were also assessed in the current study.

This study addressed the following research question: What percentage of unique variance do speech prosody and text reading prosody explain in reading comprehension scores, when decoding, vocabulary and syntactic awareness are accounted for?

Method

Participants

Participants in this study were 106 fourth grade primary school children (60 girls and 46 boys, mean age = 9 years and 9 months, SD = 7.6 months), recruited from four primary schools located in the East of The Netherlands. The primary language of all participating children was Dutch. Two children, who were diagnosed with dyslexia and whose results on the decoding task were more than 2 SD’s below the mean, were excluded from the study.

Parents were informed about the study and gave their consent for their child’s participation. The children were part of a larger study investigating the relationship between text reading fluency and reading comprehension.

Materials

Decoding efficiency. A standardized pseudoword test was used to assess decoding efficiency (Verhoeven, in press). Four lists with pseudowords were presented to the children. The wordlists consisted of four categories of pseudowords: consonant-vowel-consonant (CVC) words, double consonant (CC) words, two-syllable and multi-syllable words. Children had one minute to read the pseudowords as quickly and accurately as they could. The number of correctly read pseudowords per minute has been recorded for each list. As the four separate lists of the decoding task were strongly correlated (r > .83) and Principle
Component Analysis resulted in one factor (eigenvalue 3.598, explaining 90% of variance) we used the averaged z-score (over all four lists) for analysis. Cronbach’s alpha reliability coefficient has been reported to be greater than .85 for this task (Verhoeven, in press).

Vocabulary. A standardized receptive vocabulary test was used (Verhoeven & Vermeer, 1993). Children were asked to choose the correct definition of a word, which was presented in a written sentence. The test used a multiple choice format and fifty items were presented in total. Cronbach’s alpha reliability coefficient was .82 for this test.

Syntactic awareness. A standardized syntactic awareness test was used (Verhoeven & Vermeer, 1993). Children were shown 40 items in written format. For each item, four sentences were presented to the child. Children were instructed to select the sentence that contained a syntactic mistake (such as word order, verb conjugation, grammatical rules). The reliability coefficient was $\alpha = .79$ for this task.

Text reading prosody. Four short, grade-level stories (approximately 100 words each) were selected; two stories were narratives and two were expository texts. These four texts were adapted to control the level of difficulty. This was based on the number of syllables in words, the number of words in sentences and the level of familiarity of words to primary school children (Vermeer, 2000; Visser, 1997). Because children in the Netherlands are generally taught to pay attention to clarity and intonation while reading in class (Aarnoutse, Verhoeven, van het Zandt, & Biemond, 2003), children were instructed to read each text aloud the way they would normally do in class. The text reading performance was recorded on an Olympus VN-5500PC digital recorder in order to score text reading prosody at a later time. This was done using the Multidimensional Fluency Scale (Rasinski, 2004). This scale consists of the following four sections: A) Expression and volume (ranging from: [1] little sense of making text sound like natural language to [4] varies expression and volume to match interpretation of the passage), B) Phrasing (ranging from [1] shows little awareness of word boundaries and phrase boundaries to [4] generally reads with good phrasing), C) Smoothness (ranging from [1] makes frequent extended pauses, false starts, sound outs and hesitations to [4] generally reads smoothly, resolves word and sentence structures quickly) and D) Pace (ranging from [1] reads slowly and laboriously to [4] consistently reads at conversational pace). Performance on each section was marked on a scale from 1 – 4. Scores per text thus ranged from 4 to 16. Text reading prosody on all four texts correlated highly ($r > .77$) therefore the averaged z-score (over the four texts) was used for analysis.

The ratings of the text reading prosody performance were performed by the first author. Fifteen percent of the sample was scored by an independent rater. Rater agreement percentages and intraclass correlation coefficients were examined.

Median agreement for exact scores was 65% and intraclass correlation coefficients (ICC) were sufficient: A) Expression and volume: ICC = .669, $F(59,118) = 8.94$, $p < .001$, B) Phrasing: ICC = .786, $F(59,118) = 11.89$, $p < .001$, C) Smoothness: ICC = .685, $F(59,118) = 7.76$, $p < .001$, and D) Pace: ICC = .614, $F(59,118) = 7.113$, $p < .001$.

Speech prosody. To assess speech prosody the child was shown two story cards, each containing a sequence of eight pictures (Verhoeven & Vermeer, 2001). Children were firstly asked to familiarize themselves with the pictures after which they were asked to tell the story that the picture sequence depicted. The child was instructed to make the story sound interesting for a younger child who would not see the pictures. The stories were recorded on an Olympus VN-5500PC digital recorder and speech prosody was scored at a later time. The Multidimensional Fluency Scale by Rasinski (2004), which was designed to assess reading performance, was adapted to make it more suitable for assessing the use of speech prosody. The adapted scale contained the same four sections as the original Multidimensional Fluency Scale. In the adapted version these sections referred to: A) Expression and volume (ranging from: [1] speaks quietly, little use of expression in creating storyline, to [4] adequate expression and enthusiasm, adapts expression and volume to storyline), B) Phrasing (ranging from: [1] monotone storytelling, little indication of word and sentence boundaries, uses single utterances, to [4] mostly syntactically correct sentences, adequate indication of sentence, phrase and passage boundaries), C) Smoothness (ranging from: [1] frequent extended pauses, hesitations, false starts and/or multiple attempts, to [4] generally smooth speech, word- and structure difficulties resolved quickly) and D) Pace (ranging from: [1] slow and laborious storytelling, to [4] consistently conversational pace). Performance on each section was marked with 1-4 points, so total scores per story ranged from 4 to 16. As speech prosody is about how something is said and not so much about what is said, speech performance was rated only on expressiveness, phrasing, smoothness and pace, and not on the content of the story.

The speech prosody ratings were again performed by the first author and an independent rater scored fifteen percent of the sample. The median agreement for exact scores was 42%. Furthermore, intraclass correlation coefficients (ICC) were performed, using absolute agreement and single measures. The ICC results were moderate, although on section D the ICC was low: A) Expression and volume: ICC = .535, $F(29,58) = 5.16$, $p < .001$, B) Phrasing: ICC = .539, $F(29,58) = 4.42$, $p < .001$, C) Smoothness: ICC = .495, $F(29,58) = 3.90$, $p < .001$, and D) Pace = .201, $F(29,58) = 1.84$, $p = .025$.

Reading comprehension. The children were presented with two standardized reading comprehension tests (Verhoeven & Vermeer, 1993). In the first test, children read two short stories; one story about the making of bread and one
about large felines. Children were instructed to indicate the correct connective or reference word from four possible options (words such as ‘and’, ‘although’, ‘that’, ‘however’) for gaps within the text (cloze format). In the second comprehension test the same cloze format was used, only this time children were asked to select the correct content word (nouns, verbs or adjectives). Again, two written stories were presented; one story was about wild animals and one about the making of paper. The missing content words referred to the context of the preceding or following paragraphs within the texts. As the two reading comprehension tasks correlated ($r = .58, p < .001$) and Principle Component Analysis resulted in one factor (eigenvalue 1.578, explaining 79% of variance), the averaged z-score (over the two tests) was used for analysis. Cronbach’s alpha reliability coefficient for the reading comprehension task was .84.

Procedure
All assessments were carried out during school hours. Data collection took place in spring 2011. The tests to assess syntactic awareness, vocabulary and reading comprehension were administered group-wise by the teacher. Children performed these tests silently and no time limits were set. The other assessments were performed on an individual basis and were administrated in two separate sessions (A and B) by the first author. Individual testing was carried out in a separate room, provided by the schools. The text reading prosody data were collected together with three other tests (not discussed in this paper) in session A and the decoding and storytelling data (speech prosody) were collected in session B (together with two other tests not discussed). The order of the four tests used to assess text reading prosody, the four decoding lists and the two storytelling cards was counter-balanced.

Data Analysis
All data were converted into z-scores. For the speech and text reading prosody measures the four subsections of the scale were used for analyses (section A to D). Two text reading prosody measures (A: expression and B: phrasing) and one speech prosody measure (C: smoothness) were negatively skewed. As reverse and square root or log transformations did not solve this, a non-parametric correlation (Spearman) has been used. Further, a principle component analysis (PCA) was run to determine whether speech prosody and text prosody constituted different factors. Two factors with an eigenvalue above 1 were extracted (3.638 for text reading prosody, explaining 45% of variance and 1.522 for speech prosody, explaining 19% of variance).

In order to assess the unique contributions of text reading prosody and speech prosody to reading comprehension scores a three-step hierarchical regression analysis was performed. Before performing the regression analysis, the data were inspected to ensure that they met the required assumptions. Casewise diagnostics revealed that the standardized residuals of three cases were outside the accepted limit of two standard deviations according to Field (2009) and had undue influence on the regression parameters. After exclusion of these cases, the standardized residuals were normally distributed. The results described below are from the remaining 101 participants.

Results

Descriptives
Table 1 below shows means and standard deviations for all variables. According to national norms, children scored above average on the vocabulary task and the reading comprehension task, whereas on the syntactic awareness test they scored just below average (Verhoeven & Vermeer, 1993). Relatively high mean scores were obtained for text reading prosody (an average of 3.44 from a maximum score of 4) and the variability in text reading prosody was quite low (SD = .048). There was more variability in speech prosody (SD = .70) and the mean score was slightly lower (an average of 2.91 from a maximum score of 4).

Correlations
Because of the non-normal distribution of some of the speech prosody and text reading prosody measures, non-parametric correlations were performed. Table 2 shows Spearman’s rho correlation coefficients for all variables. There was a very weak, non-significant, correlation between reading comprehension and decoding efficiency ($r = -.12, p = .222$). Reading comprehension was moderately correlated with vocabulary performance ($r = .53, p < .001$) as well as with syntactic awareness ($r = .43, p < .001$). There were moderate correlations between reading comprehension scores and two speech prosody ratings; with section A (expression): $r = .30, p = .002$, and section B (phrasing): $r = .43, p < .001$. Correlations between reading comprehension and text reading prosody were low to moderate, section A (expression): $r = .20, p = .046$, Section B (phrasing): $r = .45, p < .001$, section C (smoothness): $r = .20, p = .044$ and section D (pace): $r = .30, p = .002$.

Hierarchical Regression Analysis
To examine whether text reading prosody and speech prosody explained any additional variance in reading comprehension scores, a hierarchical regression analysis was performed. In the first step, decoding efficiency, vocabulary and syntactic awareness were entered ($R^2 = .43, F(3,97) = 24.30, p < .001$). This was
followed by adding text reading prosody in step two. Table 3 shows that, after controlling for decoding efficiency, vocabulary and syntactic awareness, text reading prosody accounted for 6% unique variance in reading comprehension scores ($R^2 = .49, F(7,93) = 12.60, p < .001$). Of the four subsections of the scale, only subsection B (phrasing) was significant. When speech prosody was added instead of text reading prosody in step three, it accounted for 8% unique variance in reading comprehension outcomes ($R^2 = .51, F(7,93) = 13.85, p < .001$). Likewise, of the four subsections only subsection B (phrasing) was significant.

Table 1 Means and Standard Deviations for Raw Scores of Decoding Efficiency, Vocabulary, Syntactic Awareness, Prosody Measures, and Reading Comprehension (N=101)

<table>
<thead>
<tr>
<th></th>
<th>M (SD)</th>
<th>Minimum</th>
<th>Maximum</th>
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</thead>
<tbody>
<tr>
<td>Decoding efficiency</td>
<td>43.59 (13.73)</td>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>Vocabulary (max. 50)</td>
<td>34.29 (6.41)</td>
<td>16</td>
<td>48</td>
</tr>
<tr>
<td>Syntactic awareness (max. 40)</td>
<td>21.84 (5.66)</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>Text reading prosody A (max. 4)</td>
<td>3.66 (0.46)</td>
<td>2.25</td>
<td>4.00</td>
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<tr>
<td>Text reading prosody B (max. 4)</td>
<td>3.47 (0.50)</td>
<td>2.00</td>
<td>4.00</td>
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<tr>
<td>Text reading prosody C (max. 4)</td>
<td>3.32 (0.41)</td>
<td>2.25</td>
<td>4.00</td>
</tr>
<tr>
<td>Text reading prosody D (max. 4)</td>
<td>3.31 (0.56)</td>
<td>2.00</td>
<td>4.00</td>
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<tr>
<td>Speech prosody A (max. 4)</td>
<td>2.83 (0.81)</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Speech prosody B (max. 4)</td>
<td>2.97 (0.71)</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Speech prosody C (max. 4)</td>
<td>3.03 (0.60)</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Speech prosody D (max. 4)</td>
<td>2.82 (0.68)</td>
<td>1.50</td>
<td>4.00</td>
</tr>
<tr>
<td>Reading comprehension (max. 40)</td>
<td>30.23 (4.14)</td>
<td>16</td>
<td>37.50</td>
</tr>
</tbody>
</table>

Note. * = correctly read words per minute, † = average number of correct responses, ‡ = score per subsection of Multidimensional Fluency Scale (Rasinski, 2004), A = expression, B = phrasing, C = smoothness, D = pace.

Table 2 Spearman Correlations for Decoding, Vocabulary, Syntactic Awareness, Prosody Measures and Reading Comprehension (N=101)

<table>
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<tbody>
<tr>
<td>1. Decoding efficiency</td>
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<td>2. Vocabulary</td>
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<td>0.16</td>
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<td>3. Syntactic awareness</td>
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<td>0.40</td>
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<td>4. Text reading prosody A</td>
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<td>0.50</td>
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<td>5. Text reading prosody B</td>
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<td>6. Text reading prosody C</td>
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<td>0.48</td>
<td>0.47</td>
<td>0.41</td>
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<td>7. Text reading prosody D</td>
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<td>0.45</td>
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<td>8. Speech prosody A</td>
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<td>0.49</td>
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<td>9. Speech prosody B</td>
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<td>0.67</td>
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<td>10. Speech prosody C</td>
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<td>12. Reading comprehension</td>
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Note. * = $p < .05$, ** = $p < .01$, *** = $p < .001$. 
The main aim of the study was to determine the unique variance explained by speech prosody and text reading prosody in reading comprehension scores, when decoding efficiency, vocabulary and syntactic awareness were accounted for. It was found that speech prosody during storytelling explained 8% of the variance in reading comprehension scores, whereas text reading prosody explained 6% of the variance. The fact that text reading prosody explained additional variance in reading comprehension scores corresponds to previous studies that consistently found that text reading prosody and reading comprehension are related (e.g. Benjamin & Schwanenflugel, 2010; Klauda & Guthrie, 2008; Miller & Schwanenflugel, 2006, 2008; Rasinski et al., 2009; Veenendaal et al., 2015).

As far as we know, the influence of speech prosody during a storytelling task has not been related to reading comprehension outcomes before. Whalley and Hansen (2006) investigated the influence of the perception of speech prosody on reading comprehension. They used two prosodic speech tasks to assess perception of speech prosody; one at word-level and one at phrase-level. Children had to make decisions about word boundaries in compound words (e.g., black bird versus blackbird) and about rhythm and stress patterns of short phrases while listening to...
speech input. The performance on the phrase-level task was related to reading comprehension outcomes but the word-level task was not. The similarity between the study by Whalley and Hansen (2006) and the current study is that a speech prosody measure was chosen to assess prosody instead of a reading-related task. However, in contrast to the study by Whalley and Hansen, we decided to use a productive speech task – storytelling. By comparing the variance explained by speech prosody to that of text reading prosody, we could disentangle prosodic skills from reading and decoding skills. It was shown that speech prosody explained additional variance in reading comprehension, which indicates that prosody skills–unrelated to reading skills–independently contribute to reading comprehension. Furthermore, it has been suggested that text reading prosody could be an epiphenomenon of reading comprehension performance (e.g., Torgesen & Hudson, 2006). The fact that speech prosody contributed to reading comprehension contradicts this suggestion, because speech prosody is not dependent on reading ability.

Unlike most studies in English speaking populations, the current results showed no correlation between decoding efficiency and reading comprehension. It is important to note that the present findings apply to Dutch, which can be considered to have a relatively transparent orthography. It has been shown that Dutch decoding development across the primary grades is more a matter of increased speed than of increased accuracy (Verhoeven & van Leeuwe, 2009). It is therefore feasible that the nature of the Dutch language influenced the current finding.

Apart from decoding efficiency, the knowledge of word meanings and syntactic awareness seems mandatory in order to comprehend the text that is being read. Our results show that, in this sample of fourth grade children, vocabulary and syntactic awareness indeed explained the largest part of variance in reading comprehension scores. Interestingly, even after taking these measures into account, additional variance in reading comprehension scores was still explained by text reading prosody and speech prosody. Acquired prosody skills therefore seem to help a child in constructing meaning from written text. This finding is in line with claims that, when reading silently, implicit prosody (an ‘inner voice’) may facilitate reading comprehension (Kentner, 2012, Kuhn, Schwanenflugel, & Meisinger, 2010, Rasinski et al., 2009). In order to determine how prosody skills relate to the linguistic abilities that are needed for text comprehension, it would be an interesting direction for future research to investigate whether speech prosody and text reading prosody are perhaps mediated by other language skills, such as phonological awareness, vocabulary or syntactic awareness.

The results from the regression analysis showed that it was the phrasing aspect of speech and text reading that was significantly associated with comprehension scores. Phrasing relates to reading or speaking in sentence and clause units, as opposed to word-by-word reading or speaking. This result is in line with results from the study by Klauda and Guthrie (2008) that also showed that phrasing in text reading was strongly related to reading comprehension. Furthermore, a number of other studies reported positive correlations between phrasing and comprehension (e.g., Daane et al., 2005, Mokhtari, Thompson, 2006, Finnell et al., 1995, Valencia et al., 2010). The fact that phrasing was important, both in speech and in text reading, seems to be in accordance with the proposed mechanism that the use of prosody facilitates syntactic parsing or chunking (Frazier et al., 2006, Kintsch, 1998, Snedeker & Trueswell, 2003, Snedeker & Yuan, 2008). Clay and Imlach (1971) showed that children who had difficulty ‘chunking’ text, experienced problems with reading comprehension. Furthermore, segmenting text based on phrase boundaries has been shown to improve children’s reading comprehension (Weiss, 1983).

Phrasing in storytelling was more strongly related to reading comprehension than phrasing in text reading. It could be argued that each requires a different skill. After all, when reading text, children need to interpret the writer's intention by, for example, adhering to the syntactic phrasing. In storytelling the child has to actively construct phrases him- or herself. Previous research has indeed shown that aspects of phrasing differ when read speech is compared to spontaneous speech (e.g., Blaauw, 1994, Laan, 1997). According to Blaauw (1994), pauses and pre-boundary lengthening were often related to syntactic structure in reading, but not in speech. Speech also contained simpler syntactic structures and more grammatical errors (Blaauw, 1994, Laan, 1997). This is in agreement with the results of the current study because the mean score for phrasing in speech was lower than the mean score for phrasing in text reading. Furthermore, the variance in phrasing in speech was larger. The ability to construct appropriate phrases in speech apparently varies more between children. This skill may, therefore, discriminate between children who accomplish this and children who struggle in creating a syntactic structure. Phrasing in speech may provide an indication of how well a child understands sentence structure, which may, in turn, provide insight into their reading comprehension ability.

A limitation of the study is that the storytelling task may not have been the most appropriate measure for assessing speech prosody. As a consequence of using story cards some children would just sum up what was happening in the pictures in a relatively monotonous voice, despite our instructions to make the story sound interesting for younger children. Previous research comparing spontaneous and read speech used the same text, by transcribing a spontaneous speech sample (Blaauw, 1994, 1995; Howell & Kad-Hanifi, 1991, Laan, 1997). The prosody performances would have been easier to compare than the
inter-rater reliability might have been higher on speech prosody. Furthermore, the small range on the subsections of the scale was not ideal. In the current study we have chosen to assess prosody skills and text reading prosody with a variety of texts and stories in order to obtain a representative sample. For a future study it may be interesting to use fewer stories in order to be able to use spectrographic analyses.

Conclusion

Our results suggest that prosody skills contribute to reading comprehension above and beyond reading skills because we used a task–speech prosody during story telling–that did not involve reading. Phrasing was shown to be the most important factor, which is in agreement with the proposed theoretical mechanism of chunking skills as a facilitator of reading comprehension. The ability to construct phrases in speech may therefore provide an indication of how well a child will succeed in reading comprehension.

References


4
The Role of Prosody in Reading Comprehension: Evidence from Poor Comprehenders

Based on:
Veenendaal, N.J., Groen, M.A., & Verhoeven, L. (Submitted). The Role of Prosody in Reading Comprehension: Evidence from Poor Comprehenders.
Abstract

It has consistently been shown that children with better text reading prosody—a component of text reading fluency, in addition to accuracy and speed—also perform better at reading comprehension. However, the fact that text reading prosody and reading comprehension are both reading-related skills that rely on decoding makes it far from clear whether the same association would hold if prosodic abilities are assessed outside the context of reading. Therefore, the aim of the current study was to disentangle the contribution of reading skills, decoding efficiency, from that of prosody skills. We examined the performance on both text reading prosody and speech prosody tasks—storytelling, speech rhythm, word boundaries and stress placement—in Dutch, fifth grade, poor comprehenders. Poor comprehenders are children with age-appropriate decoding efficiency but weak comprehension skills. We compared the performance of poor comprehenders ($n=21$), to that of a chronological-age control group ($n=21$), and a younger, comprehension-level control group ($n=21$). The results showed that despite adequate decoding efficiency, poor comprehenders scored significantly below the chronological-age control group on text reading prosody. Importantly, poor comprehenders were also outperformed on the speech prosody tasks and even scored below the younger, comprehension-level control group on the speech rhythm task. This suggests that poor comprehenders have a delay in prosodic development, with an additional indication of a deficiency in their ability to perceive speech rhythm. Notably, the results show that the relation between text reading prosody and reading comprehension does not exclusively rely on decoding efficiency and that prosody skills are independently related to reading comprehension.

The Role of Prosody Skills in Reading Comprehension: Evidence from Poor Comprehenders

Prosody is the melodic aspect of spoken language and involves cues such as stress placement, word boundaries and rhythm. It has been shown that the degree to which children use prosody when reading aloud (i.e., text reading prosody) is associated with their reading comprehension ability (e.g., Miller & Schwanenflugel, 2006, 2008; Rasinski, Rikli, & Johnston, 2009; Veenendaal, Groen & Verhoeven, 2015). However, both text reading prosody and reading comprehension strongly rely on the ability to read well. Indeed, it has been found that efficient and automatized decoding is an essential skill for ‘adult-like’ text reading prosody to develop in primary school children (Miller & Schwanenflugel, 2006; Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004). Therefore, an outstanding question in the current literature is whether decoding is mainly necessary, or also sufficient for the relation between text reading prosody and reading comprehension to develop.

In this context ‘poor comprehenders’—children with age-appropriate decoding but with persisting difficulties in reading comprehension (e.g., Nation, Cocksey, Taylor, & Bishop, 2010)—are of interest. If decoding efficiency is sufficient for text reading prosody to develop, then it is expected that poor comprehenders will show an age-appropriate level of text reading prosody. If, however, decoding is necessary but not sufficient for text reading prosody to develop, and text reading prosody is more tied to reading comprehension, we expect their text reading prosody performance to be weak. A second approach to address this question is to examine the relation between speech prosody—speech rhythm, word boundaries and stress placement—and reading comprehension. Little is currently known about this relation, but as speech development precedes literacy, it is plausible that acquired speech abilities form the pillars for reading development to build upon. As reading skills are not required in speech prosody tasks, we use the performance on these tasks to further disentangle the contribution of decoding to the association between prosody skills and reading comprehension. Therefore, in order to determine the exact relation between prosody skills and reading comprehension, we examined if and how poor comprehenders differ in performance on a reading-related prosody task as well as on speech prosody tasks, compared to typical readers.

Text Reading Prosody and Reading Comprehension

Text reading prosody is the most recent addition to the components of text reading fluency, together with reading speed and reading accuracy (e.g., Kuhn, Schwanenflugel & Meisinger, 2010; Kuhn & Stahl, 2003). Although evidence has been found for a relation between text reading fluency—defined as text reading...
speed and accuracy—and reading comprehension (e.g., Berninger et al., 2010; Kim, Wagner, & Lopez, 2012; Kim & Wagner, 2015), there is a growing literature that emphasizes the significance of text reading prosody in this relation (e.g. Klauda & Guthrie, 2008; Miller & Schwanenflugel, 2006, 2008; Rasinski et al., 2009; Schwanenflugel et al., 2004). Text reading prosody can be assessed by means of rating scales, to obtain a holistic measure of prosody, or by spectrographic analyses, to measure individual features of prosody. Rating scales assess prosodic aspects such as enthusiasm, phrasing, general smoothness and pace, when children read a text aloud.

Studies that used such rating scales showed that text reading prosody was significantly correlated to reading comprehension in children from third, fifth, and seventh grade (Rasinski et al., 2009), and that text reading prosody accounted for substantial variance in reading comprehension scores in children from fourth grade (Calet, Defior, & Gutiérrez-Palma, 2015; Veenendaal et al., 2015) and fifth grade (Klauda & Guthrie, 2008). Other studies used spectrographic analyses in order to assess prosodic aspects such as pauses, intonation contours and end-of-sentence pitch. Miller and Schwanenflugel (2008) showed that children with a decreasing number of inappropriate pauses in their oral reading from first to second grade and an early adult-like intonation contour, performed better on a reading comprehension test in third grade. Further, it was shown that skilled readers read with fewer inappropriate pauses and with more intonation than beginning readers (Schwanenflugel et al., 2004). Because inappropriate pausing is associated with decoding problems, it has been proposed that automaticity in reading, i.e., decoding efficiency, is necessary for text reading prosody to develop (Schwanenflugel et al., 2004). However, even though decoding may be a necessary pre-requisite for an appropriate text reading prosody performance, no studies have yet investigated whether it is also sufficient.

Speech Prosody and Reading Comprehension

Developmentally, speech prosody is part of the first language experiences of a child. An example is infant-directed speech, which is more melodic and more rhythmic than adult-directed speech (e.g., Fernald, 1992; Gleitman, Newport, & Gleitman, 1984). It has been claimed that the function of these exaggerated speech patterns is to facilitate language learning by emphasizing the lexical and grammatical structure of speech (e.g., Dowhower, 1991; Estes, 2014; Estes & Bowen, 2013; Kemler Nelson, Hirsh-Pasek, Jusczyk, & Wright Cassidy, 1989; Snow & Ferguson, 1977). Although it was shown that early prosodic speech perception contributed to reading-related skills, such as phonological and morphological awareness (Zhang & McBride-Chang, 2010), little is known about the contribution of early speech prosody skills to later reading comprehension.

Only a few studies examined the relation between speech prosody and reading comprehension, as a part of general reading skills (Holliman, Williams, Mundy, Wood, Hart, & Waldron, 2014; Kent, 2013; Loehr, Arciuli, & Sharma, 2015; Whalley & Hansen, 2006). Holliman et al. (2014) showed that the performance on a receptive speech prosody test that assessed stress placement, pitch, and duration was correlated with reading comprehension in children from first and second grade. Speech prosody, however, may not be a unitary construct as it has been proposed that different aspects of prosody are differently related to reading comprehension. For example, it was shown that intonation was more strongly related to reading comprehension than the use of pauses (e.g., Miller & Schwanenflugel, 2006; Ravid & Mashraki, 2007). Most studies therefore assessed multiple aspects of prosody, typically; speech rhythm, word boundaries and stress placement.

Speech rhythm is often assessed by using low-pass filtered speech, a manipulation that removes all phonemic content but keeps the rhythmic aspects of a phrase. Speech rhythm has been shown to correlate with reading comprehension in fourth grade children (Kent, 2013), and in children between 7 to 12 years-of-age (Lochrin et al., 2015). The second aspect, the ability to successfully perceive or produce word boundaries (e.g., the difference between fruit, salad and milk, and fruit-salad and milk), accounted for unique variance in reading comprehension scores in fourth grade children (Kent, 2013), in children from 7 to 12 years-of-age (Lochrin et al., 2015), and in college students (Kitzen, 2001). On the other hand, Whalley and Hansen (2006) did not find a significant correlation between the performance on word boundary tasks and reading comprehension in fourth grade children.

Divergent results were also found for the relation between contrastive stress placement and reading comprehension. Contrastive stress refers to an emphasis on new or important information within a phrase, such as ‘I wanted TEA, not coffee’ (Peppé & McCann, 2003, Warren, 1996). Awareness of contrastive stress was shown to be significantly correlated with reading comprehension but explained no variance in reading comprehension scores (Lochrin et al., 2015). In contrast, Kent (2013) showed that contrastive stress explained 17% unique variance in reading comprehension. The above results show that different aspects of speech prosody might indeed differently relate to reading comprehension, although they also show that results are not consistent between studies. The inconsistent results mainly seem to relate to task-dependent factors with most studies assessing perception of speech prosody (Kent, 2013; Whalley & Hansen, 2006), and some studies assessing production as well as perception (Lochrin et al., 2015). Furthermore, the age of the children that participated differed and the control variables included differed (phonological awareness and rhythmic sensitivity: Whalley and Hansen, 2006; age and phonological awareness: Loehr et al., 2015; decoding and listening comprehension: Kent, 2013).
The Present Study
The aim of the present study was to disentangle the contribution of reading skills—decoding efficiency—to the association between prosody skills and reading comprehension, by using two different approaches. First, the current literature proposes that efficient decoding is a necessary skill for the relation between text reading prosody and reading comprehension to emerge, but it is as yet unclear whether decoding is also sufficient. We investigated the performance of children with strong decoding but weak reading comprehension skills (poor comprehenders) to provide more insight into this. Second, we examined whether speech prosody skills—more specifically, storytelling, and the perception and production of speech rhythm, word boundaries, and stress placement—are related to reading comprehension as strongly as reading-related prosody tasks are.

This lead to the following research question: To what extent do poor comprehenders differ in their prosodic abilities across written and spoken modalities from a chronological-age control group and a younger, comprehension-level control group? The inclusion of a younger, comprehension-matched control group allowed us to determine the extent to which the prosody skills of poor comprehenders are in line with their level of reading comprehension. If the poor comprehenders would perform at a lower level than the younger, comprehension-level control group, this could provide an indication of a restricting factor in their reading comprehension performance.

Method
Participants
Poor comprehenders were referred by teachers from six medium-sized, primary schools in the Eastern part of the Netherlands, based on performance on national annual assessments on word recognition (Kron, Jongen, Verhelst, Kamphuis, & Kleintjes, 2010) and reading comprehension (Staphorsius & Krom, 2011). The poor comprehenders (fifth grade) were that children had average to above-average word recognition skills (above the 50th percentile) but lower than average reading comprehension skills (below the 25th percentile), following selection criteria from previous studies (e.g., Catts, Adlof, & Weismer, 2006; Fletcher et al., 1994; Stanovich & Siegel, 1994). The poor comprehenders were matched on chronological-age with class-mates from fifth grade, who performed above the 50th percentile on both word recognition and reading comprehension. Then, a younger group of children, from the same school, was selected who performed at the same reading comprehension level as the poor comprehenders, but above the 50th percentile for their age. The word recognition skills of these children were also above the 50th percentile for their age. Children in the younger control group were predominantly from third grade, with a few children from second or fourth grade. Twenty-eight children were selected per group, with a total of 84 children participating.

To confirm the status of ‘poor comprehender’ as indicated by the schools, we assessed reading comprehension, word recognition and decoding (pseudowords) ourselves for all children. See for a full description the materials section below. Data from poor comprehenders with reading comprehension scores above the sample-based 50th percentile were rejected. It is important to note that all poor comprehenders performed below the 25th percentile (norm-based scores) on the national assessment of reading comprehension at school. After this final selection 63 participants remained (21 per group); 12 girls and 9 boys in the poor comprehender group, 14 girls and 7 boys in the chronological-age control group and 9 girls and 12 boys in the comprehension-level control group. All participating children were native speakers of Dutch. Children with a diagnosis of a language or reading impairment or with behavioural problems were excluded from the study. Parental informed consent was obtained for all participating children.

Materials
Selection variables. The level of reading comprehension, word recognition and pseudoword decoding was assessed in order to confirm the selection of the poor comprehenders by the schools.

Reading comprehension. The reading comprehension test was constructed of two standardized reading comprehension tests (Aarnoutse & Kapinga, 2006). One of these tests was a reading comprehension test for children from first, second and third grade, and the other one a test for children from fourth, fifth, and sixth grade. Questions from both tests were included to prevent floor and ceiling effects. The reading comprehension test presented the children with seven short texts; each followed by three multiple choice questions and two to four ‘true or false’ questions about each text. Four texts were informative and three texts were narratives. The total number of items for this test was 44. Cronbach’s alpha reliability coefficient has been calculated for this sample and was .83.

Word recognition. Word recognition efficiency (rate) was assessed with a standardized test by Brus and Voeten (1973). Three columns of 116 words were presented to the children, who were given one minute to read as many words as possible, as quickly and accurately as they could. The wordlist included one-syllable words as well as two- and multi-syllable words. Raw scores were converted to standard scores ($M = 10, SD = 3$). Cronbach’s alpha reliability was reported to be between .73 - .92 (Brus & Voeten, 1973).
**Pseudoword decoding.** Efficiency of pseudoword decoding was measured with a standardized test by Van den Bos, Rutje Spelberg, Scheepstra, and De Vries (1994). The pseudowords were based on the existing words from the word recognition task described above. The presented pseudowords were therefore similar in structure and had the same number of syllables. Children had two minutes to read as many words, as quickly and accurately as they could. Raw score were converted to standard scores (M = 10, SD = 3). Cronbach’s alpha was reported to be between .63 - .80 for the pseudoword decoding test (Van den Bos, Rutje Spelberg, Scheepstra, & De Vries, 1994).

**Prosody assessment.** The use of prosody during reading (text reading prosody) as well as during storytelling (speech prosody) was assessed by means of a rating scale which distinguishes enthusiasm, phrasing, smoothness and pace. In addition, six subtasks of the Dutch version of the PEPS-C computer task (Peppe & McCann, 2003) were used to assess speech prosody: two speech rhythm tasks (PEPS-C: Long item Discrimination and Imitation), two word-boundary tasks (PEPS-C: Chunking), and two stress placement tasks (PEPS-C: Contrastive Stress). Each subtask had a receptive part (perception of prosody) where children listened to sound samples, presented via the speakers of a computer, and an expressive part (production of prosody), where children had to produce prosodic utterances themselves. There were 16 items per task, plus two practice items to start each task with. The practice items were not included in the scores. Due to problems with the expressive Word Boundary subtask this task was not included in the analyses. Because of the translation into Dutch, half of the items became too lengthy and therefore too complex for the children. Therefore, we report the results on the five remaining PEPS-C subtasks. Each of the prosody tasks, text reading prosody as well as the speech prosody tasks, is described in more detail below.

**Text reading prosody.** To assess text reading prosody we used two short narratives (approximately 100 words each). Word frequency was based on a selection of wordlists naming the most frequent words for Dutch schoolchildren (Vermeer, 2000) to make sure that the texts were not too difficult for the younger children participating. Children were first asked to read the two short stories silently and then to read these aloud. They were asked to read the way they would normally read aloud in class. The reading was recorded on a digital voice recorder and an expressive performance on each section was marked with 1-4 points, so total scores per story ranged from 4 to 16. An average score over the two stories has been used for analysis. Reliability of this task has been calculated and Cronbach’s alpha was .86. Twenty percent of the data were scored by an independent rater and inter-rater reliability was calculated using Intraclass Correlation Coefficients (ICCs). ICC on the average score for the two texts (as used for analysis) was excellent: ICC = .940, F(11,11) = 29.625, p < .001.

**Storytelling prosody.** Speech prosody was firstly assessed by using two storytelling cards (Verhoeven & Vermeer, 2001). Each card showed a sequence of six pictures. Children were asked to look at these pictures and to tell a story about what happened. The child was asked to make the story sound interesting for a younger child that would not see the pictures. The stories were recorded on a digital recorder and speech prosody was scored at a later time. The Multidimensional Fluency Scale (Rasinski, 2004) was adapted to make it more suitable for assessing storytelling prosody. In the adapted version the four sections refer to: Expression (making it sound like a natural story, adequate expression and enthusiasm), Phrasing (adequate indication of word, sentence and passage boundaries), Smoothness (generally smooth speech, structure difficulties resolved quickly) and Pace (consistently conversational pace, not too fast and not too slow). Performance on each section was marked with 1-4 points, so total scores per story ranged from 4 to 16. An average score over the two stories has been used for analysis. Reliability of this task has been calculated and Cronbach’s alpha was .86. Twenty percent of the data were scored by an independent rater and inter-rater reliability was calculated. The ICC on the average score for the two stories (as used for analysis) was excellent: ICC = .873, F(11,11) = 16.777, p < .001.

**Speech rhythm.** The Long Item Discrimination task of the PEPS-C computer test assessed the ability to hear differences in rhythmic patterns of filtered speech. Children heard two short phrases (6-7 syllables) that were taken from two other PEPS-C subtasks (word boundaries and stress placement). These phrases were low-pass filtered, and therefore sounded as if someone was talking in a room next door. The child was asked to indicate whether the two phrases sounded the same or different from each other. In 6 cases the phrases were the same and in 6 cases they were different. Because there was no phonemic content in these sentences, the decision was purely based on the speech rhythm. The child received one point per correct answer. The internal reliability of this task has been calculated. After removing four items, Cronbach’s alpha was reasonable, α = .59. Twelve items were therefore included in further analyses.

The second speech rhythm task was the Long Item Imitation task. Children heard short phrases and had to repeat not only the words but also the speech
pattern of the phrase as precisely as possible. The sentences had 6-7 syllables and were based, in structure, on the sentences in the word boundary task and the stress placement task, but they were not identical to these. An example is: “I wanted yellow SHOES.” The tester decided whether the imitation was correct and children received either one or a half point for their performance. Twenty percent of the data was scored by an independent rater, and inter-rater reliability was calculated. The ICC on the Imitation task was excellent: ICC = .851, F(11,11) = 11.725, p < .001. Reliability was calculated and after removing two items Cronbach’s alpha was .69. The remaining fourteen items have been included in further analyses.

**Word boundaries.** The Receptive Chunking subtask of the PEPS-C computer test assessed the perception of Word Boundaries. Children saw two pictures on a computer screen and heard either a compound noun and a noun or a string of nouns (e.g., “Chocolate-cake and jam” versus “Chocolate, cake and jam”). Children had to select the corresponding picture on the screen. Every correct answer resulted in a point for the child. The reliability of this task was calculated and after removing four items Cronbach’s reliability coefficient was fair, α = .59. Twelve items have therefore been included in further analyses.

**Stress placement.** The two Contrastive Stress tasks of the PEPS-C computer test assessed receptive and expressive use of stress placement. The first task was a receptive task. The child heard a short story about someone who went shopping to buy socks but later realized she had forgotten to buy one specific colour of socks. The child heard sentences such as: “I wanted BLUE and black socks”. Children had to decide which colour of socks the speaker had forgotten to buy. Half of the time stress was placed on the first word and the other half on the second word. Reliability of this task has been calculated and Cronbach’s alpha was .80.

Secondly, children performed a productive Contrastive Stress task where they had to place stress on certain words themselves. Children saw a picture and heard an incorrect commentary. An example is a picture of a white cow with a ball and the speaker saying: “The red cow has got the ball!”. This was said in a neutral tone of voice, without any pitch or stress changes. The child had to correct the speaker by saying: “No, the WHITE cow has got the ball!”. The tester decided whether the stress placement was appropriate. Twenty percent of the data was scored by an independent rater. Inter-rater reliability analysis was performed and the ICC on the productive focus task was excellent: ICC = .914, F(11,11) = 11.725, p < .001. Reliability analysis of this task showed a Cronbach’s reliability coefficient has been reported to be .79 for this test (Kort et al., 2005). Twenty percent of the data was scored by an independent rater and inter-rater reliability was calculated. The ICC on the vocabulary task was excellent: ICC = .972, F(11,11) = 75.602, p < .001. Reliability was calculated and after removing two items Cronbach’s alpha was .69. The remaining fourteen items have been included in further analyses.

**Non-verbal cognitive reasoning.** Non-verbal cognitive reasoning was assessed using the Raven Progressive Matrices Test (Raven, 1976). Children received a booklet with 60 incomplete patterns and were asked to identify the missing element that completed the pattern. Cronbach’s alpha has been reported to be .90 for this test (Raven, 1976).

**Procedure**

All assessments were carried out during school hours. The tests to assess reading comprehension and non-verbal cognitive reasoning were administered group-wise in two sessions of 40 minutes each. All participating children of one school sat together in one room to complete these tests silently. The other assessments were performed on an individual basis and were administrated in two separate sessions by the first author and two trained master’s students. Individual testing was carried out in a separate room, provided by the schools. In the first individual session, text reading prosody and speech prosody were assessed and three tasks not discussed in the current paper. The order of the two narratives and the two story cards was counter-balanced. During the second session, word recognition, pseudoword decoding, vocabulary and the subtasks of the PEPS-C computer task were assessed.

**Data Analyses**

Firstly, data was visually inspected to determine whether the data were normally distributed. As some variables were non-normally distributed and a correction in the form of transformations did not solve this, we used a non-parametric ANOVA (Kruskal-Wallis). All data have been converted to standard scores or (averaged) z-scores.

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Compaan, Dekker, Vermeir, & Verhaeghe, 2005). Children were aurally presented with a word and were asked for a spoken definition of this word. Raw scores were converted to standard scores (M = 10, SD = 3). Cronbach’s alpha reliability coefficient has been reported to be .79 for this test (Kort et al., 2005). Twenty percent of the data was scored by an independent rater and inter-rater reliability was calculated. The ICC on the vocabulary task was excellent: ICC = .972, F(11,11) = 75.602, p < .001.
Results

Selection and control variables

Descriptives for age, performance on reading comprehension, word recognition and pseudoword decoding are presented in Table 1, together with the control variables vocabulary and non-verbal cognitive reasoning. Due to the non-normal distribution of some variables and the use of non-parametric analyses we report the Median and the Range.

Table 1 Median (Range) for Age, Selection Variables and Control Variables (n=21)

<table>
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<tr>
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<td>(19.00-34.00)</td>
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<tr>
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<td>12.00</td>
<td>=**</td>
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<td></td>
<td>(10.00-19.00)</td>
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<td>(8.00-16.00)</td>
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<td>(10.00-16.00)</td>
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<tr>
<td>Pseudoword dec. b</td>
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<td>=</td>
<td>13.00</td>
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<td>(10.00-19.00)</td>
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<td>(9.00-18.00)</td>
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<td>Control</td>
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<td>Vocabulary b</td>
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<td>=</td>
<td>9.00</td>
<td>=**</td>
<td>11.00</td>
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<tr>
<td></td>
<td>(7.00-15.00)</td>
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<td>(6.00-15.00)</td>
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<td>(4.00-13.00)</td>
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<tr>
<td>Non-verbal cogn. reasoning c</td>
<td>90.00</td>
<td>=</td>
<td>30.00</td>
<td>&lt;**</td>
<td>75.00</td>
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<td>(25.00-99.00)</td>
<td></td>
<td>(5.00-95.00)</td>
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<td>(5.00-99.00)</td>
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</tbody>
</table>

Note. Reading comp. = reading comprehension, Pseudoword dec. = pseudoword decoding, Non-verbal cogn. reasoning = non-verbal cognitive reasoning, " = raw scores, = standard scores (M = 10, SD = 3, range 1-19), = percentiles, = p < .05, = p < .01, = p < .001, = not significant (p > .05).

There were group differences on the scores of the reading comprehension task, as expected ($H(2,63) = 34.83$, $p < 0.001$). The reading comprehension scores were similar for the poor comprehenders and the younger, comprehension-level control group ($p = 1.00$), but both groups scored significantly lower than the chronological-age control group ($p < 0.001$). There were no significant differences between the three groups regarding the standard scores on the word recognition task ($H(2,63) = 5.50$, $p = .064$) and the standard scores on the pseudoword decoding task ($H(2,63) = 3.04$, $p = .219$). Further, there were significant group differences on the standard scores on the productive vocabulary test ($H(2,63) = 7.56$, $p = .023$). Pairwise comparisons with adjusted significance levels showed that poor comprehenders had significantly lower scores on the vocabulary test than the chronological-age control group ($p = .027$), but similar scores to the comprehension-level control group ($p = .118$). Nevertheless, all children performed within the average range for their age, according to norms. There were also significant group differences on the percentile scores on the Raven, the non-verbal cognitive reasoning test ($H(2,63) = 14.81$, $p = .001$). Poor comprehenders had lower scores on this test than the chronological-age controls ($p = .003$) and also lower scores than the younger, comprehension-level controls ($p = .003$).

Prosody Skills

Table 2 shows the median and the range of the raw scores of all prosody skills. Group differences were found on text reading prosody, ($H(2,63) = 23.56$, $p < 0.001$). Pairwise comparisons showed that poor comprehenders had significantly lower scores on text reading prosody than the chronological-age control group ($p = .001$), but similar scores to the comprehension-level control group ($p = 1.00$).

The results of the performance on the speech prosody tasks, firstly storytelling prosody, also showed group differences ($H(2,63) = 17.91$, $p < 0.001$). Poor comprehenders had a weaker performance on storytelling prosody than the chronological age controls ($p = .023$), but also similar to the younger comprehension-level controls ($p = .396$). The results on the other speech prosody tasks, i.e., the PEPS-C subs tasks, showed that there were significant group differences on all tasks, except one, on the receptive stress placement task no significant group differences were found ($H(2,63) = 5.94$, $p = .051$). The chronological-age control group scored at ceiling level on this task, with a high median score and a small range (Mdn =16/16, Range = 12.00-16.00), whereas the scores from the poor comprehenders and the comprehension-level control group had a wider range (Range = 7.00-16.00). Group differences were found on the expressive stress placement task ($H(2,63) = 7.71$, $p = .021$), the receptive word boundary task ($H(2,63) = 11.15$, $p = .004$), and the expressive speech rhythm task ($H(2,63) = 6.48$, $p = .039$). Pairwise comparisons showed that poor comprehenders scored significantly lower than the chronological-age control group ($p = .027$, $p = .006$, $p = .036$, respectively), but similar to the comprehension-level control group ($p = .105$, $p = 1.00$, $p = .325$) on these tasks. Finally, significant group differences were also found on the receptive speech rhythm task ($H(2,63) = 11.68$, $p = .003$). On this task, poor comprehenders scored lower than the chronological-age control group ($p = .006$), but also lower than the younger, comprehension-level control group ($p = .015$).
Chapter 4 Evidence from poor comprehenders

Table 2 Median (Range) for Prosody Skills (n = 21)

<table>
<thead>
<tr>
<th></th>
<th>Chronological-Age Controls</th>
<th>Δ</th>
<th>Poor Comprehenders</th>
<th>Δ</th>
<th>Comprehension-Level Controls</th>
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<tr>
<td><strong>Text reading prosody</strong></td>
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<tr>
<td>Text reading prosody</td>
<td>13.00 (10.50-16.00)</td>
<td>&gt;**</td>
<td>11.50 (9.50-13.50)</td>
<td>=**</td>
<td>11.00 (6.50-13.00)</td>
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<tr>
<td>Speech prosody</td>
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<tr>
<td>Storytelling prosody</td>
<td>12.50 (8.00-16.00)</td>
<td>&gt;*</td>
<td>10.50 (5.50-13.50)</td>
<td>=*</td>
<td>9.50 (5.50-12.50)</td>
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<td><strong>Speech Rhythm</strong></td>
<td></td>
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<tr>
<td>Receptive</td>
<td>11.00 (6.00-12.00)</td>
<td>&gt;**</td>
<td>9.00 (5.00-12.00)</td>
<td>&lt;**</td>
<td>11.00 (7.00-12.00)</td>
</tr>
<tr>
<td>Expressive</td>
<td>11.00 (6.00-14.00)</td>
<td>&gt;*</td>
<td>9.50 (3.00-12.50)</td>
<td>=*</td>
<td>10.50 (2.00-13.00)</td>
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<td><strong>Stress Placement</strong></td>
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<tr>
<td>Receptive</td>
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<td>=*</td>
<td>14.00 (7.00-16.00)</td>
<td>=*</td>
<td>15.00 (7.00-16.00)</td>
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<tr>
<td>Expressive</td>
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<td>&gt;*</td>
<td>12.00 (5.00-16.00)</td>
<td>=*</td>
<td>14.00 (10.00-16.00)</td>
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<td><strong>Word Boundaries</strong></td>
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<tr>
<td>Receptive</td>
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<td>&gt;**</td>
<td>10.00 (5.00-12.00)</td>
<td>=**</td>
<td>9.00 (5.00-12.00)</td>
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</tbody>
</table>

Note: * = p < .05, ** = p < .01, *** = p < .001, ns = not significant (p > .05).

Discussion

In the current study we examined to what extent poor comprehenders differed in their prosodic abilities across written and spoken modalities from a chronological-age control group and a younger, comprehension-level control group, in order to disentangle the contribution of reading skills (decoding) to the association between prosody skills and reading comprehension. The first main result was that, despite having age-appropriate decoding efficiency, poor comprehenders were outperformed on the text reading prosody task by the chronological-age control group. In fact, their performance was in line with the performance of the younger, comprehension-level control group. This suggests that although decoding may be necessary for text reading prosody performance, it is, in itself, not sufficient for text reading prosody to develop. This conclusion is reinforced by the second main result that poor comprehenders performed weaker than the chronological-age controls, but similar to the comprehension-level controls, on most speech prosody tasks. Finally, on the receptive speech rhythm task poor comprehenders performed weaker than both control groups, indicating that the ability to perceive speech rhythm might restrict reading comprehension development.

Reading comprehension is a complex process that requires children to quickly and accurately recognize the words in a text (‘the automaticity aspect’) while simultaneously constructing meaning. It has been proposed that text reading fluency—as a combination of accuracy, automaticity, and text reading prosody—facilitates the reader’s construction of meaning (Kuhn et al., 2010). The results from the current study, however, suggest that the ‘automaticity aspect’ of reading is a distinct process from the construction of meaning. The construction of meaning seems more closely tied to text reading prosody than to decoding efficiency, at least, when children have mastered automaticity in reading. The theoretical rationale behind this is that text reading prosody may facilitate the unification between the retrieved words on a phonological, syntactic and semantic level. This is in line with neurocognitive models of language processes that propose that memory retrieval and unification processes comprise two distinct brain areas that operate in parallel (Hagoort, 2007). This proposed facilitation in unification processes could have implications for the construct of text reading fluency in relation to reading comprehension. We suggest that in mature readers that have automatized decoding, assessment of text reading fluency should always include the component of text reading prosody. Text reading prosody performance could provide an insight in how well a child manages to unify the phonological, syntactic and semantic levels, and therefore, how well he or she constructs meaning from the text.

The second main result concerns the performance on the speech prosody tasks and provides further evidence for a relation between prosody skills and reading comprehension. Poor comprehenders performed more weakly than the chronological-age control group on the storytelling prosody task—a task in which decoding efficiency did not play a role. They also scored significantly lower on the performance on the PEPS-C speech prosody tasks than the chronological-age control group, apart from the receptive stress placement task (Contrastive Stress), where the chronological-age controls scored at ceiling level. On all but one speech prosody task, poor comprehenders performed at the level of the younger, comprehension-level control group. There was one exception: poor comprehenders performed more weakly than either control group on speech rhythm discrimination, suggesting that poor comprehenders are less aware of small differences in speech patterns. The fact that the poor comprehenders were outperformed by both control groups indicates that this is not merely a delay in development, but a skill that is deficient in this group. Interestingly, in typical readers the performance on this task was only weakly to moderately correlated with reading comprehension...
Chapter 4 Evidence from poor comprehenders

It has been proposed that rhythm perception skills—in speech as well as in music—are strongly related to the production of syntax and the understanding of grammar in spoken language (Gordon, Jacobs, Schuele, & McAuley, 2015). The inability to grasp differences in speech rhythm could obstruct the use of implicit prosody (an inner representation of what a text should sound like) when reading a text silently. It is suggested that implicit prosody may facilitate text comprehension (Kentner, 2012; Kuhn et al., 2010; Rasinski et al., 2009). Fodor (1998, 2002) proposed the implicit prosody hypothesis. In this hypothesis, she stated that a default prosodic contour is projected onto a text in order to help solve syntactic ambiguity when reading silently. The results from the current study raise the question whether poor comprehenders may not have access to a default prosodic contour; this question certainly requires further investigation.

Although the prosodic abilities of poor comprehenders have, as far as we know, not been examined before, a considerable body of research has investigated oral language problems in poor comprehenders. It has been shown that poor comprehenders have weaker grammatical, syntactic and semantic skills (Nation et al., 2004; Nation & Snowling, 2000). The impairment of poor comprehenders in these language skills could be related to prosody skills. It has been proposed that one of the functions of prosody in speech is the attribution of syntactic roles to words within sentences (Chafe, 1988; Koriat, Greenberg, & Kreiner, 2002). Furthermore, an appropriate use and understanding of speech prosody may assist in segmenting a sentence into syntactically and semantically correct chunks (Kintsch, 1998; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008).

Importantly, longitudinal research showed that the weaker grammatical, syntactic and semantic skills in poor comprehenders are persisting and can, in retrospect, be related to oral language impairments in earlier school years (Catts et al., 2006; Nation et al., 2010). Since speech prosody develops well before learning to read, it seems plausible to assume that delays in prosodic development may be observed well before poor comprehenders start to fail at reading comprehension. This could potentially provide valuable information for early language screening, as delayed development in speech prosody may hinder later reading comprehension. The relation between speech prosody and reading comprehension is in line with the developmental trajectory of speech prosody and its influence on later literacy development, such as phonological and morphological awareness, as outlined by Zhang and McBride-Chang (2010). Future studies, however, are needed to further examine the relation between early speech prosody and later reading comprehension and the potential of this for early screening possibilities.

It is noteworthy that despite the finding that the poor comprehenders in the current study had lower scores than both control groups on non-verbal cognitive reasoning, a correlation analysis showed no significant correlations between non-verbal cognitive reasoning and the text reading prosody and speech prosody tasks for the poor comprehenders (p > .08). Lower scores on cognitive reasoning in poor comprehenders have been found in other studies as well (e.g., Catts et al., 2006; Nation et al., 2010; Nation, Clarke, & Snowling, 2002). An interesting consideration is whether there would be a relation between the pattern recognition in the non-verbal cognitive reasoning task (Raven) and the pattern recognition in the speech rhythm task (PEPS-C). There is some neurocognitive evidence that points in this direction. Studies have shown that subcortical brain structures, the basal ganglia, are involved in perception of speech melody (Kotz, Meyer, Alter, Besson, von Cramon, & Friederici, 2003; Meyer, Steinhauser, Alter, Friederici, & von Cramon, 2004) and at the same time it has been suggested that the basal ganglia are involved in sequence and category learning (Seger, 2006). It could therefore be that pattern sequencing and speech rhythm detection rely on the same neurocognitive processes and that these processes are underdeveloped in poor comprehenders, although this largely remains an empirical question.

The fact that some subtasks of the PEPS-C had a low internal reliability is a limitation of the study and this means that the findings of the current study need to be interpreted with some caution. Nevertheless, it should be mentioned that there are currently very few highly reliable measures of prosodic sensitivity (see Holliman et al., 2014). The current study is the first to examine prosodic abilities in poor comprehenders and the results should therefore be taken as a first step. Further research is needed to confirm these results and to examine differences in prosody development in more depth.

Conclusion

The current study provides evidence for a delay in both text reading prosody and speech prosody for poor comprehenders, compared to typical readers of the same age. Because poor comprehenders have age-appropriate decoding but weak reading comprehension skills, we were able to show that decoding efficiency in itself is not sufficient to establish the relation between text reading prosody and reading comprehension. It is therefore proposed that text reading prosody...
may be more strongly related to the level of reading comprehension. This was also shown by our finding that poor comprehenders had impairments in speech prosody, and more specifically, a deficiency in speech rhythm discrimination. Not being able to perceive speech rhythm may hinder an internal representation of what a text should sound like, which is suggested to obstruct comprehension of written text.

References


Based on:
Abstract

The aim of the present study was to examine the relation between decoding and segmental and suprasegmental phonology, and their contribution to reading comprehension, in the upper primary grades. Following a longitudinal design, the performance of 99 Dutch primary school children on phonological awareness (segmental phonology) and text reading prosody (suprasegmental phonology) in fourth grade and fifth grade, and reading comprehension in sixth grade were examined. In addition, decoding efficiency as a general assessment of reading was also examined in fourth and fifth grade. Structural path modelling firstly showed that decoding efficiency in fourth grade contributed to both measures of phonology in fifth grade but not vice versa. Secondly, the contribution of decoding in fourth and fifth grade to reading comprehension in sixth grade became indirect when segmental and suprasegmental phonology were added to the model. Both factors independently exerted influence on later reading comprehension. This leads to the conclusion that not only segmental, but also suprasegmental phonology, contributes substantially to children’s reading development.

The Contribution of Segmental and Suprasegmental Phonology to Reading Comprehension

Learning to read starts with acquiring the alphabetic principle, but the ultimate goal of reading acquisition is to learn to comprehend written text. Decoding and reading comprehension in primary school children have been shown to correlate (e.g., Goff, Pratt, & Ong, 2005; Shankweiler et al., 1999) and decoding efficiency often predicts success in reading comprehension (Kendeou, van de Broek, White, & Lynch, 2009; Verhoeven & van Leeuwe, 2008; Verhoeven, van Leeuwe, & Vermeer, 2011). Apart from decoding, phonological awareness has also been proposed to predict later reading comprehension (e.g., Ehri et al., 2001). Phonological awareness is a segmental phonology skill, referring to the awareness of separable sound units in speech and the ability to manipulate these. More recently, it has been shown that suprasegmental phonology is associated with reading comprehension as well (e.g., Benjamin & Schwanenflugel, 2010; Miller & Schwanenflugel, 2006, 2008; Rasinski, Rikli, & Johnston, 2009). Suprasegmental phonology refers to aspects of spoken language such as intonation patterns, stress placement and rhythm, that are not bound to any specific segments of speech. Suprasegmental phonology is sometimes called prosody. To date, longitudinal studies combining measures of both segmental and suprasegmental phonology, especially in older school children, are scarce. Furthermore, there is some evidence that decoding is related to segmental phonology (Melby-Lervåg, Lyster, & Hulme, 2012; Nation & Hulme, 2011) as well as to suprasegmental phonology (Goswami et al., 2002; Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004). Therefore the goal of the present study was twofold; firstly, to take a longitudinal stance on the relation between decoding and segmental and suprasegmental phonology and, secondly, to examine the contribution of decoding, segmental and suprasegmental phonology to reading comprehension.

Reading starts with the ability to decipher printed words. In order to do so, a child has to learn how to decode words. Decoding involves the coupling of phonemes to orthographic print. Decoding efficiency is strongly associated with phonics instruction. In the Dutch educational system, early reading is predominantly taught using phonics instruction (Reitsma & Verhoeven, 1993). However, in the intermediate classes of primary school the focus shifts to word recognition rather than sounding out words, as children are expected to know the rules of orthographic-phonological coupling by then (Aarnoutse, Verhoeven, Zandt, & Biemond, 2003). Some of the classic studies on literacy showed that decoding abilities form an important foundation skill for reading comprehension (LaBerge & Samuels, 1974; Perfetti, 1985). The lexical quality hypothesis by Perfetti (2007; Perfetti & Hart, 2002) states that the quality of word representations, such as
knowledge about word forms and meanings, affects general reading outcomes, including reading comprehension. Nevertheless, decoding has been shown to exert most influence on early reading comprehension skills and its effect is generally weaker at the end of primary school (Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009; Verhoeven & van Leeuwe, 2009; Veenendaal, Groen, & Verhoeven, 2015). Moreover, there is some evidence that decoding develops according to the orthography of a language. In languages with a transparent orthography, such as Dutch, 90% of words are read accurately after one year of formal reading instruction, whereas in a more opaque orthography such as English, only 41% of words are read correctly after the first year at school (Seymour, Aro, & Erskine, 2003). Regarding the assessment of decoding, decoding can be measured by the accuracy of pronouncing words or pseudowords, as described above, or by the rate used to pronounce these words (efficiency). The latter form of assessment is used more in transparent languages, as accuracy has been shown to reach ceiling quickly, after the first year of official reading instruction (e.g., Seymour et al. 2003).

It has been claimed that decoding is preceded by phonological awareness in reading development (Muter, Hulme, Snowling, & Stevenson, 2004; Torgesen, 2002; Torgesen & Mathes, 2000). Phonological awareness develops gradually, and this development occurs from larger to smaller units (Kamil, Mosenthal, Pearson, & Bar, 2000; Geijsel & Aarnoutse, 2006). Children can, in general, segment words into syllables before they can segment them into phonemes (e.g., Carrol, Snowling, Stevenson, & Hulme, 2003; Treiman, 1992, 1986). A meta-analytic review of 235 studies by Melby-Lervåg et al. (2012) showed that of the three most widely studied phonological skills—phoneme awareness, rime awareness, and verbal short-term memory—phoneme awareness was most closely related to growth in children’s word reading ability. These effects were shown to be similar across different languages (Melby-Lervåg et al., 2012). However, it has also been suggested that once the beginning stages of reading are mastered, the relationship between phonological awareness and word reading becomes reciprocal (Nation & Hulme, 2011; Wagner, Torgesen, & Rashotte, 1994). Experience in reading may thus facilitate further development of phonological awareness in more advanced readers (e.g., Cheung, Chen, Lai, Wong, & Hills, 2001; Mann, 1986).

In addition, suprasegmental phonology has also been reported to be related to word decoding. Suprasegmental phonology involves the melody of spoken language; this includes awareness of speech rhythm, and perception and production of stress placement and word boundaries. Apart from speech prosody, suprasegmental phonology can also be assessed in a reading performance, namely with text reading prosody. In this type of assessment, a correct use of pauses, phrase boundaries and intonation patterns is assessed, when children are reading aloud. Regarding the first assessment; speech prosody, it has been shown that speech rhythm sensitivity was well developed in children who started to read at a young age and less so in children with dyslexia (Goswami et al., 2002). Furthermore, Kitzen (2001) found that the perception of rhythm and stress in short phrases was a significant predictor of decoding in university students. In contrast, when suprasegmental phonology is assessed by text reading prosody a reversed relation has been found. Decoding was shown to play an essential role in prosodic text reading performance (Schwanenflugel et al., 2004). As soon as decoding was mastered, children generally read with shorter pauses between words and sentences, with more smoothness and with an adult-like intonation contour (Schwanenflugel et al., 2004).

Both segmental and suprasegmental phonology have been shown to contribute to reading comprehension. Regarding segmental phonology, a meta-analysis by Ehri et al. (2001) concluded that instruction in phonological awareness benefitted children’s reading comprehension. In addition, Engen and Høen (2002) proposed that phonological awareness contributed to reading comprehension in both average and good decoders in first grade. Efficient phonological awareness can even benefit readers in intermediate and upper grades, as shown by a phonologically based reading program that improved reading abilities, including reading comprehension, in children from first grade to sixth grade (Rashotte, MacPhee, & Torgesen, 2001). Nonetheless, a question remains as to the underlying processes assessed by phonological awareness tasks and their contribution to reading comprehension. Specifically, phonological awareness tasks that included a working memory component were stronger predictors of comprehension than tasks that did not tax working memory (Cain, Oakhill, & Bryant, 2000).

A contribution of suprasegmental skills to reading comprehension in primary school children has also been found. For instance, text reading prosody has been associated with reading comprehension in several studies (e.g., Benjamin & Schwanenflugel, 2010; Kuhn & Stahl, 2003; Miller & Schwanenflugel, 2006, 2008; Rasinski et al., 2009; Veenendaal et al., 2014). Rasinski et al. (2009) used the Multi-dimensional Fluency Scale (Rasinski, 2004) to assess different aspects of text reading prosody, such as expression, phrasing, smoothness and pace. The authors found that text reading prosody and reading comprehension were significantly correlated in primary school children in third grade and fifth grade, and even beyond primary school, in seventh grade (Rasinski et al., 2009). Studies using spectrographic analyses have shown that third grade children who used larger pitch changes and larger basic declarative sentence declinations in reading, performed better on reading comprehension tests than children who used these prosodic features to a lesser extent (Miller & Schwanenflugel, 2006). Nevertheless, text reading prosody and reading comprehension share a common factor. Both
Despite the abovementioned outcomes, data on the relation between all three skills; decoding, segmental and suprasegmental phonology is still largely missing. Further, little is known about the contribution of phonology to reading comprehension in more mature readers, specifically in an orthographically transparent language. Therefore the aim of this study was to shed more light on the influence of suprasegmental phonology, next to segmental phonology, on reading comprehension outcomes in children from intermediate and upper grades of primary school. The necessity to investigate the relation between decoding, and segmental and suprasegmental phonology, and their contribution to reading comprehension, warrants a longitudinal study which takes the contribution of all three variables to reading comprehension into account. Specifically, the research questions were:

1. How are decoding, and segmental and suprasegmental phonology related over time?
2. In what way do segmental and suprasegmental phonology, in addition to decoding, predict later reading comprehension?

In order to answer the first question, the relation between decoding, and segmental and suprasegmental phonology from fourth to fifth grade was examined. We examined whether the relations between decoding efficiency, phonological awareness (phoneme deletion and spoonerisms) and text reading prosody were unidirectional or bidirectional. As it has been shown that experience in reading facilitates further development of phonological awareness (Mann, 1986; Nation & Hulme, 2011), the expectation was to find a relation from decoding to phonological awareness in these mature readers. The reversed relation, from phonological awareness to decoding, is mostly found in younger, beginning readers (e.g., Muter et al., 2004) and is therefore not expected. Regarding the relation between decoding and suprasegmental phonology, speech rhythm sensitivity (Goswami et al., 2002) and perception of rhythm and stress (Kitzen, 2001) have been shown to contribute to decoding, but this relation has not been found for text reading prosody. Text reading prosody is a reading related skill and it has been shown that children who master decoding generally use a more adult-like text reading prosody in their reading performance (Schwanenflugel et al., 2004). The relation between decoding and text reading prosody was therefore expected to be unidirectional.

The second question was answered in two parts; firstly, it was established whether there was a relation between decoding efficiency in fourth and fifth grade and reading comprehension in sixth grade. Secondly, phonological awareness (phoneme deletion and spoonerisms) and text reading prosody from fourth and fifth grade were added in order to examine the contribution of segmental and suprasegmental phonology to reading comprehension, above and beyond the
contribution of decoding. Based on the literature it was expected that the effect of decoding on reading comprehension would be less prominent for more advanced readers in a transparent orthography. We therefore expected a modest contribution of decoding to reading comprehension. When segmental and suprasegmental phonology are added to the model, we would expect the relation between decoding and reading comprehension to change. It has been shown that text reading prosody performs a mediating role between decoding and reading comprehension (Schwanenflugel et al., 2004). Further, phonological awareness tasks that included a working memory component, such as a spoonerism task, have been shown to be relatively strong predictors of reading comprehension (Cain et al., 2000). Lastly, it was expected that text reading prosody and phonological awareness will make an independent contribution to reading comprehension, as is suggested by Goswami et al. (2010).

Method

Participants
Participants were 99 primary school children (57 girls and 42 boys), who remained from the original sample of 104 participants in fourth grade. The mean age in fourth grade was 9 years and 9 months, SD = 7.6 months. Five children dropped out of the study, four children moved to another town and one child was referred to special education. A non-parametric analysis found no significant group differences in performance on any of the language tasks between the children who dropped out and the remaining 99 children. The participants came from four medium-sized, primary schools in the Eastern part of the Netherlands. The primary language of all participating children was Dutch. Children with language impairments or behavioural problems were excluded from the study. Each year, parents gave informed consent for participation of their child to the study.

Materials
Decoding efficiency. Due to the orthographically transparent nature of the Dutch language, we used the rate of pseudoword reading (efficiency) to assess decoding efficiency. Pseudowords are non-existing, but legal (in terms of phonotactics) words. Four lists with pseudowords were presented to the children (Verhoeven, in press). The word lists consisted of four categories of pseudowords: consonant-vowel-consonant words (CVC), double consonant words (CCVCC), two-syllable and multi-syllable words. For each list, children had one minute to read the pseudowords as quickly and accurately as possible. Per list, the number of correctly read words per minute was recorded. As the data on the four separate lists of the decoding task were highly correlated (r > .83), the average score over all four lists has been used for analyses. Cronbach’s alpha reliability coefficient has been reported to be greater than .85 for this task (Verhoeven, in press).

Phonological awareness. Phonological awareness was assessed in fourth grade by means of a phoneme deletion task (Verhoeven, in press). Children were aurally presented with an existing word and were asked to repeat the word while omitting the first, the second, the penultimate, or the last sound of this word. Twenty items were presented in total, thus five words per type of omission. In each case the remaining sounds formed another existing word in Dutch. As the phoneme deletion task proved to be relatively easy for the children in fourth grade, a more complex phonological awareness test was added to the test battery in fifth grade. We used a spoonerism task where children were aurally presented with the first and last name of well-known characters from TV and films. Children were asked to reverse the first sound of the first and the last name, for example, Harry Potter would become Paddy Hotter. Twelve names were presented in total and children could receive two points per name (first name and/ or last name correct).

Text reading prosody. Text reading prosody was measured by asking children to read two short, grade-level texts (approximately 100 words each). In fourth grade, one story was a folktale about a turtle and a spider and the other story was about a summer holiday. One text from fourth grade (the summer holiday) was also presented in fifth grade, together with a new grade-level text (a folktale about a tiger and a squirrel). Each year, children were instructed to first read each text silently, after which they were asked to read each text aloud. Children were instructed to read the way they would normally read in class. The text reading was recorded on an Olympus VN-S500PC digital recorder and was scored at a later time to assess text reading prosody. The Multidimensional Fluency Scale (Rasinski, 2004) was used to determine the quality of text reading prosody. This scale distinguishes four aspects of prosodic text reading. Performance on each section was marked on a scale from 1-4. The different sections were: Expression and volume (expression adapted according to storyline, level of enthusiasm), Phrasing (use of intonation and pauses to mark clause and sentence units), Smoothness (no hesitations, quickly resolving structure difficulties) and Pace (natural, conversational pace). Total scores per text could range from 4 to 16. An independent second rater scored 10 percent of the data and inter-rater reliability was assessed with an intraclass correlation (ICC), using absolute agreement and single measures. The ICC on the average score for both stories (as used for analysis) in fourth grade and fifth grade was acceptable, fourth grade: ICC = .760, F(99) = 6.72, p = .005, and fifth grade: ICC = .779, F(99) = 7.66, p = .003. Cronbach’s alpha reliability coefficient was .94 for the text reading prosody assessment in fourth grade and .93 for the assessment in fifth grade.
Reading comprehension. In order to provide a thorough assessment of reading comprehension we used three standardized tests. The first reading comprehension test (RCI) used a cloze format (Verhoeven & Vermeer, 1993). Children read two short stories (one story about the making of bread and one about big felines) and were instructed to choose the correct connective word or conjunction out of four possible options for gaps within the text (words such as ‘and’, ‘although’, ”that”, “however”). The second reading comprehension test (RCII) used the same cloze format (Verhoeven & Vermeer, 1993), but this time children were asked to select the correct content word (nouns, verbs or adjectives) for gaps within the texts of two written stories (one story was about wild animals and one about the making of paper). The missing content words referred to the coherence of the preceding or following paragraph within the text. Both reading comprehension tests (RCI and RCII) had 40 items. The third reading comprehension test (RCIII; Aarnoutse & Kapenga, 2006) presented the children with seven short texts; each followed by three multiple choice questions and two to four ‘true or false’ questions about Kapinga, 2006) presented the children with seven short texts; each followed by three multiple choice questions and two to four ‘true or false’ questions about each text. These texts were informative; topics ranged from the Olympic games and the history of folk stories, to different cultures, for example in Bali, Indonesia. The total number of items for this test was 40. Cronbach’s alpha reliability coefficient has been reported to be .80 for the first reading comprehension test (RCI), .70 for the second reading comprehension test (RCII) (Verhoeven & Vermeer, 1996) and .82 for the third reading comprehension task (RCIII) (Aarnoutse & Kapenga, 2006).

Procedure

All assessments were carried out during school hours. Data collection took place in the spring of consecutive years. The tests to assess reading comprehension were administered group-wise by the teacher. Children performed these tests silently and no time limits were set. The decoding task, phonological awareness tasks and the text reading prosody assessment were performed on an individual basis and were administrated by the first author. Individual testing was carried out in a separate room, provided by the schools. The reading measures were collected together with three other tests (not discussed in this paper). The order of the four word lists for the decoding task and the two tests for assessing text reading prosody was counterbalanced.

Data Analysis

In order to standardize the data, averaged z-scores have been calculated for text reading prosody, decoding efficiency and the phonological awareness task in fourth grade (deletion). For the two phonological awareness tasks in fifth grade (phoneme deletion and spoonerisms) and for the three reading comprehension tests in sixth grade, factor scores have been calculated. The two phonological awareness tasks in fifth grade could be reduced to one factor with an eigenvalue of 1.193, explaining 39.65 % variance. Each of the two phonological awareness tests had a loading of .77. The three reading comprehension tasks in sixth grade could also be reduced to one factor with an eigenvalue of 2.137, explaining 71.25 % variance. The cloze test assessing correct use of conjunctions (RCI) had a factor loading of .81, the cloze test assessing coherence (RCII) .87 and the third reading comprehension task (RCIII; multiple choice and true/false questions) had a factor loading of .85. The factor scores and averaged z-scores as described above have been used for the analyses.

Structural Path Modelling was used to analyse the data, using LISREL software (version 8.80, Jöreskog & Sörborn, 1996) and maximum likelihood estimation. The fit of the models was evaluated by chi-square analyses and a number of goodness of fit indices: goodness of fit index (GFI), comparative fit index (CFI), adjusted goodness of fit index (AGFI), normed fit index (NFI), and root mean square error of approximation (RMSEA). For an adequate fit the chi-square test should exceed a p value of .05 (Ullman, 2001). According to both Jaccard and Wan (1996) and Hu and Bentler (1999), the fit of a model is satisfactory when the GFI, CFI, AGFI, and NFI are greater than .90 and the RMSEA is lower than .08.

Results

Descriptives

Table 1 shows the mean and standard deviation of the raw scores for decoding efficiency, phoneme deletion and spoonerisms (segmental phonology), text reading prosody (suprasegmental phonology) and reading comprehension.

Statistical differences in the performance on decoding, text reading prosody and phoneme deletion (the recurring tasks) over the two years were examined by means of a repeated-measures analysis of variance. As the assumption of sphericity was violated Greenhouse-Geisser corrections were applied. Significant increases in the performance on each of the word lists for the decoding task were found from fourth to fifth grade: CVC word list: F(1.00, 98.00) = 141.11, p < .001, partial η2 = .59; CCVCC word list: F(1.00, 98.00) = 140.63, p < .001, partial η2 = .59; the two-syllable word list: F(1.00, 98.00) = 102.48, p < .001, partial η2 = .51; and the multi-syllable word list: F(1.00, 98.00) = 283.58, p < .001, partial η2 = .74. The performance on the recurrent text reading prosody task about the summer holiday also increased significantly from fourth to fifth grade: F(1.00, 98.00) = 79.79, p < .001, partial η2 = .45. Lastly, no significant differences in performance on the phoneme deletion task were found between fourth and fifth grade: F(2, 196) = 2.17, p = .144, partial
Relations between Decoding, Segmental and Suprasegmental Phonology

The first Structural Path Model examined the relation between decoding, and segmental and suprasegmental phonology. The correlation matrix presented above was used for this analysis. Based on the literature we expected that decoding efficiency in fourth grade would contribute to phonological awareness and text reading prosody in fifth grade. However, in order to investigate the direction of this relationship, the reversed relation, from phonological awareness and text reading prosody in fourth grade to decoding efficiency in fifth grade, was also mapped. An initial Structural Path Model, however, showed that neither phonological awareness nor text reading prosody in fourth grade contributed to decoding efficiency in fifth grade (respectively: path coefficient = -.01, t-value = -0.21, path coefficient = .06, t-value = 1.34). These paths have therefore not been included in the final model. Results of the final model are presented in Figure 1. The fit of this model was satisfactory (χ²(8, N = 99) = 8.82, p = .36, RMSEA = .03, GFI = .97, NFI = .98, CFI = 1.00, AGFI = .92). All connected paths in this path model are significant (p < .05) and dashed lines are non-significant.

Correlations

Table 2 shows bivariate correlations between the z-scores of the decoding task and the text reading prosody, and the factor scores of phonological awareness and the reading comprehension tests. There were moderate correlations between reading comprehension outcomes and decoding in fourth grade (r = .36, p < .001) and fifth grade (r = .35, p < .001). A weak but significant correlation was found between reading comprehension scores and phoneme awareness in fourth grade

\[ r = .23, p = .022 \] and a moderate correlation between reading comprehension and phoneme awareness in fifth grade (r = .51, p < .001). Moderate correlations were also found between reading comprehension scores and text reading prosody in fourth grade (r = .49, p < .001), as well as in fifth grade (r = .58, p < .001).

Table 1 Means and Standard Deviations (raw scores) for Decoding Efficiency, Phoneme Deletion, Spoonerisms, Text Reading Prosody and Reading Comprehension (N=99)

<table>
<thead>
<tr>
<th></th>
<th>4th grade</th>
<th>5th grade</th>
<th>6th grade</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Decoding efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decoding CVC</td>
<td>66.22</td>
<td>18.24</td>
<td>78.60</td>
</tr>
<tr>
<td>Decoding CCVCC</td>
<td>50.84</td>
<td>18.34</td>
<td>61.73</td>
</tr>
<tr>
<td>Decoding two-syllable</td>
<td>31.74</td>
<td>12.50</td>
<td>38.95</td>
</tr>
<tr>
<td>Decoding multi-syllable</td>
<td>23.36</td>
<td>9.44</td>
<td>28.60</td>
</tr>
<tr>
<td>Phonological awareness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoneme deletion (max. 20)</td>
<td>19.00</td>
<td>1.34</td>
<td>18.66</td>
</tr>
<tr>
<td>Spoonerisms (max. 24)</td>
<td></td>
<td>20.82</td>
<td>2.83</td>
</tr>
<tr>
<td>Suprasegmental phonology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text reading prosody</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosody story 'turtle'</td>
<td>11.70</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>Prosody story 'holiday'</td>
<td>11.35</td>
<td>2.68</td>
<td>12.73</td>
</tr>
<tr>
<td>Prosody story 'tiger'</td>
<td>12.89</td>
<td>2.21</td>
<td></td>
</tr>
<tr>
<td>Reading comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RC (max. 40)</td>
<td>37.62</td>
<td>3.65</td>
<td></td>
</tr>
<tr>
<td>RCII (max. 40)</td>
<td>31.36</td>
<td>3.73</td>
<td></td>
</tr>
<tr>
<td>RCIII (max. 40)</td>
<td>31.11</td>
<td>5.30</td>
<td></td>
</tr>
</tbody>
</table>

Note. */+ = correctly read words per minute, + = Multidimensional Fluency Scale (Rasinski, 2004), maximum score was 16, RC = reading comprehension: cloze (conjunctions), RCII = reading comprehension: cloze (coherence), RCIII = reading comprehension: multiple choice questions.

\[ r^2 = .02 \] This is most likely due to the fact that the performance on the phoneme deletion task in fourth grade was close to ceiling; therefore a second phonological awareness task was introduced in fifth grade.

Table 2 Bivariate Correlations between Decoding Efficiency, Phonological Awareness, Text Reading Prosody and Reading Comprehension (N=99)

<table>
<thead>
<tr>
<th></th>
<th>4th grade</th>
<th>5th grade</th>
<th>6th grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 4th</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA 4th</td>
<td>.21*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pros 4th</td>
<td>.58**</td>
<td>.16</td>
<td></td>
</tr>
<tr>
<td>Dec 5th</td>
<td>.93***</td>
<td>.19</td>
<td>.58***</td>
</tr>
<tr>
<td>PA 5th</td>
<td>.43***</td>
<td>.33**</td>
<td>.38***</td>
</tr>
<tr>
<td>Pros 5th</td>
<td>.59***</td>
<td>.13</td>
<td>.84***</td>
</tr>
<tr>
<td>RC 6th</td>
<td>.36***</td>
<td>.23</td>
<td>.49***</td>
</tr>
</tbody>
</table>

Note. Dec = decoding efficiency, PA = phonological awareness, Pros = text reading prosody, RC = reading comprehension, * p = < .05, ** p = < .01, *** p = < .001.
Firstly, Figure 1 shows that phonological awareness in fourth grade only moderately predicted phonological awareness in fifth grade. This is most likely due to the limited amount of variance in the phoneme deletion task in fourth grade and the subsequent addition of the more complex spoonerism task in fifth grade. Both decoding and text reading prosody in fourth grade strongly predicted the performance on the same skill in fifth grade. Decoding efficiency in fourth grade contributed to phonological awareness as well as to text reading prosody in fifth grade.

Prediction of Reading Comprehension

The second Structural Path Model firstly examined the contribution of decoding efficiency to reading comprehension (Figure 2, i). The fit of this model was satisfactory ($\chi^2(1, N = 99) = 0.98, p = 0.32, \text{RMSEA} = 0.00, \text{GFI} = 0.99, \text{NFI} = 0.99, \text{CFI} = 1.00, \text{AGFI} = 0.96$). Decoding efficiency from fourth and fifth grade contributed to reading comprehension outcomes in sixth grade. The proportion of explained variance in reading comprehension scores was quite low: $R^2 = 0.12$. All paths in Figure 2 are significant ($p < 0.05$).

The bottom part of Figure 2 (ii) shows the extended Structural Path Model in which the contribution of segmental and suprasegmental phonology were added to decoding efficiency. This path model had a satisfactory fit ($\chi^2(11, N = 99) = 9.90$, $p = 0.54$, RMSEA = 0.000, GFI = 0.97, NFI = 0.98, CFI = 1.00, AGFI = 0.93). The proportion of explained variance in reading comprehension scores was moderate: $R^2 = 0.39$. All connected paths in this path model are significant ($p < 0.05$) and dashed lines are non-significant. Regarding the contribution to reading comprehension, phonological awareness and text reading prosody in fifth grade contributed directly to reading comprehension outcomes in sixth grade, whereas fifth grade decoding efficiency no longer contributed. However, decoding efficiency in fourth grade contributed to both phonological awareness and text reading prosody in fifth grade. Therefore, the relation between decoding and reading comprehension between fifth and sixth grade became indirect, via segmental phonology and suprasegmental phonology.
Discussion

The aim of this study was, firstly, to determine the relation between decoding, and segmental and suprasegmental phonology from fourth to fifth grade and, secondly, to determine the contribution of these skills to reading comprehension in sixth grade.

The Relation between Decoding, Segmental and Suprasegmental Phonology

The first Structural Path Model showed that fourth grade decoding efficiency contributed to phonological awareness one year later. This is in accordance with the idea that advanced reading skills may facilitate development of further phonological awareness skills (e.g., Mann, 1986; Nation & Hulme, 2011). This relation was unidirectional, as expected, as phonological awareness in fourth grade did not contribute to decoding in fifth grade. The absence of this contribution may be due to the fact that the children in the current study were between 9 and 12 years-of-age and therefore quite advanced readers. Phonological awareness has been shown to contribute to decoding ability mostly in early readers (Melby-Lervåg et al., 2012). Another possible reason for this absent contribution, and a limitation of the current study, is that the performance on the phoneme deletion task in fourth grade was at ceiling level. This might have influenced the level of prediction.

Decoding efficiency in fourth grade also contributed to text reading prosody in fifth grade. This was expected because text reading prosody is a reading-dependent measure. It has been proposed that efficient and automatized decoding frees up cognitive resources which can be used for prosodic processing (Schwanenflugel et al., 2004). Moreover, Miller and Schwanenflugel (2006) found that, once automatic word- and text-level skills are acquired, more adult-like text reading prosody emerges in reading. Regarding the reversed relation, text reading prosody did not predict decoding one year later. Previous research proposed that prosodic sensitivity provides cues which facilitate segmenting the speech stream and identifying phonemes (Holliman, Wood, & Sheehy, 2008, 2012; Wood, 2006). However, Holliman et al. (2008, 2012) used perception of word-level and phrase-level prosody in speech whereas the current study examined productive, text-level prosody. Text-level prosody relies more on aspects such as syntactic parsing (Kentner, 2012), intonational phrase boundaries (Steinhauer, Alter, & Friederici, 1999; Steinhauer, 2003), and given versus new information (Bock & Mazella, 1983). These are important aspects in reading comprehension. Furthermore, in oral text reading, aspects such as morphemic, pragmatic, syntactic and semantic cues would have to be unified into one prosodic representation (Frazier, Carlton and Clifton, 2006), which largely extends reading at the word-level. In contrast to text reading performance, perception of word- and phrase-level speech prosody relies more on aspects such as stress patterns (Holliman, Wood, & Sheehy, 2008, 2012; Whalley & Hansen, 2006), which could be more useful for decoding.

To summarize, the results showed that decoding efficiency is still an important base-level skill, even for more advanced readers, and that the relation between decoding and segmental and suprasegmental phonology is unidirectional in the upper primary grades.

The Prediction of Reading Comprehension

The first step of the second path model showed that decoding efficiency in fourth and fifth grade contributed to reading comprehension outcomes in sixth grade, confirming results from previous research (e.g., Perfetti, 2007; Perfetti & Hart, 2002). This contribution changed, however, when segmental and suprasegmental phonology were added to the model, as was expected. The second step of this path model showed that phonological awareness, as a measure of segmental phonology, and text reading prosody, as a measure of suprasegmental phonology, contributed directly to reading comprehension in sixth grade and that the influence of decoding was no longer significant. This suggests that the relation between decoding and reading comprehension becomes indirect when phonology measures are taken into account.

The contribution of phonological awareness to reading comprehension may be explained by the fact that phonological awareness was measured by a spoonerism task in fifth grade. A spoonerism task can be seen as a more complex phonological awareness task that taxes higher-level, working-memory dependent phonological processing, which may also be important in reading comprehension. Indeed, Cain et al. (2000) showed that memory-dependent phonological awareness tasks strongly predicted reading comprehension, even after controlling for IQ, vocabulary and word reading abilities, whereas less memory-dependent tasks did not. The memory-dependent phonological awareness task used in the current study may therefore have increased the relation between segmental phonology and reading comprehension. In turn, efficient decoding may have facilitated the memory component of the spoonerism task; as fewer cognitive resources were needed for the coupling of phonology and orthography; more resources were available for the higher-level processing that this task demanded.

A key finding in this study was the contribution of suprasegmental phonology to reading comprehension, in addition to segmental phonology. This result is in line with the relation between text reading prosody and reading comprehension found in intermediate and upper grade school children (Rasinski et al., 2009).
However, the study by Rasinski et al. (2009) was not longitudinal in design and did not include segmental phonology or decoding efficiency. The current study showed that text reading prosody is not only related to reading comprehension, but even predicts reading comprehension one year later. A theoretical explanation for the role of text reading prosody as facilitator of reading comprehension is that the use of prosody aids the extraction of the syntactic structure from a sentence (Koriat, Greenberg, & Kreiner, 2002) as well as the facilitation of parsing processes (Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). Furthermore, Frazier, Carlson and Clifton (2006) suggested that text reading prosody might play a role in solving the ‘binding’ problem of language. A text passage can be divided in different ways; words may either be units in a phonological representation or units in a syntactic representation, and these are not necessarily the same. Frazier et al. (2006) proposed that the prosodic representation of a sentence aids the unification of a sentence. When children perform a silent reading comprehension test, it is therefore possible that an internal phonological representation of the text facilitates their comprehension of the text. The results from the current study could therefore be explained by taking an interactive perspective in which the complex segmental phonological awareness task taxes memory-dependent processes, whereas the suprasegmental phonology task touches upon higher-order sentence unification processes. Neurocognitive studies showed that both these processes constitute a neural network which optimally fosters reading comprehension (Hagoort, 2005; Snijders et al., 2009).

The mediation of suprasegmental phonology between decoding and reading comprehension as found in the current study should also be seen in the light of the high orthographic-phonological consistency in Dutch. The contribution of text reading prosody to later reading comprehension can be examined more directly in a transparent orthography, as decoding difficulties generally do not occur that often in reading performances, even in more complicated texts. For children learning to read in English, a mastery level in reading efficiency may occur at a later age than for children learning to read in more transparent orthographies. Therefore, in studies on opaque orthographies, decoding often remains more influential in reading comprehension compared to suprasegmental phonology, such as text reading prosody (e.g., Schwanenflugel et al., 2004).

Another important consideration is the type of reading instruction that children receive in the Netherlands. Phonics instruction is the most prevailing type of early reading instruction for Dutch children (Reitsma & Verhoeven, 1990). Decoding is well developed by third grade and from fourth grade onwards the focus shifts more towards development of spelling, vocabulary and reading comprehension (Aarnoutse, Van Leeuwe, Voeten, & Oud, 2001; Reitsma, & Verhoeven, 1990). This basis in phonics instruction could partly explain the relatively strong relation between phonological awareness and reading comprehension. Future studies should investigate whether the results from the current study could be generalized to children who have received different types of reading instruction or to children who learn to read in a more opaque language.

Conclusion
To conclude, the present study showed that there is a unidirectional relation from decoding to segmental as well as to suprasegmental phonology. Further, it was shown that the relation between decoding and reading comprehension becomes indirect when segmental and suprasegmental phonology were taken into account. Both factors were shown to independently contribute to later reading comprehension.

Chapter 5 Phonology and reading comprehension


Bidirectional Relations between Text Reading Prosody and Reading Comprehension in the Upper Primary School Grades: A Longitudinal Perspective

Based on:
Chapter 6 Longitudinal evidence

Abstract

The purpose of this study was to examine the directionality of the relationship between text reading prosody and reading comprehension in the upper grades of primary school. We compared three theoretical possibilities: Two unidirectional relations from text reading prosody to reading comprehension and from reading comprehension to text reading prosody and a bidirectional relation between text reading prosody and reading comprehension. Further, we controlled for autoregressive effects and included decoding efficiency as a measure of general reading skill. Participants were 99 Dutch children, followed longitudinally, from fourth to sixth grade. Structural equation modelling showed that the bidirectional relation provided the best fitting model. In fifth grade, text reading prosody was related to prior decoding and reading comprehension, whereas in sixth grade, reading comprehension was related to prior text reading prosody. As such, the results suggest that the relation between text reading prosody and reading comprehension is reciprocal, but dependent on grade level.

Bidirectional Relations between Text Reading Prosody and Reading Comprehension in the Upper Primary School Grades: A Longitudinal Perspective

Recent studies have consistently shown that text reading prosody—a constituent of text reading fluency—and reading comprehension are associated (Benjamin & Schwanenflugel, 2010; Kuhn & Stahl, 2003; Miller & Schwanenflugel, 2006, 2008; Rasinski, Rikli, & Johnston, 2009; Veenendaal, Groen, & Verhoeven, 2014, 2015). Text reading prosody refers to the extent to which children use appropriate intonation, such as phrasing, use of pauses, and signalling of word boundaries which makes reading aloud sound more like natural speech. One of the outstanding questions in the current literature is the direction of the relationship between text reading prosody and reading comprehension. It has proved difficult to determine whether text reading prosody facilitates reading comprehension (Kentner, 2012; Kuhn, Schwanenflugel, & Meisinger, 2010; Rasinski et al., 2009) or whether text reading prosody is a reflection of the level of text comprehension (Torgesen & Hudson, 2006). The purpose of this study was to investigate this directionality by comparing three theoretical possibilities. In order to do so, we compared two unidirectional relations, from text reading prosody to reading comprehension and from reading comprehension to text reading prosody, and a bidirectional relation between text reading prosody and reading comprehension. We examined these relations in advanced Dutch readers from fourth to sixth grade. Importantly, as text reading prosody and reading comprehension are both reading-dependent measures, decoding efficiency—the fast and accurate retrieval of the phonological code for written words—as a measure of general reading skill, was added to the models.

Text reading fluency has traditionally been defined as the ability to read a connected text quickly and accurately (e.g., Fuchs, Fuchs, Hosp, & Jenkins, 2001), and a child’s ability to do so has been found to be related to their reading comprehension level (e.g., Berninger et al., 2010; Kim, Wagner, & Lopez, 2012; Kim & Wagner, 2015). Two recent longitudinal studies showed that text reading fluency mediated between, on the one hand, word reading and listening comprehension, and on the other hand, reading comprehension (Kim et al., 2012; Kim & Wagner, 2015). The mediating role of text reading fluency appeared as soon as children became beginning readers in first grade (Kim et al., 2012) and the relation between text reading fluency and reading comprehension remained stable from second to fourth grade (Kim & Wagner, 2015). In recent years, though, not only the child’s ability to read a text quickly and accurately, but also their ability to read it with appropriate prosody (i.e., text reading prosody) has been found to be associated with reading comprehension (e.g., Benjamin & Schwanenflugel, 2010; Calet, Defior, & Gutiérrez-Palma, 2013; Miller & Schwanenflugel, 2006, 2008; Rasinski et al., 2009).
Apart from correlations between text reading prosody and reading comprehension (e.g., Rasinski et al., 2009), studies also showed that text reading prosody accounted for substantial variance in reading comprehension, in addition to rate and accuracy (Klauda & Guthrie, 2008). Further, it was shown that early text reading prosody contributed to later reading comprehension (Miller & Schwanenflugel, 2008).

Although most studies showed that these two skills are associated, studies examining the directionality of this relationship are rare. This is partly due to the methodological requirements needed to examine this. Because it takes time for a cause to have an effect, evidence of bidirectional relations requires longitudinal data (Gollob & Reichardt, 1987). Currently, longitudinal studies including text reading prosody are scarce. Moreover, when performing longitudinal studies it is important to control for autoregressive effects. The largest contribution to later reading comprehension is most likely the level of reading comprehension at a prior time (Gollob & Reichardt, 1987). It is therefore important to determine the relation between text reading prosody and reading comprehension, above and beyond autoregressive effects.

Theoretically, three possibilities in this directionality exist: Unidirectional relations can be from text reading prosody to reading comprehension or from reading comprehension to text reading prosody, or a bidirectional relation can exist between these two skills. Evidence for each of these theoretical relations will be discussed in the light of the above described methodological requirements.

**Text Reading Prosody as Facilitator of Reading Comprehension**

The first theoretical model proposes that text reading prosody facilitates reading comprehension. The theoretical reasoning behind this model is that text reading prosody would assist in the attribution of syntactic roles to words within sentences (e.g., Koriat, Kreiner, & Greenberg, 2002). Prosody in oral speech has been shown to facilitate segmenting sentences into syntactically and semantically correct chunks, for example, in ambiguous instructions, such as: “Tickle the frog with a feather” (Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). Awareness of syntactically and semantically correct chunks is also important in text reading prosody. It has been proposed that chunking could aid memory processes in reading comprehension, as chunks of texts are easier to recall than individual words (Frazier, Carlson, & Clifton, 2006).

Evidence for the role of text reading prosody as a facilitator of reading comprehension was provided by Schwanenflugel, Hamilton, Kuhn, Wisenbaker and Stahl (2004). This study examined the directionality between decoding, text reading prosody and reading comprehension in second and third grade children. The results showed a modest relation between an adult-like intonation contour and reading comprehension. Importantly, no evidence was found for a reversed relation, from reading comprehension to text reading prosody (Schwanenflugel et al., 2004). However, a problem with interpreting these results is that this study was cross-sectional, therefore the contribution to later reading comprehension remains unclear. One of the few longitudinal studies that exist, examined the contribution of text reading prosody in first and second grade, to reading comprehension outcomes in third grade (Miller & Schwanenflugel, 2008). This study showed that children with a decreasing number of pauses in their oral reading from first to second grade and an early adult-like intonation contour, performed better on a reading comprehension test in third grade. Even though the results seem to point in the direction of a facilitating effect of text reading prosody on later reading comprehension, this study did not examine the reversed relation from reading comprehension to text reading prosody. Moreover, reading comprehension scores from first and second grade were not included, therefore, autoregressive effects could not be established.

A more recent longitudinal study, in the lower primary grades, did control for autoregressive effects (Lai, Benjamin, Schwanenflugel, & Kuhn, 2014). The direction of the relationship between reading fluency (a latent variable including decoding, text reading rate and text reading prosody) and reading comprehension was measured at three times points in second grade. It was concluded that there was a unidirectional relation, from reading fluency to reading comprehension (Lai et al., 2014).

**Text Reading Prosody as Reflection of Reading Comprehension**

A second theoretical model suggests that the quality of text reading prosody is a reflection of the level of text comprehension. As far as we know, there is little evidence of a unidirectional relation from reading comprehension to text reading prosody. Nevertheless, research has shown that text reading fluency—measured as speed and accuracy—was correlated with a reading comprehension test by 91% in middle- and high school students (Fuchs et al., 2001). This correlation was higher than with other reading comprehension tests which the authors saw as evidence that the level of text reading fluency reflected the level of reading comprehension (Fuchs et al., 2001). Another study showed that reading comprehension explained 28% additional variance in text reading fluency performance, after word reading fluency was controlled for (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). Apart from the fact that these studies did not include text reading prosody, neither of these studies was longitudinal in design. Therefore, directional effects cannot fully be established. Hypothetically, as text reading prosody is a part of text reading fluency and related to syntactic and semantic processing of sentences (e.g., Koriat et al., 2002; Snedeker & Yuan, 2008; Snedeker & Trueswell, 2003), it is not implausible that text reading prosody would (at least partly) reflect the level of text understanding.
Bidirectional Relation between Text Reading Prosody and Reading Comprehension

The third theoretical model proposes that the relation between text reading prosody and comprehension is bidirectional. Bidirectional relations have mostly been found in older, more proficient readers (Klauda & Guthrie, 2008; Ravid & Mashraki, 2007). It has been proposed that the prosodic structure of a text is more accessible to skilled readers than to beginning readers (Ravid & Mashraki, 2007), which may aid comprehension. On the other hand, a better understanding of the syntactic structure of a text and of the context may facilitate a correct use of text reading prosody. Evidence for this comes from interactive theories of reading which suggest that context is used to facilitate word identification and prediction of sentence structure (e.g., Stanovich, 1991, 1984).

Only a few studies have investigated the bidirectionality of the relation between text reading prosody and reading comprehension. Ravid and Mashraki (2007) found that, in Hebrew-speaking children from fourth grade, text reading prosody contributed to reading comprehension, but the reversed relation was also found. However, this study was cross-sectional in design, therefore, the direction of this relationship over a longer time cannot be determined. Klauda and Guthrie (2008) examined longitudinal relations in fifth grade children by determining the contribution of the separate components of text reading fluency to reading comprehension outcomes 12 weeks later. They showed that accuracy and rate, as well as text reading prosody, predicted reading comprehension, when word recognition was controlled for. Furthermore, they found a bidirectional relationship between rate and accuracy of text reading and reading comprehension, but not between text reading prosody and reading comprehension (Klauda & Guthrie, 2008). Because the authors did not control for autoregressive effects, the actual relation, above and beyond autoregressive effects, remains unclear.

The Present Study

Studies investigating the direction of the relation between text reading prosody and reading comprehension are limited in light of the methodological requirements needed to determine directionality. One recent longitudinal study took these requirements into account but used a restricted time span, of three time points within one school year (Lai et al., 2014). Furthermore, the children in this study were relatively young and not yet very skilled in reading. It is therefore not known whether a unidirectional relation from text reading prosody to reading comprehension, as reported by Lai et al., (2014), would also be found in older, more advanced readers.

Furthermore, existing studies into the relation between text reading prosody and reading comprehension have not always included decoding (e.g., Rasinski et al., 2009), or used a latent variable that included decoding, speed and accuracy of text reading, and text reading prosody (e.g., Lai et al., 2014). It is important to disentangle these skills because decoding is a foundation skill for text reading fluency (Pikulski & Chard, 2005; Wagner & Espin, 2015), including text reading prosody (Kuhn & Stahl, 2003; Miller & Schwaneflugel, 2006), and reading comprehension (Beck & Juel, 1995; LaBerge & Samuels, 1974; Perfetti, 2007; Perfetti & Hart, 2002). However, decoding mostly contributes to early reading comprehension and its effect is generally weaker at the end of primary school (Kim & Wagnier, 2015; Tilsta, McMaster, van den Broek, Kendeou, & Rapp, 2009; Verhoeven & van Leeuwe, 2008, 2009). More importantly, the relation between text reading prosody and reading comprehension is suggested to be age-dependent, or more specifically, dependent on the level of automaticity in decoding (Wood, Wade-Woolley & Holliman, 2009). That, in turn, makes it interesting to examine these relations in a transparent orthography such as Dutch, as decoding has been found to be established at an earlier age in transparent orthographies (Aro & Wimmer, 2003; Seymour, Aro, & Erskine, 2003; Share, 2008).

The relevance of the current study is, therefore, that we examined the direction of the relationship between text reading prosody and reading comprehension over a period of three grade levels and in older, Dutch primary school children (fourth to sixth grade). Also, we took decoding efficiency into account as a measure of general reading ability. Further, we included autoregressive effects on all three skills, to fulfill the methodological requirements for studies into directionality. In order to compare the three theoretical possibilities regarding the relationship between text reading prosody and reading comprehension we compared three Structural Path Models: (i) a unidirectional relation from text reading prosody to reading comprehension, (ii) a unidirectional relation from reading comprehension to text reading prosody, and (iii) a bidirectional relation between text reading prosody and reading comprehension.

Method

Participants

Participants were 99 primary school children (57 girls and 42 boys), from an original sample of 106 participants in fourth grade. The mean age in fourth grade was 9 years and 9 months, SD = 7.6 months. The participants came from four medium sized, primary schools in the Eastern part of the Netherlands, which is relatively rural. From each school, only one class of children participated. The composition of the four classes that participated in the current study was identical from fourth to sixth grade. Ninety-six percent of the children had Dutch parents, 4 percent...
of the children had one or two parents of non-Western European descent. The primary language of all participating children was Dutch and they predominantly came from middle-class families. The average vocabulary score of the children was in the 50th percentile. Parents gave informed consent for the participation of their child in the study in each year.

Materials
Decoding efficiency. Due to the transparent Dutch orthography we assessed the number of correctly read pseudowords per minute, rather than sight word efficiency. Pseudoword reading could be seen as a more sensitive measure to distinguish between poor and strong readers since Dutch children already read 90% of existing words correctly after only one year of formal reading instruction (Seymour et al., 2003). A standardized pseudoword reading test was used to assess decoding efficiency in each year (Verhoeven, in press). Four lists with pseudowords were presented to the children and each list consisted of one of four categories of pseudowords: consonant-vowel-consonant (CVC) items (e.g., laas), double consonant (CC) items (e.g., stoef), two-syllable items (e.g., gluifel) and multi-syllable items (e.g., waagdoller). For each list, children had one minute to read the pseudowords as quickly and accurately as possible. The number of correctly read pseudowords per minute (rate) was recorded for each list. The norm research report states a substantial Cronbach alpha for this task (α > .85) (Verhoeven, in press). In additional support of this we calculated a sample-based Cronbach’s alpha over the data from the first year, which was .99 for the four word lists taken together (as used for analyses).

Text reading prosody. In each consecutive year, two short, grade-level stories (approximately 100 words each) were used. In fourth grade, one story was about a cycling holiday and the other story was a folktale about a turtle and a spider. The story about the cycling holiday was presented again in fifth grade, together with a new folktale about a tiger and a squirrel. In sixth grade, a folktale about a crane and a fox was presented, in addition to the folktale from fifth grade. To establish the appropriate grade level, a Dutch readability measure was used based on average word length (syllables per word) and sentence length (words per sentence) (Visser, 1997). The level of this readability measure increased from fourth grade to sixth grade, and therefore the complexity of the (second) text also increased each year. Children were instructed to first read a text silently and then read aloud, in the way they would normally read in class. Text reading performance was recorded and the Multidimensional Fluency Scale (Rasinski, 2004) was used to score text reading prosody. This scale distinguishes four sections related to text reading prosody. The different sections were: A) Expression and volume (varies expression and volume to match interpretation of the passage), B) Phrasing (generally reads with good phrasing), C) Smoothness (generally reads smoothly without hesitations) and D) Pace (consistently reads at conversational pace, not too slow and not too fast). Performance on each section was marked on a scale from 1-4, and total scores per text could thus range from 4 to 16. Cronbach’s alpha was .94 in fourth grade, .93 in fifth grade and .92 in sixth grade.

The ratings of text reading prosody were performed by the first author. Ten percent of the data was scored by an independent rater (60 stories). Inter-rater reliability was determined by rater agreement percentages and intraclass correlation coefficients (ICC). Intraclass correlation coefficients are generally seen as more suitable for examining relations among variables from a common class (the same assessment) than interclass correlation coefficients (McGraw & Wong, 1996). Interpreting the output is similar to Cohen’s Kappa. We used ‘absolute agreement’ (rather than consistency) and ‘single measures’ (rather than average measures) as these are appropriate and more stringent measures for interrater reliability of individual scores (McGraw & Wong, 1996). Rater agreement percentages on each section of the scale (A-D) were 43% exact agreement and 46% adjacent agreement in fourth grade, 58% exact agreement and 36% adjacent agreement in fifth grade and 64% exact agreement and 36% adjacent agreement in sixth grade. The ICC on the average score for both stories in one year (as used for analysis) was substantial, fourth grade: ICC = .760, F(9,9) = 6.72, p = .005, fifth grade: ICC = .779, F(9,9) = 7.66, p = .003 and sixth grade: ICC = .829, F(9,9) = 12.21, p < .001.

Reading comprehension. Two standardized reading comprehension tests for children in intermediate and upper grades were presented to the children in each of the three years (Verhoeven & Vermeer, 1993). In the first reading comprehension test (RCI) children read two short stories. One story about the making of bread and one about big felines. Children were instructed to choose the correct connective word or conjunction out of four possible options for gaps within the text (words such as ‘and’, ‘although’, ‘however’). The second reading comprehension test (RCII) used the same cloze format with two different texts (one story was about wild animals and one about the making of paper), but this time children were asked to select the correct content word (nouns, verbs or adjectives). The missing content words referred to the coherence of the preceding or following paragraph within the text. Both reading comprehension tests had 40 items. The test manual reports a substantial Cronbach alpha for both reading comprehension tests: RCI α > .88 and RCII α > .75 (Verhoeven & Vermeer, 1996). Additionally, we calculated a sample-based Cronbach’s alpha over the data from the first year, this was .87 for RCI and RCII taken together (as used for analyses).
Chapter 6 Longitudinal evidence

Results

Descriptives

Table 1 shows means and standard deviations of the raw scores for each of the tasks of decoding efficiency, text reading prosody, and reading comprehension in fourth, fifth and sixth grade. The results of the interrater reliability analysis of the text reading prosody assessment can also be found in Table 1.

Table 1 Means and Standard Deviations for Raw Scores on Decoding Efficiency, Text Reading Prosody and Reading Comprehension (N=99).

<table>
<thead>
<tr>
<th></th>
<th>4th grade M</th>
<th>SD</th>
<th>5th grade M</th>
<th>SD</th>
<th>6th grade M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decoding efficiency</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Decoding CVC a</td>
<td>66.22</td>
<td>18.24</td>
<td>78.60</td>
<td>20.88</td>
<td>85.06</td>
<td>20.15</td>
</tr>
<tr>
<td>Decoding CCVCC a</td>
<td>50.84</td>
<td>18.34</td>
<td>61.73</td>
<td>20.78</td>
<td>68.39</td>
<td>20.65</td>
</tr>
<tr>
<td>Decoding two-syllable a</td>
<td>31.74</td>
<td>12.50</td>
<td>38.95</td>
<td>14.54</td>
<td>44.57</td>
<td>14.87</td>
</tr>
<tr>
<td>Decoding multi-syllable a</td>
<td>23.36</td>
<td>9.44</td>
<td>28.60</td>
<td>10.56</td>
<td>33.90</td>
<td>11.42</td>
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<tr>
<td><strong>Text reading prosody (max. 16)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosody: turtle &amp; spider b</td>
<td>11.70</td>
<td>2.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosody: cycling holiday b</td>
<td>11.35</td>
<td>2.68</td>
<td>12.89</td>
<td>2.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosody: tiger &amp; squirrel b</td>
<td>12.73</td>
<td>2.37</td>
<td></td>
<td></td>
<td>13.76</td>
<td>2.05</td>
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<tr>
<td>Prosody: crane &amp; fox b</td>
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<tr>
<td><strong>Reading comprehension</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>RCI (max. 40) c</td>
<td>33.17</td>
<td>5.91</td>
<td>36.40</td>
<td>3.50</td>
<td>37.62</td>
<td>3.65</td>
</tr>
<tr>
<td>RCIi (max. 40) c</td>
<td>26.60</td>
<td>4.67</td>
<td>29.74</td>
<td>4.64</td>
<td>31.36</td>
<td>3.73</td>
</tr>
</tbody>
</table>

Note. * = correctly read words per minute, " = Multidimensional Fluency Scale (Rasinski, 2004), " = average number of correct responses.

Procedure

All assessments were carried out during school hours. Data collection took place in the spring of three consecutive years. The tests to assess reading comprehension were administered group-wise by the teacher. Children made these tests silently and no time limits were set. The other assessments were performed on an individual basis and were administered in two separate sessions by the first author. Individual testing was carried out in a separate room, provided by the schools. The text reading prosody data were collected along with three other tests (not discussed in this paper) in one session and the decoding data were collected in another session (together with two other tests not discussed here). Parts of these data were reported in earlier papers, where we examined cross-sectional relationships between text reading prosody and reading comprehension (authors, 2015, 2014).

Data Analysis

The text reading prosody, decoding efficiency and reading comprehension data were converted into averaged z-scores. Structural Path Modelling was used to analyse the data, using LISREL software (version 8.80, Jöreskog & Sörborn, 1996) and maximum likelihood estimation. We firstly identified model fit to establish whether the models could be interpreted. For an adequate fit the chi-square test should exceed a p value of .05 (Ullman, 2001). The chi-square can be sensitive to sample size, however, therefore we also included the Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI), the Normed Fit Index (NFI), the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximations (RMSEA). Of these, the CFI and RMSEA are the more robust indices for smaller sample sizes (Fan, Thompson, & Wang, 1999). According to both Jaccard and Wan (1996) and Hu and Bentler (1999), the fit of a model is satisfactory when the GFI, CFI, AGFI, and NFI are greater than .90 and the RMSEA is lower than .08.

In order to examine the existence of a unidirectional or bidirectional relation between text reading prosody and reading comprehension, we contrasted model fit of the unidirectional models to the bidirectional model, using chi-square difference tests.

Differences in performance on each skill over the three years were examined by means of a repeated-measures analysis of variance. Greenhouse-Geisser corrections were applied when the data violated the assumption of sphericity. The performance on each of the word lists of the decoding task differed significantly between fourth-, fifth-, and sixth-grade: CVC word list: $F(1.93, 188.96) = 155.36, p < .001$, partial $\eta^2 = .61$; CCVCC word list: $F(1.93, 189.22) = 167.66, p < .001$, partial $\eta^2 = .74$; the two-syllable word list: $F(1.96, 191.54) = 153.72, p < .001$, partial $\eta^2 = .61$; and the multi-syllable word list: $F(1.96, 192.39) = 158.01, p < .001$, partial $\eta^2 = .62$. Post-hoc tests (LSD) revealed that the scores from fourth-
fifth-grade and from fifth- to sixth-grade improved significantly on all four word lists (p < .001).

The performance on the recurrent text reading prosody text about the cycling holiday also differed significantly between fourth-, fifth-, and sixth-grade: F(1,00, 98.00) = 79.79, p < .001, partial η² = .45, just as the performance on the recurrent story about the tiger and the squirrel: F(1,00, 98.00) = 53.39, p < .001, partial η² = .35. Post-hoc tests revealed that scores improved significantly from fourth- to fifth-grade and from fifth- to sixth-grade (p < .001). Lastly, scores on each of the reading comprehension tests also differed significantly between fourth-, fifth-, and sixth-grade: RC1: F(1,77, 173.82) = 52.72, p < .001, partial η² = .35, and RCII: F(1, 182.99) = 66.93, p < .001, partial η² = .41. Post-hoc tests revealed that the scores on RC-I improved from fourth to fifth-grade (p = .001) and from fifth to sixth grade (p < .001), as did the scores on RCII from fourth- to fifth-grade and from fifth- to sixth-grade (p < .001).

Correlations
Table 2 shows bivariate correlations between decoding efficiency, text reading prosody and reading comprehension across all three grades. There was a weak correlation between decoding efficiency in fourth grade and reading comprehension in fifth grade (r = .23, p = .024) and a moderate correlation between decoding efficiency in fifth grade and reading comprehension in sixth grade (r = .36, p < .001). Moderate to strong correlations were found between decoding efficiency in fourth grade and text reading prosody in fifth grade (r = .59, p < .001), and between decoding efficiency in fifth grade and text reading prosody in sixth grade (r = .65, p < .001). A moderate correlation was found between text reading prosody in fourth grade and reading comprehension in fifth grade (r = .32, p = .001) and between text reading prosody in fifth grade and reading comprehension in sixth grade (r = .57, p < .001).

Structural Path Models
The first Structural Path Model (i) examined a unidirectional relation from text reading prosody to reading comprehension (Figure 1). The correlation matrix from the previous section was used for this analysis. The fit indices of this path model were as follows: χ²(18, N = 99) = 30.09, p = .018, RMSEA = .08, GFI = .94, NFI = .97, CFI = .99, AGFI = .84.

The proportion of explained variance in text reading prosody was R² = .75 and the explained variance in reading comprehension was R² = .63, in sixth grade. This path model firstly shows that, similar to decoding efficiency and reading comprehension, the strongest predictor for text reading prosody was text reading prosody one year earlier (the autoregressive effect). Regarding the direction of

<p>| Table 2 Bivariate Correlations between averaged Z-scores of Decoding Efficiency, Text Reading Prosody and Reading Comprehension in Fourth-, Fifth-, and Sixth-grade (N=99) |
|---------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|</p>
<table>
<thead>
<tr>
<th>Dec 4th</th>
<th>Dec 5th</th>
<th>Dec 6th</th>
<th>Pros 4th</th>
<th>Pros 5th</th>
<th>Pros 6th</th>
<th>RC 4th</th>
<th>RC 5th</th>
<th>RC 6th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 4th</td>
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<tr>
<td>Dec 5th</td>
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<tr>
<td>Dec 6th</td>
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<tr>
<td>Pros 4th</td>
<td>.58**</td>
<td>.58**</td>
<td>.56**</td>
<td>-</td>
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<td>.56**</td>
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<tr>
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<td>.63***</td>
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<tr>
<td>RC 4th</td>
<td>.12</td>
<td>.13</td>
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<td>.39**</td>
<td>.44***</td>
<td>.39***</td>
<td>-</td>
<td></td>
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<tr>
<td>RC 5th</td>
<td>.23</td>
<td>.25**</td>
<td>.26</td>
<td>.32**</td>
<td>.39**</td>
<td>.43***</td>
<td>.68***</td>
<td>-</td>
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<tr>
<td>RC 6th</td>
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<td>.36**</td>
<td>.35***</td>
<td>.51**</td>
<td>.57**</td>
<td>.60**</td>
<td>.61***</td>
<td>.75**</td>
</tr>
</tbody>
</table>

Note. Dec = decoding efficiency, Pros = text reading prosody, RC = reading comprehension, *p < .05, **p < .01, ***p < .001

the relation between text reading prosody and comprehension, text reading prosody in fifth grade contributed to reading comprehension in sixth grade. No significant contribution from text reading prosody to reading comprehension was found in the transition from fourth to fifth grade. Regarding the relation with decoding efficiency, decoding contributed to text reading prosody in both years, but to reading comprehension only from fourth to fifth grade.

The second Structural Path Model (ii) examined a unidirectional relation from reading comprehension to text reading prosody (Figure 1). The fit indices of this model were the following: χ²(18, N = 99) = 32.64, p = .018, RMSEA = .09, GFI = .93, NFI = .97, CFI = .98, AGFI = .83. The proportion of explained variance in text reading prosody in sixth grade was R² = .75 and in reading comprehension R² = .59. The second path model (ii) shows that reading comprehension contributed to text reading prosody one year later, in fifth as well as in sixth grade. In this path model, decoding efficiency contributed to text reading prosody as well as to reading comprehension in both years. However, modification indices indicated that paths from text reading prosody (from fourth, fifth and sixth grade) to reading comprehension (in sixth grade) were necessary for better model fit.

The last Structural Path Model (iii) examined bidirectional relations between text reading prosody and reading comprehension (Figure 1). The fit indices of this model were: χ²(16, N = 99) = 20.44, p = .20, RMSEA = .05, GFI = .96, NFI = .98, CFI = 1.00, AGFI = .88. The proportion of explained variance was R² = .76 in text reading prosody and R² = .65 in reading comprehension, in sixth grade. The third
path model (iii) shows that reading comprehension contributed to text reading prosody from fourth to fifth grade, whereas text reading prosody contributed to reading comprehension from fifth to sixth grade. The latter regression path, however, was stronger than the path from reading comprehension to text reading prosody. Similar to path model (i), decoding efficiency contributed to text reading prosody in both years, but only to reading comprehension from fourth to fifth grade.

In order to compare the fit of the two unidirectional models and the bidirectional model we performed two chi-square difference tests. Compared to the first unidirectional path model (i) the bidirectional model fitted the data significantly better (\(\Delta \chi^2(2, N = 99) = 9.65, p < .01\)), indicating that the bidirectional model is preferred over the unidirectional model from text reading prosody to reading comprehension. The bidirectional model also had a better fit than the second unidirectional path model (ii) from reading comprehension to text reading prosody (\(\Delta \chi^2(2, N = 99) = 12.20, p < .001\)). From this, and also from the fit indices, we can conclude that the bidirectional model is the best fitting path model.

**Discussion**

The aim of the current study was to compare three theoretical possibilities regarding the directionality of the relationship between text reading prosody and reading comprehension. We examined two unidirectional relations, from text reading prosody to reading comprehension and from reading comprehension to text reading prosody, and a bidirectional relation between text reading prosody and reading comprehension. Importantly, we took into account autoregressive effects and decoding efficiency. The results showed that the autoregressive effects indeed had the strongest regression paths; performance in the previous year was the strongest predictor for each of the skills. The direction of the relationship between text reading prosody and reading comprehension was estimated above and beyond the effect of each skill on itself.

The most important result from this study was that the bidirectional model fitted the data better than the two unidirectional models. The bidirectional model showed that the relation between text reading prosody and reading comprehension was dependent on grade level. It was shown that not only decoding efficiency but also reading comprehension contributed to text reading prosody from fourth to fifth grade. This means that decoding efficiency in itself was not enough for text reading prosody to develop. Remarkably, our data showed that a contribution from text reading prosody to reading comprehension only appeared in the upper grades, from fifth to sixth grade. The results therefore
sugest that text reading prosody needed to become stably developed, before it started to facilitate reading comprehension one year later.

The reciprocal relation between reading comprehension and text reading prosody can be related to interactive theories of reading (Stanovich, 1991, 1984; Rumelhart, 1994). These theories assume that syntactic and semantic knowledge, needed for text comprehension, may also facilitate assignment of word stress, prediction of sentence structure and therefore, likely, prosodic reading of text. Indeed, Jenkins et al. (2003) concluded that a mutual reliance on syntactic and semantic processes may explain the strong association between text reading prosody and reading comprehension. One of the ways in which prosody skills are proposed to facilitate reading comprehension is by enabling segmentation of text (text reading prosody: Arcand et al, 2014; speech prosody: Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008). This can, in turn, aid the memory processes needed for reading comprehension (Frazier et al., 2006). In silent text reading the facilitating effect of text reading prosody is proposed to take place by the use of implicit prosody—the projection of intonation patterns on written text (Stolterfoht, Friederici, Alter, & Steube, 2007; Fodor, 2002, 1998). Fodor (2002, 1998) proposed the implicit prosody hypothesis to account for this facilitating effect. She stated that a default prosodic contour is projected onto a text, which helps to solve syntactic ambiguity when reading silently. Our data suggest that the facilitating effect of text reading prosody in the transition between intermediate and upper grade levels may only take place when a child masters decoding efficiency and has an adequate level of reading comprehension.

This is not to say that text reading prosody would not relate to reading comprehension in earlier grades. Indeed, previous studies convincingly showed that text reading prosody was related to reading comprehension as early as in grade 2 or 3. For example, a cross-sectional study by Arcand et al. (2014) showed that prosodic aspects, such as use of pauses and attention to punctuation, were related to a re-tell comprehension task, in second grade (Arcand et al., 2014). Similarly, Miller and Schwanenflugel (2008) found that children with a decreasing number of pauses in their oral reading from first to second grade and an early adult-like intonation contour, performed better on a reading comprehension task in third grade.

The longitudinal design used in the current study, however, provides an insight into the changes and stability of the relation between text reading prosody and reading comprehension over a longer period of time. The results showed, first, that text reading prosody and reading comprehension were related in the first year of assessment, in grade 4 (as shown by the covariances in the structural path model). In addition to this, it was shown that the development of this relation is dependent on grade level—and therefore on the reading-level of children—when measured over a period of three years. Because only a few studies addressed the long term relation between text reading prosody and reading comprehension, especially in intermediate and upper grades, this was largely unknown until now. The results from the current study can therefore be seen as robust evidence for a relation between text reading prosody and reading comprehension, and should be seen as complementing the results from cross-sectional studies. For a more complete picture, future studies could explore the relation between text reading prosody and reading comprehension from first to fourth grade, using a similar design.

The current results may, at first glance, appear contradictory to the results from another longitudinal study that took autoregressive effects into account (Lai et al., 2014). In this study, in second grade children learning to read in English, a unidirectional relation from text reading prosody to reading comprehension was found (Lai et al., 2014). However, the contribution of decoding and text reading prosody was not separated in this study. It is likely that in beginning readers of an opaque orthography, decoding still contributed heavily to reading comprehension outcomes and therefore explained most of the variance. The results from the current study showed that the effect of decoding efficiency on reading comprehension differed according to whether text reading prosody was included in the model or not. When text reading prosody was included as a predictor (path model i and iii), the significant regression paths from decoding efficiency to text reading prosody remained, whereas the path from decoding efficiency to reading comprehension between fifth and sixth grade disappeared. This suggests that decoding efficiency is partly necessary for text reading prosody to develop, but that the relation between decoding efficiency and reading comprehension becomes more indirect, via text reading prosody, once children become more advanced readers. Nevertheless, the current study provides an insight in these relations in a specific population: in Dutch, advanced readers. Therefore, more longitudinal research, in different age-groups and in different languages, is necessary to get a better picture of the complex relation between decoding efficiency, text reading prosody and reading comprehension.

The present study has several limitations. Firstly, text reading prosody has been measured by use of a rating scale. Even though inter-rater reliability was substantial, for future studies spectrographic analyses of text reading prosody may be used in order to obtain more objective measures. Another potential problem with the text reading prosody measure is that each year, one of the texts was the same as the previous year but the other text changed, which may have caused passage effects. However, correlations between the scores on each text were strong ($r = .75 - .90$, $p < .001$). Secondly, reading comprehension has been assessed with two cloze tests. Research has shown that this type of test relies
mostly on decoding (e.g., Francis, Fletcher, Catts, & Tomblin, 2005; Nation & Snowling, 1997), which could be reflected by the fact that decoding efficiency still contributed to reading comprehension from fourth to fifth grade. Little is known about the effect of text reading prosody on different types of reading comprehension tests. A wider range of reading comprehension tests could be used in future studies to examine any potential differences in this. In addition, our sample was too small to include other variables in the path models. Including other potential predictors, such as vocabulary or syntactic awareness, could have provided a more complete picture and would reduce the possibility of a third variable bias.

Conclusion
In conclusion, the current study compared three theoretical possibilities regarding the relationship between text reading prosody and reading comprehension. It was found that a bidirectional model fitted the data best. The two key findings from the bidirectional model were, first, that text reading prosody was dependent on efficient decoding and reading comprehension from the previous year. Second, only once text reading prosody was more stably developed, a relation occurred from text reading prosody to later reading development. The nature of the relationship between text reading prosody and reading development seems to differ according to the reading level of the children and the characteristics of the language under consideration. It is therefore suggested that the relation between text reading prosody and reading comprehension is more dynamic than generally thought.

References


General Discussion
General discussion

The aim of this dissertation was to explore the role of text reading fluency—reading a text aloud with speed, accuracy and prosody—in reading comprehension, in Dutch primary school children. Cross-sectional as well as longitudinal studies were performed to investigate different aspects of the relation between text reading fluency and reading comprehension. The main focus in this was on the ‘prosody’ component of text reading fluency. The following three research questions were addressed in this dissertation:

1. What constitutes text reading fluency and how are its constituents related to reading comprehension in proficient readers of a transparent orthography?
2. To what extent is the prosody aspect of text reading fluency independent of the automaticity aspect of text reading fluency, in its relation to reading comprehension?
3. How are text reading prosody and reading comprehension related during development over an extended period, from intermediate to upper grades of primary school?

This final chapter will provide a summary of the main results, followed by the theoretical implications and a proposed theoretical model of the relation between text reading fluency and reading comprehension. Following, limitations of this dissertation and recommendations for future research will be reviewed and, lastly, the practical implications will be discussed.

Text Reading Fluency in Relation to Reading Comprehension

The first research question examined which independent component of text reading fluency—reading rate or text reading prosody—contributed to reading comprehension, when decoding, vocabulary and syntactic awareness were accounted for. The study presented in chapter 2 showed that in Dutch children from fourth grade, only text reading prosody explained additional variance in reading comprehension scores, after accounting for vocabulary and syntactic awareness. Neither decoding nor text reading rate (automaticity in reading) contributed to individual differences in reading comprehension. This is in contrast to the English language literature that has reported that reading rate or decoding still explained variance in reading comprehension scores, often in addition to text reading prosody (e.g., Klauda & Guthrie, 2008; Miller & Schwanenflugel, 2006). This difference in results is most likely due to the transparent characteristics of the Dutch orthography. Dutch children master automaticity in reading at an earlier age than children learning to read a more opaque orthography, such as English. This emphasizes the need for studies in different languages, in order to understand the more universal aspects of the relation between text reading fluency and reading comprehension.
The results in chapter 2 suggest that once reading has become automatized, as in these skilled readers in fourth grade, the role of text reading prosody becomes more prominent. At what stage automaticity in reading is mastered depends most likely on the maturity of the child, the reading level and the particular language under consideration.

The Prosody Aspect versus the Automaticity Aspect of Reading
Because these children from fourth grade were relatively advanced readers, the second research question was aimed at determining how dependent text reading prosody is on the automaticity aspect of reading. This question was addressed in two studies. The study in chapter 3 examined this by comparing the contribution of speech prosody, in addition to text reading prosody, to reading comprehension, when controlling for decoding, vocabulary and syntactic awareness. The results showed that speech prosody—assessed with a storytelling task—explained more variance in reading comprehension than text reading prosody. It was shown that especially the ability to phrase a story well was important in the relation to reading comprehension. Phrasing relates to speaking in sentence and clause units, as opposed to speaking in a word-by-word manner. This result suggests that phrasing in speech may provide an indication of the child’s awareness of sentence structure, which may indirectly provide insight into their reading comprehension skills.

In addition, phrasing was also the strongest contributor of text reading prosody in relation to reading comprehension. This result is in accordance with other studies that found evidence for a relation between phrasing in text reading and reading comprehension (Daane, Campbell, Grigg, Goodman, & Oranje, 2005; Klauda & Guthrie, 2008; Mokhtari & Thompson, 2006; Pinnell, Pikulski, Wixson, Campbell, Gough, & Beatty, 1995; Valencia, Smith, Reece, Li, Wixson, & Newman, 2010). Indeed, one of the proposed mechanisms for the relation between speech prosody and language comprehension (Frazier, Carlson, & Clifton, 2006; Snedeker & Trueswell, 2003, Snedeker & Yuan, 2008) as well as between text reading prosody and reading comprehension (Kintsch, 1998; Schreiber, 1991) is that prosody facilitates chunking language (spoken and written) into syntactic or semantic units.

The aim of the study presented in chapter 4 was to further disentangle reading-related from prosody-related skills in the relation between text reading fluency and reading comprehension. This was done by examining the performance of poor comprehenders—children with age-appropriate decoding but with weak comprehension skills—on text reading prosody, as well as on speech prosody. Speech prosody was assessed with a storytelling task and with a number of subtasks from a computer test (PEPS-C, Peppé & McCann, 2003). This computer test was used to assess production as well as perception of speech rhythm, word boundaries and stress placement. The performance of the poor comprehenders was compared to that of a chronological-age control group and a younger comprehension-level control group. It was found that poor comprehenders were delayed in text reading prosody as well as in storytelling prosody, word boundaries and stress placement. On all these tasks they were outperformed by the chronological-age control group and they scored at the level of the younger, comprehension-level control group. On the perception of speech rhythm, however, poor comprehenders scored significantly lower than both control groups. Not being able to perceive speech rhythm may hinder an internal representation of what a text should sound like, which is suggested to obstruct comprehension of written text. Because poor comprehenders have age-appropriate decoding but weak reading comprehension skills, this result also showed that decoding efficiency in itself is not sufficient for the relation between text reading prosody and reading comprehension to develop. It seems that text reading prosody is more strongly related to the level of reading comprehension. In addition, the results suggest that impaired oral prosody skills may underlie reading comprehension problems.

A Longitudinal Perspective
The last two chapters explored the longitudinal relation between text reading prosody and reading comprehension. Chapter 5 examined whether text reading prosody continued to contribute to later reading comprehension when not only decoding but also the influence of phonological awareness was taken into account. Phonological awareness is a segmental phonology skill, referring to the awareness of separable sound units (segments) in speech and the ability to manipulate these. For this study we used a phoneme deletion task and a spoonerism task. Prosody is a form of suprasegmental phonology and refers to aspects of speech that extend over more than one sound segment (such as intonation patterns, word boundaries and rhythm). We used text reading prosody, in a similar way as in the previous chapters, to assess suprasegmental phonology. Further, we included a comprehensive assessment of text reading comprehension by using three standardized reading comprehension tests, two cloze tests and one multiple choice test. The results presented in chapter 5 showed that segmental and suprasegmental phonology were independently related to later reading comprehension. Because the spoonerism task is quite a complex phonological awareness task that includes a memory component, the segmental phonology task most likely taxed memory-dependent processes, which are important for reading comprehension. In addition, the text reading prosody performance may have played a role in solving the ‘binding’ problem of language. A text passage can be divided in different ways; words may either be units in a
phonological representation or units in a syntactic representation, and these are not necessarily the same. Frazier et al. (2006) proposed that the prosodic representation of a sentence aids the unification of the sentence. In this way, both segmental and suprasegmental phonology contribute to reading comprehension in children from intermediate to upper grades.

Lastly, an important outstanding question in the literature is the direction of the relation between text reading prosody and reading comprehension. This question was addressed in chapter 6. We compared three theoretical possibilities: A unidirectional relation from text reading prosody to reading comprehension, a unidirectional relation from reading comprehension to text reading prosody and a bidirectional relation between text reading prosody and reading comprehension. Current studies on the direction of the relation between text reading prosody and reading comprehension are scarce and limited in light of the methodological requirements needed to determine directionality. Because the largest contribution to later reading comprehension is most likely the level of reading comprehension at a prior time (Gollob & Reichardt, 1987), it is important to determine the relation between text reading prosody and reading comprehension above and beyond these autoregressive effects. We assessed decoding, text reading prosody and reading comprehension over a period of three years and included autoregressive effects on all three skills. The results showed that the bidirectional model fitted the data better than the two unidirectional models. The relation was shown to be dependent on grade level though. Decoding efficiency and reading comprehension contributed to text reading prosody from fourth to fifth grade. From fifth to sixth grade it was text reading prosody that contributed to reading comprehension. In silent text reading, the facilitating effect of prosody on reading comprehension is proposed to take place by the use of implicit prosody, which is the projection of intonation patterns on written text (Fodor, 2002, 1998; Stolterfoht, Friederici, Alter, & Steube, 2007). The results suggest that the facilitating effect of text reading prosody develops when children master decoding efficiency and when they have an adequate level of reading comprehension.

Theoretical Implications
The first theoretical insight from this dissertation concerns the construct of text reading fluency. Text reading fluency (traditionally defined as rate and accuracy) has been proposed to have a strong association with reading comprehension (e.g., Berninger et al., 2010; Jenkins, Fuchs, Espin, Van de Broek, & Deno, 2003; Kim & Wagner, 2015). However, it has been shown that one-third of strong readers (who read accurately and fast) struggle with reading comprehension (Applegate, Applegate, & Modla, 2009). This indicates that rate and accuracy cannot always explain the relation between text reading fluency and reading comprehension. It has been proposed that a combination of accuracy, automaticity, and text reading prosody facilitates the reader’s construction of meaning (Kuhn, Schwaneflügel, & Meisinger, 2010). However, the results from chapter 2 showed that, when text reading prosody was included, reading rate (automaticity) no longer explained any variance in reading comprehension, in Dutch children. In addition, the results from chapter 4, about the prosodic abilities of poor comprehenders, suggest that the ‘automaticity aspect’ of reading is a distinct process from the construction of meaning. The construction of meaning seems more closely tied to text reading prosody than to decoding efficiency, at least at the level where children have already mastered automaticity in reading. These results make a strong appeal for including text reading prosody in text reading fluency assessments, especially when considered in relation to reading comprehension. This may be particularly important in more advanced readers and in readers of languages with transparent orthographies.

Another theoretical implication is that, although decoding may be necessary for text reading prosody to develop, decoding efficiency alone does not seem to be sufficient for this development to take place. In chapter 4 it was shown that poor comprehenders—children with age-appropriate decoding, but weak comprehension skills—scored lower than typical readers on text reading prosody as well as on speech prosody tasks. This suggests that prosody skills are independently related to reading comprehension. An interesting aspect of speech prosody is that it develops long before children start to learn how to read. Cutler and Mehler (1993) proposed that children are born with a ‘periodicity bias’ that makes them sensitive to the specific rhythmic properties of their native language. Speech rhythm sensitivity should therefore, in typical speech development, start to develop at an early age, and delays or impairments in this development may have an impact on later reading development. An indication for this is that the poor comprehenders had impaired speech rhythm discrimination (chapter 4).

A third important theoretical insight is that the relation between text reading prosody and reading comprehension is more dynamic than generally thought. Studies have shown that the relation between text reading fluency (defined as rate and accuracy) and reading comprehension remained stable over multiple grade-levels (Kim, Wagner, & Lopez, 2012; Kim & Wagner, 2015). The results in chapter 6 showed that this is different for the relation between text reading prosody and reading comprehension. This relation was shown to change, depending on grade-level. Whereas in grade 5, text reading prosody was preceded by decoding and reading comprehension, one year later in grade 6, reading comprehension was preceded by text reading prosody. This suggests that the development of text reading prosody is partly based on basic reading...
skills (decoding), and partly on an understanding of the semantic structure of a text and the context. Chapter 6 showed that once children knew how to use text reading prosody, by grouping words together, placing stress on important words and by adjusting their voice to what is happening in the text, the use of text reading prosody started to contribute to later reading comprehension.

Summary and Proposed Theoretical Model
Figure 1 shows a schematic representation of the proposed theoretical model for the relation between text reading fluency and reading comprehension in Dutch children from intermediate and upper grades of primary school. This dissertation showed that when text reading prosody was included in text reading fluency assessment, only text reading prosody explained significant variance in reading comprehension scores in Dutch, advanced readers (Figure 1). However, initially decoding efficiency as well as a basic understanding of the semantic structure of a text is necessary for text reading prosody to develop (Figure 1). Only when text reading prosody has been developed to some extent can it make a contribution to later reading comprehension. The reliance of text reading prosody on decoding and reading comprehension is mostly due to the fact that all three skills are reading related. The fact that speech prosody is also related to reading comprehension provides an indication that an awareness of spoken word boundaries, stress placement and most of all speech rhythm is important in making sense of a text (Figure 1). Speech prosody offers two advantages that text reading prosody does not: it can be used when reading silently (‘implicit prosody’) and it develops at an early age. This latter characteristic may be promising for early screening purposes. Regarding implicit prosody, it has been proposed that speech prosody facilitates reading comprehension by creating an internal prosodic representation of a text. Fodor (2002, 1998) talked about a default prosodic contour in her implicit prosody hypothesis. If speech prosody is delayed, or less well developed, this may affect the development of a default prosodic contour, which then, in turn, may have an impact on reading comprehension.

Limitations and Future Directions
There are a number of limitations of the studies presented in this dissertation that are important to address. Firstly, text reading prosody was assessed with a rating scale which may not have been precise enough to capture all relevant aspects. Some studies have used spectrographic analyses (e.g., Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004; Miller & Schwanenflugel, 2006, 2008) which may be more specific and, to a certain degree, more objective. Nevertheless, the inter-rater reliability of the text reading prosody assessment was generally good. The rating scale may also have assessed some elements that are related to the automaticity aspect of reading, such as smoothness (reading without hesitations) and pace (not too fast and not too slow). This emphasizes the fact that text reading prosody is a reading-related measure which does depend on basic reading skills, such as decoding. We included speech prosody measures to disentangle the reading-related contribution versus the contribution of prosody skills, and found that speech prosody also explained unique variance in reading comprehension scores.

A potential problem with the speech prosody measures is that some subtasks of the PEPS-C had a low internal reliability. Unfortunately, there are currently very few highly reliable measures of prosodic sensitivity in speech in reading research (e.g., Holliman, Williams, Mundy, Wood, Hart, & Waldron, 2014). New speech prosody tests are currently being developed (Holliman et al., 2014) and this is certainly a worthwhile direction for future research to explore. Lastly, the cloze tests used to assess reading comprehension may have emphasized the role of decoding (e.g., Francis, Fletcher, Catts, & Tomblin, 2005; Nation & Snowling, 1997). Although studies have shown that decoding mainly affects early reading comprehension in Dutch children (e.g., Verhoeven & van Leeuwe, 2008), an effect of decoding was still found from fourth to fifth grade and when text reading prosody was not included, even from fifth to sixth grade in chapter 6. Nevertheless, a similar relation between decoding and reading comprehension was found in chapter 5, when we included a multiple choice test in addition to the cloze tests.

The aim of this dissertation was to explore the relation between text reading fluency and reading comprehension in Dutch children from intermediate and upper grades. Consequently, we still do not know exactly what precedes the development of this relation. In order to get a more complete overview of the
development of text reading fluency and reading comprehension, these reading skills could be examined in younger Dutch children, who are only just learning to read. In addition, speech prosody, rather than text reading prosody, would be a promising tool for assessing prosody skills in young children, because speech prosody can be measured well before children start formal reading education. If early speech prosody would be related to later reading comprehension, then this would offer possibilities for early screening procedures. Poor comprehenders are currently identified at an age where they should already have mastered text comprehension, in order to make sense out of the text books they need for the general curriculum. Hypothetically, early screening procedures could identify children at risk of later reading comprehension problems at an age where they have not even learned their first letters. By exposing these children to prosodic speech examples and by letting them practice with speech in a playful setting (e.g., nursery rhymes, storytelling, reading aloud, role play), a possible delay in developing perception and production of speech prosody could be prevented, averting later problems. It is evident that more research is needed, firstly to examine if, and which, specific aspects of prosodic speech are related to later reading comprehension problems, and secondly, to examine the effectiveness of both early screening procedures and speech interventions.

Practical Implications

It has been proposed in the literature that in transparent orthographies reading speed is the only reading measure that differentiates between poor and good readers in children from intermediate and upper grades of primary school (e.g., Landerl & Wimmer, 2008). The current educational system in the Netherlands emphasizes reading speed throughout the six years of primary school, in word reading as well as in text reading. The results from this dissertation, however, suggest that once decoding has become automatized, text reading prosody should be added to the text reading assessments. In typically developing children, text reading prosody will, first of all, reflect the level of automatization in reading. After all, if the automatization of reading (decoding efficiency) still takes up too much of the child’s cognitive resources, little attention can be paid to text reading prosody. When a child starts to use text reading prosody by using correct word boundaries, use of pauses and intonation patterns, this initially reflects their understanding of the semantic structure of a text and of the content. Once text reading prosody performance becomes more advanced it will, in turn, start to facilitate reading comprehension. This facilitation most likely happens by using an internal template of what a text should sound like. Children who master automaticity in reading but do not achieve appropriate levels of text reading prosody could potentially have problems with reading comprehension. Text reading prosody could, in this sense, be seen as a marker of reading comprehension skills. This is especially important in identifying poor comprehenders—children with age-appropriate decoding but weak comprehension skills. Nonetheless, in the current educational system much emphasis is placed on reading speed, therefore children may get the impression that being a good reader is effectively the same as being a fast reader. As a consequence, the reading performance may become monotonous and reading comprehension may suffer.

Modelling of text reading prosody by the teacher is essential in making children aware of the possibilities of using their voice in comprehending text, whether implicitly or explicitly. On an implicit level, this awareness may be induced by exposing children to many different examples of speech, for example, in songs, storytelling or reading aloud. This is often part of the curriculum at kindergarten, but as soon as formal reading education starts, spoken input diminishes quickly. Children in the upper grades generally still enjoy listening to stories being read to them. Explicit teaching in text reading prosody can be provided by talking about the use of one’s voice, for example to create emphasis on important words. Another explicit teaching method would be to talk about the effect of omitting, or including, a comma. The difference between: “Let’s eat grandma” and “Let’s eat, grandma” is an amusing example that children will not forget very quickly. Exercises such as these may eventually help children in constructing an inner representation (implicit prosody) of what a text should sound like, which may potentially aid their reading comprehension.

Because speech prosody has also been shown to contribute to reading comprehension this may offer a potential for intervention programs based on oral language, rather than on reading. Children who have weak reading comprehension skills often suffer from low motivation in reading and therefore reading interventions may not always be enthusiastically received. Practice in speech by, for example, adjusting their voice to the content of a story or even to a character in a play, may be a lot more enjoyable for these children. There are currently software programs available that emphasize ‘reading with intonation’—but this material is mainly intended as supplementary teaching material for individual use in more advanced readers (Zwijsen, 2009: De leestrainer). This software makes it possible for children to record their own reading performance and they can then choose to read the text in the style of a character, for example reading as a newsreader or as a king or queen. Research into the effectiveness of interventions such as these in order to enhance reading comprehension is needed, but the idea is promising.
References


Nederlandse samenvatting
Nederlandse Samenvatting

Hoe vloeiend lezen gerelateerd is aan begrijpend lezen

Het doel van leesonderwijs is niet alleen om kinderen te leren lezen maar vooral ook om kinderen geschreven teksten te leren begrijpen. Begrijpend lezen is belangrijk op de basisschool, maar ook essentieel voor een succesvol verloop van de middelbare school als wel tijdens het latere sociale en professionele leven. Traditioneel gezien worden het technisch lezen–goed en snel woorden kunnen lezen–samen met het taalbegrip van een kind–zoals woordenschat en syntactisch begrip–aangemerkt als factoren die het begrijpend lezen beïnvloeden (the simple view of reading: Gough & Tunmer, 1986; Hoover & Gough, 1990). Meer recent onderzoek heeft echter laten zien dat ook vloeiend lezen–de accuratesse, snelheid en intonatie tijdens het hardop lezen van teksten–gerelateerd is aan begrijpend lezen (Silverman, Speece, Harring, & Ritchey, 2012; Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009). Het promotieonderzoek van Nathalie Veenendaal heeft verschillende aspecten van de relatie tussen vloeiend lezen en begrijpend lezen onderzocht, door middel van cross-sectionele studies (een meting op één bepaald moment in tijd) als wel longitudinale studies (metingen in opeenvolgende jaren). De focus van deze studies lag met name op het ‘intonatie aspect’ van vloeiend lezen, ook wel prosodie genoemd.

Prosodie is de melodie van gesproken taal, hieronder vallen bijvoorbeeld accentplaatsing, frasering (het groeperen van woorden), gebruik van intonatie en het ritme van gesproken taal. Prosodie heeft niet te maken met wat men zegt, maar met hoe men het zegt. Als een klant in een restaurant bijvoorbeeld een kopje koffie krijgt in plaats van het bestelde kopje thee, dat wordt deze vergissing vaak met een accentplaatsing op het belangrijkste woord aangegeven: “Sorry, maar ik heb THEE besteld”. Een voorbeeld van woordgroeperingen is het verschil tussen “chocolade, taart en koekjes” en “chocoladetaart en koekjes”. Het zijn vaak subtiele verschillen in toon die heel belangrijk kunnen zijn voor de betekenis van wat er gezegd wordt. In het hardop voorlezen van teksten is het aangeven van dit soort subtiele verschillen net zo belangrijk voor een goed begrip van de tekst als in gesproken taal. Er is erg weinig bekend over de relatie tussen prosodie, als onderdeel van het vloeiend lezen, en begrijpend lezen bij Nederlandse kinderen. De volgende drie onderzoeksfragen werden daarom in het promotieonderzoek behandeld:

1. Hoe zijn de verschillende onderdelen van vloeiend lezen–accuratesse, snelheid en prosodie–gerelateerd aan het begrijpend lezen van kinderen uit groep 6?
2. Tot op welke hoogte is het ‘intonatie-aspect’ (prosodie) van vloeiend lezen afhankelijk van het ‘snelheidsaspect’ (automatisering) van vloeiend lezen, in de relatie tot begrijpend lezen?
3. Hoe is de prosodie tijdens het voorlezen gerelateerd aan het begrijpend lezen over een periode van drie schooljaren, van groep 6 tot en met groep 8?

Vloeiend lezen: Snelheid of Intonatie?
De eerste onderzoeksvraag waar door middel van dit promotieonderzoek een antwoord op gezocht werd gaat over welk onderdeel van vloeiend lezen – accuratesse, snelheid en prosodie – het sterkst gerelateerd is aan begrijpend lezen. Om dit te onderzoeken hebben we een studie opgezet waarin we eerst de belangrijkste ‘traditionele’ voospellers van begrijpend lezen onderzocht: technisch lezen, woordenschat en syntactisch begrip. Meer dan 100 kinderen uit groep 6 (104), afkomstig van 4 basisscholen, hebben aan deze studie deelgenomen. Deze kinderen waren gemiddeld 9 jaar oud. Het bleek dat bij deze kinderen alleen woordenschat en syntactisch begrip verschillen in scores op begrijpend lezen konden voorspellen. Toen de accuratesse en snelheid (het aantal correct gelezen woorden per minuut) en de prosodie van vloeiend lezen daaraan werden toegevoegd, bleek dat de prosodie tijdens het lezen ook een voorspellende waarde had voor het begrijpend lezen, terwijl de accuratesse en snelheid van lezen niet meer bijdroegen hieraan. Kinderen in groep 6 hebben over het algemeen het technisch lezen (zowel woord lezen als tekstlezen) aardig onder de knie, en daarom was de volgende vraag van het promotieonderzoek in hoeverre dit ‘geautomatiseerde lezen’ van belang is voor het kunnen ‘lezen op toon’. Met andere woorden, is de relatie tussen prosodie tijdens het lezen en begrijpend lezen puur afhankelijk van het goed en snel kunnen lezen of spelen andere factoren van prosodiegebruik hier een rol bij?

Prosodie: een Leesaspect of een Gesproken Taalaspect?
In de literatuur wordt veelal verondersteld dat de gesproken taalvaardigheden van een kind een bijdrage leveren aan het ‘op toon’ kunnen lezen (Dowhower, 1991; Schwanenflugel, Westmoreland, & Benjamin, 2013). Er zijn echter geen studies bekend die dit daadwerkelijk onderzoeken. Daarnaast wordt verondersteld dat de technische leesvaardigheid een vereiste is voor het ontwikkelen van het gebruik van prosodie tijdens het lezen. Het is echter niet bekend of deze vaardigheid ook voldoende is om goed ‘op toon’ te kunnen lezen. In twee studies zijn deze vragen nader onderzocht. In de eerste van deze twee studies, met 104 kinderen uit groep 6, afkomstig van 4 scholen, hebben we het gebruik van prosodie tijdens het tekstlezen vergeleken met het gebruik van prosodie tijdens het vertellen van een verhaal. Omdat het vertellen van een verhaal niet afhankelijk is van het leesvermogen van een kind konden we goed het ‘leesaspect’ van het ‘prosodie aspect’onderscheiden. Net als in de eerste studie hebben we de voorspellende waarde van prosodie op begrijpend lezen onderzocht in toepassing op technisch lezen, woordenschat, en syntactisch begrip. De resultaten van deze studie toonden aan dat het prosodiegebruik tijdens het vertellen van een verhaal net iets sterker gerelateerd was aan begrijpend leesuitkomsten dan het gebruik van prosodie tijdens het voorlezen. Beide droegen echter significant bij aan de scores op begrijpend lezen, bovenop de voorspellende waarde van woordenschat en syntactisch begrip. Vooral het vermogen om zinnen goed te fraseren bleek belangrijk. Weten welke woorden in een zin bij elkaar horen en dit door middel van je stem kunnen aangeven is dus een belangrijk aspect voor het begrijpend lezen. De relatie tussen begrijpend lezen en goed kunnen fraseren is ook in eerdere studies aangetoond (e.g., Daane, Campbell, Grigg, Goodman, & Oranje, 2005; Mokhtari & Thompson, 2006; Pinnell, Pikulski, Wixson, Campbell, Gough, & Beatty, 1995; Valencia, Smith, Reece, Li, Wixson, & Newman, 2010). Als een kind er goed in slaagt om woorden op een correcte manier te groeperen en juiste grammaticale zinnen weet samen te stellen, dan kan dit dus een indicatie geven van zijn of haar begrijpend leesvermogen.

In de tweede studie naar deze tweede onderzoeks vraag hebben we onderzocht of het technisch leesvermogen van een kind voldoende basis legt voor de ontwikkeling van prosodie tijdens het lezen of dat andere factoren hier een rol in spelen. We hebben daarvoor het prosodiegebruik tijdens het voorlezen van 21 kinderen (van 6 verschillende basisscholen) met specifieke begrijpend leesproblemen onderzocht. Deze kinderen waren goed in technisch lezen maar desondanks zwak in begrijpend lezen. Als prosodiegebruik voornamelijk gerelateerd zou zijn aan het technisch lezen, dan zouden deze kinderen goed moeten zijn in prosodiegebruik. Als het prosodiegebruik echter ook met andere factoren samenhangt, zoals met de kwaliteit van het begrijpend lezen zelf bijvoorbeeld, dan is de verwachting dat deze kinderen zwakker zijn in het gebruik van prosodie tijdens het voorlezen. Daarnaast hebben we ook het begrip en het gebruik van prosodie tijdens het spreken gemeten in deze groep kinderen.

De 21 zwakke begrijpend lezers waar we deze vaardigheden bij hebben gemeten zaten in groep 7 van de basisschool en waren gemiddeld 10 jaar oud. We hebben twee controlegroepen gebruikt (21 kinderen per groep) om de prestaties van de kinderen met begrijpend leesproblemen mee te kunnen vergelijken. De eerste controlegroep bestond uit kinderen uit dezelfde klas (gemacht op geboorte- maand) die op een gemiddeld tot goed niveau presteerden op zowel technisch lezen als begrijpend lezen. De tweede controlegroep bestond uit een groep jongere kinderen van dezelfde school. De zwakke begrijpend lezers waren vaak één of twee jaar achter met begrijpend lezen en iedere zwakke begrijpend lezer is daarom gemacht met een jonger kind dat op hetzelfde niveau van begrijpend lezen presteerde. Op hun eigen leeftijd presteerden deze jongere kinderen echter wél op een gemiddeld tot goed niveau op zowel technisch lezen als
begrijpend lezen. Door middel van de jongere groep kinderen kon vastgesteld worden of de zwakke begrijpend lezers achter lopen bij hun leeftijdsgenoten op het gebruik van prosodie. Als de zwakke begrijpend lezers namelijk op hetzelfde niveau zouden presteren als de jongere groep is er niet alleen sprake van een vertraagde ontwikkeling van begrijpend lezen maar ook van een vertraagde ontwikkeling van prosodie. Mochten de zwakke begrijpend lezers echter onder het niveau van de jongere groep presteren, dan kan worden vastgesteld dat deze specifieke vaardigheden niet helemaal ontwikkeld zijn in deze groep kinderen. Dit kan een indicatie geven van vaardigheden die ten grondslag liggen aan begrijpend leesproblemen.

De resultaten lieten zien dat de zwakke begrijpend lezers lager scoorden op het prosodiegebruik dan hun leeftijdsgenoten, zowel in het voorlezen als in het begrip en gebruik van prosodie tijdens het spreken. Op bijna alle taken scoorden ze op hetzelfde niveau als de jongere kinderen, wat aangeeft dat deze kinderen inderdaad achter lopen in het gebruik en begrip van prosodie. Dit geeft ook aan dat de ontwikkeling van prosodie gekoppeld lijkt te zijn aan de ontwikkeling van begrijpend lezen. Daarnaast blijkt het goed technisch kunnen lezen onvoldoende basis te leggen voor een juist gebruik van prosodie tijdens het voorlezen.

Op één taak presteerden de zwakke begrijpend lezers zelfs onder het niveau van de jongere kinderen. Dit was een taak waar kinderen twee korte zinnen hoorden die klonken alsof er iemand aan het woord was in de kamer ernaast. Er kon dus niet woorlijk verstaan worden wat er gezegd werd maar de kinderen konden het spraakritme wel goed horen. De zwakke begrijpend lezers konden in deze taak niet goed bepalen of twee of zulke zinnen hetzelfde klonken of dat ze verschillend waren. Dit was een taak die wel goed werd uitgevoerd door beide andere groepen kinderen. Deze kinderen met problemen met begrijpend lezen blijken dus moeite te hebben met het horen van kleine verschillen in het ritme van gesproken taal. Dit resultaat sluit aan bij de resultaten van een andere studie die liet zien dat kennis van ritme in spraak, maar bijvoorbeeld ook in muziek, sterk gerelateerd is aan syntactische vaardigheden en het begrip van grammatica (Gordon, Jacobs, Schuele, & McAuley, 2015). Een andere verklaring is dat kinderen bij het begrijpend lezen een innerlijke representatie van de gesproken tekst creëren tijdens het stil voor zichzelf lezen. Ze horen in hun hoofd welke woordgroepen bij elkaar horen, welke woorden belangrijk zijn en een accent krijgen, en welk karakter ze hebben in het verhaal aan het woord is. Dit zou het begrijpend lezen kunnen ondersteunen en het begrip van spraakritme, waar al deze elementen onder vallen, is belangrijk hierbij. Het zou dus kunnen dat een onderontwikkeld vermogen in het kunnen onderscheiden van ritme in spraak gedeeltelijk ten grondslag ligt aan begrijpend leesproblemen.

Tot nu toe hebben de hierboven beschreven studies vaardigheden onderzocht op één bepaald moment in tijd, bij kinderen in groep 6, of bij kinderen in groep 7. De laatste twee studies van het promotieonderzoek hebben de relatie tussen prosodie en begrijpend lezen onderzocht over een langere periode, namelijk van groep 6 tot en met groep 8. Hierdoor kunnen ontwikkelingen over een langere periode worden vastgesteld, zoals de vraag of de relatie tussen deze vaardigheden zich stabiel ontwikkelt of dat deze verandert in de loop der tijd.

**Longitundinaal Bewijs**

Prosodie is een aspect van gesproken taal, net als fonologisch begrip. Bij fonologisch begrip gaat het erom of een kind bepaalde klanken in gesproken taal kan onderscheiden en manipuleren. Hier valt bijvoorbeeld de kennis onder dat het woord ‘bal’ met de klank ‘buuh’ begint. Maar ook het kunnen manipuleren van klanken valt onder fonologisch begrip, bijvoorbeeld het kunnen toevoegen of weglaten van klanken in een woord, zoals het woord ‘flies’ zonder de klank ‘fuuh’ is het woord ‘les’. Prosodie valt ook onder fonologie alleen is prosodie niet verbonden aan specifieke segmenten van gesproken taal. Het gaat bij prosodie meer om het kunnen groeperen van woorden, om intonatie patronen, om het plaatsen van accenten op belangrijke woorden en om het ritme van spraak. Zowel fonologisch begrip als prosodie zijn volgens de literatuur gerelateerd aan begrijpend lezen. Daarnaast is technisch lezen ook van belang voor begrijpend lezen en is er een relatie aangetoond tussen technisch lezen en fonologisch begrip en prosodie. Voor de eerste longitudinale studie is een groep van 99 kinderen, afkomstig van vier basisscholen, gevolgd van groep 6 tot en met groep 8. Dus bij kinderen in de leeftijd van ongeveer 9 tot 11 jaar oud. In deze studie is onderzocht hoe het technisch lezen, het fonologisch begrip, en de prosodie tijdens het voorlezen in groep 6 en 7, gerelateerd waren aan het begrijpend lezen in groep 8. De resultaten lieten zien dat het technisch lezen in groep 6 en 7 voorspellend was voor het begrijpend lezen in groep 8. Echter, als fonologisch begrip en prosodie tijdens het voorlezen werden toegevoegd verdween de relatie tussen technisch lezen en begrijpend lezen en werden fonologisch begrip en prosodie in groep 6 en 7 de belangrijkste voorspellers voor begrijpend lezen in groep 8. Aangezien technisch lezen aldus gerelateerd was aan de ontwikkeling van fonologisch begrip en prosodie, is de conclusie van deze studie dat het technisch lezen het latere leesbegrip voorspelt via fonologisch begrip en via het gebruik van prosodie tijdens het lezen.

De tweede longitudinale studie onderzocht de richting van de relatie tussen prosodiegebruik tijdens het voorlezen en begrijpend lezen. Hoewel de literatuur voornamelijk veronderstelt dat prosodiegebruik tijdens het voorlezen het begrijpend lezen zou faciliteren (Kentner, 2012; Kuhn, Schwabenflugel, & Meisinger, 2010; Rasinski, Riki, & Johnston, 2009) is het theoretisch gezien ook mogelijk dat het
gebruik van prosodie een reflectie is van het niveau van begrijpend lezen (Torgesen & Hudson, 2006). Voor deze laatste studie van het promotieonderzoek zijn het technisch lezen, het gebruik van prosodie tijdens het voorlezen en het begrijpend lezen gemeten in een groep van 99 kinderen (vier scholen), over een periode van drie jaar, van groep 6 tot en met groep 8. De resultaten lieten zien dat in groep 7, het gebruik van prosodie voornamelijk werd voorspeld door het technisch lezen en het begrijpend lezen in groep 6. Echter, één jaar later werd deze relatie niet meer gevonden en werd het begrijpend lezen in groep 8 voornamelijk voorspeld door het gebruik van prosodie in groep 7. Dit toont aan dat het gebruik van prosodie tijdens het lezen in eerste instantie niet alleen afhankelijk is van technische leesvaardigheid maar ook van het begrijpend lezen; aspecten zoals het begrip van de syntactische opbouw en de semantische betekenis van een tekst kunnen daar een rol bij spelen. Als het gebruik van prosodie zich eindzins gevormd heeft, kan het kind deze kennis inzetten om een tekst beter te gaan begrijpen. Als een samenvoeging van een groep woorden bijvoorbeeld niet werkt, wordt het kind door het intonatiegebruik zich hier sneller van bewust. Het kind kan dan even terug in de tekst gaan om de juiste syntactische groepering te formuleren. Ook het kunnen aanvoelen van welke woorden in de tekst belangrijk zijn en welke woorden nieuwe informatie bevatten, om daar vervolgens een accent op te plaatsen kan helpen bij het begrijpen van geschreven tekst.

Er bestaat een ‘impliciete prosodie hypothese’ die veronderstelt dat kinderen bij het stil lezen van teksten een soort ‘template’ toepassen (een standaard voorbeeld) met kennis van het meest voorkomende gebruik van prosodie (Fodor, 2002, 1998). Dit ‘template’ ontstaat door veelvuldig in aanraking te komen met verschillende aspecten van gesproken taal. De faciliterende werking van het gebruik van prosodie voor het begrijpend lezen heeft dus waarschijnlijk te maken met de mate waarin het een kind lukt om een innerlijke representatie van de klink van een tekst te vormen terwijl hij of zij leest. Deze laatste studie toont ook aan dat de relatie tussen het prosodiegebruik en het begrijpend lezen niet statisch is en dat deze onderhevig is aan veranderingen die met leeservaring te maken hebben.

**Conclusie en Praktische Implicaties**

Dit promotieonderzoek heeft aangetoond dat als er een meting van prosodie wordt meegenomen als onderdeel van vloeiend lezen, prosodie het enige aspect van vloeiend lezen is dat een significante relatie toont met begrijpend lezen bij kinderen in de middenbouw. De snelheid van lezen was geen voorspeller meer van begrijpend lezen bij kinderen uit groep 6. Het gebruik van prosodie tijdens het voorlezen ontwikkelt zich echter door een combinatie van technisch lezen en begrijpend lezen. De relatie tussen prosodiegebruik en begrijpend lezen is dus bidirectioneel; kennis van begrijpend lezen is in eerste instantie nodig om de syntactische en semantische opbouw van een tekst om te kunnen zetten in een correct gebruik van prosodie. Zo gauw kinderen dit kunnen kan er een innerlijke representatie gevormd worden van hoe een tekst hoort te klinken. Deze innerlijke representatie kan vervolgens weer ingezet worden bij het begrijpen van een tekst. Aspecten zoals het groeperen van woorden, intonatie, gebruik van pauzes en ritme zijn allemaal elementen die hierbij een rol spelen. Dat deze elementen van gesproken taal belangrijk zijn voor begrijpend lezen werd ook aangetoond door het feit dat prosodie in gesproken taal een significante relatie had met begrijpend lezen. Het is mogelijk dat het sommige kinderen minder goed lukt om een innerlijke representatie te vormen van de klank van een tekst. Dit zou het geval kunnen zijn bij kinderen die goed technisch kunnen lezen maar desondanks toch zwak zijn in begrijpend lezen. Deze kinderen hadden voornamelijk moeite met het horen van kleine verschillen in spraakritme.

Wat betreft de ontwikkeling van prosodie in gesproken taal is het bekend dat baby’s, zelfs voordat ze geboren worden, al gevoelig zijn voor prosodie (Granier-Deferre, Bassereau, Ribeiro, Jacquet, & DeCasper, 2011). Er wordt dan ook verondersteld dat kinderen geboren worden met een gevoeligheid voor het herkennen van het specifieke ritme van de moedertaal (Cutler & Mehler, 1993).

Het is dus mogelijk dat de oorsprong van begrijpend leesproblemen al heel vroeg gevormd wordt. Momenteel komen problemen met begrijpend lezen vaak pas aan het licht in de middenbouw van het basisonderwijs, als er een omslag plaatsvindt van ‘het leren lezen’ naar ‘lezen om te leren’. Op dat moment hebben kinderen hun begrijpend leesvermogen echter al hard nodig om bijvoorbeeld hun tekstboeken over de zaakvakken te kunnen begrijpen en eventuele achterstand die ze oplopen is vaak moeilijk in te halen. Omdat gesproken taal zich ontwikkeld voordat kinderen leren lezen, zouden kinderen ver voordat ze met leesonderwijs in aanraking komen al getoetst kunnen worden op hun begrip van prosodie in gesproken taal. Dit zou een indicatie kunnen geven voor een risico op latere begrijpend leesproblemen. Deze kinderen zouden vervolgens veelvuldig in aanraking kunnen worden gebracht met gesproken taal, hierbij valt te denken aan voorlezen, liedjes zingen, en taalspelletjes waarbij er met verschillende spraakritmes wordt gewerkt. Meer onderzoek is echter nodig om de relatie tussen vroege gesproken taalvaardigheid en later begrijpend lezen vast te stellen en om de potentie van een vroeg screeningsprogramma te onderzoeken.

Wat betreft de praktische implicaties, dit promotieonderzoek heeft aangetoond dat in de midden- en bovenbouw het ‘automatiseren’ van lezen (snel en goed kunnen lezen) bij kinderen met een typische leesontwikkeling goed ontwikkeld is en dat dit niet meer zoveel zegt over hun begrijpend leeskwaliteiten. Het gebruik
van prosodie tijdens het voorlezen lijkt een betere afspiegeling te zijn van het begrijpend lezen. Dit suggereert dat het naast het testen van de leessnelheid een goed idee zou zijn om in de midden- en bovenbouw ook het gebruik van intonatie tijdens het lezen te testen. Ten eerste geeft dit, bij een typische leesontwikkeling, een goede indruk van het technisch lezen, en ten tweede geeft dit een goede indruk van het tekstbegrip. Bij een discrepantie tussen het niveau van het technisch (woord) lezen en het gebruik van prosodie kan het goed zijn om het begrijpend lezen extra te testen. Zwakke begrijpend lezers die wel goed technisch kunnen lezen vallen namelijk vaak uit op het gebruik van prosodie tijdens het tekstlezen. Echter, door de sterke focus op het snel lezen op de basisschool (DMT en AVI) denken veel kinderen inmiddels dat goed lezen hetzelfde is als snel lezen, waardoor veel kinderen een monotone leesprestatie neerzetten. Dit monotone lezen kan echter ten koste gaan van het begrip, zowel voor de lezer als voor de toehoorder.

Het belang van prosodie tijdens het voorlezen geeft ook aan dat ‘modelling’ door de leerkracht een belangrijk element is in het begrijpend leesonderwijs. Dit kan op een impliciete wijze gebeuren door middel van voorbeelden van het gebruik van de stem in bijvoorbeeld hardop voorlezen, zingen of het vertellen van een verhaal. Dit gebeurt over het algemeen nog veelvuldig in de onderbouw maar wordt vaak steeds minder gedaan in de midden- en bovenbouw. Ook voor kinderen in de bovenbouw kan het nog steeds leuk en van belang zijn om voorlezen te worden. Daarnaast kan bijvoorbeeld bij de uitwerking van rollen in de schoolmusical extra aandacht worden besteed aan het stemgebruik voor het bekrachtigen van een bepaalde betekenis.


Prosodie in gesproken taal is ook gerelateerd aan het begrijpend lezen en dit zou een mogelijkheid kunnen bieden om interventies op het gebied van begrijpend lezen te ontwikkelen die gebaseerd zijn op gesproken taaloeefeningen. Kinderen die zwakker zijn in begrijpend lezen hebben vaak weinig motivatie om te lezen en leesinterventies waarbij nog meer gelezen moet worden zijn daardoor vaak weinig aantrekkelijk. Oefeningen met het gebruik van de stem in het overdragen van betekenis, bijvoorbeeld in een toneelstuk of in een gedicht, kan een stuk motiverender zijn en indirect toch het begrijpend lezen bevloeden. Als deze kinderen leren om tijdens het stil lezen een overdracht van de tekst in hun hoofd te gaan horen, kan dit helpen bij hun tekstbegrip. Er bestaan momenteel software programma’s in het onderwijs die het lezen met intonatie centraal hebben staan (bijv. Zwijsen, De Leestrainer). Deze programma’s worden momenteel voornamelijk ingezet als extra lesmateriaal voor sterke lezers. Kinderen kunnen een verhaal voorlezen in de stijl van een karakter, bijvoorbeeld voorlezen zoals een nieuwslezer of een koning of koningin, en dit zelf opnemen om terug te luisteren. Het inzetten van deze programma’s voor zwakke begrijpend lezers kan goede mogelijkheden bieden om deze kinderen te helpen bij hun tekstbegrip en om het lezen weer aantrekkelijker te maken. Studies die de effectiviteit van zulke interventies gaan onderzoeken zijn vooralsnog nodig, maar het idee is veelbelovend.
Referenties


Dankwoord

Een reis van duizend mijlen begint met een enkele stap¹.
Daarheen en weer terug².

¹ Lao Tse, Chinese wijsgeer (604 BC - 531 BC)
In 2006 begon ik, met veel onzekerheid over mijn eigen kunnen, aan een Bachelor studie in psychologie. Ik ben van jongs af aan geïnteresseerd geweest in psychologie maar door andere keuzes eerder in mijn leven leek studeren altijd ver buiten mijn bereik. Desalniettemin, en mede dankzij het vertrouwen en de ondersteuning van mijn man Martin, ben ik toch begonnen aan deze studie en heb ik deze vervolgens met groot succes kunnen afronden. Dit was grotendeels te danken aan het enthousiasme van de docenten van de Open Universiteit in Edinburgh. Zij toonden niet alleen een grote liefde voor het onderwerp dat ze doceerden maar zij leerden me ook om kritisch na te denken, een vaardigheid die onmisbaar bleek in mijn verdere loopbaan in de wetenschap. De psychologiedocenten van de Open Universiteit in Edinburgh hebben mijn eerste ervaring met het studeren aan een universiteit tot een heel plezierige en inspirerende gebeurtenis gemaakt, waarvoor ik ze graag wil bedanken.

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Tijdens mijn werk voor het Infancy Studies Laboratory ontstonden de eerste gedachten aan het doorstuderen voor een Master en een PhD. Vanwege een verhuizing, terug naar Europa deze keer, heb ik mijn Masterstudie niet in het Engels, maar in het Frans gedaan. Na enig oponthoud om te taal te leren beheersen, ben ik gestart aan een Master in Cognitieve Wetenschappen aan de Universiteit van Bordeaux. In Bordeaux heb ik stage gelopen bij Isabelle Hesling, die mij kennis liet maken met het onderwerp ‘prosodie’. Isabelle had voorheen gewerkt met Sue Peppé in Schotland en Sue en Isabelle hebben mij geïnspireerd om een studie uit te voeren naar het gebruik en begrip van Engelse prosodie bij Franse volwassenen. Ik wil Isabelle en Sue allebei bedanken voor het doorgeven van hun enthousiasme voor prosodie en voor het delen van hun kennis hierover.

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A journey of a thousand miles begins with a single step. ¹
There and back again. ²

¹Lao-tzu, Chinese philosopher (604 BC - 531 BC)
In 2003, I started, with many uncertainties about my own qualities, a Bachelor of Science degree in psychology. The study of psychology had always interested me but, as I made different choices earlier in my life, a degree always seemed out of reach to me. Nevertheless, with the help and dedication of my husband Martin, who always believed in me and who supported my decisions, come rain or shine, I started the course and finished it with great success. This was largely due to the enthusiasm of the inspiring teachers at the Open University in Edinburgh. They showed great love for the subjects they taught and they made me think for myself, and more importantly, to be critical in my thinking. This skill turned out to be invaluable for my further career in science. I would like to thank all psychology teachers from the Open University in Edinburgh for making my first experience with the study of psychology such a pleasant and positive one.

After my bachelor’s degree I had a great opportunity, to work at the Infancy Studies Laboratory at Rutgers University in Newark, USA, due to my husband’s job at Rutgers. April Benasich, the lab director, instantly made me feel welcome and gave me the opportunity to train as an EEG (electroencephalogram) technician. I would like to thank April very much for introducing me to language research in children, and for believing in me and giving me the chance to show what I was worth. At the Infancy Studies Laboratory, my first thoughts of future studies started to surface. Due to another move, back to Europe this time, the language that I did my next study in was not English, but French. After the initial delay in having to learn the language, I started my Master of Cognitive Sciences degree at the University of Bordeaux. In Bordeaux, I did my traineeship with Isabelle Hesling, who introduced me to the topic of prosody. Isabelle had worked together with Sue Peppé in Scotland, and Sue and Isabelle inspired me to perform a study in the use and understanding of English prosody in French second language learners. I would like to thank both Isabelle and Sue for sharing their knowledge on prosody and for making me enthusiastic about this aspect of spoken language.

From France I moved to back to the Netherlands and this brought me to the Radboud University in Nijmegen. Because Nijmegen is the place where I did my dissertation, most of the people I would like to acknowledge are based here. The first of this long list of people I would like to thank is Toon Cillessen, who decided to admit me to the Research Master in Behavioural Science in August despite the fact that the course was starting only weeks later. Without his decision I would never have started this dissertation. The meetings I had with Janet van Hell, who was very supportive and willing to think along have also been instrumental in starting this trajectory and I would like to thank her for that.

My next meeting in Nijmegen was with Ludo Verhoeven. Ludo became my supervisor, first for my master’s thesis and later for my PhD project, and from the first moment we met I felt that I could have my own say in things and that my
opinion was valued and respected. The fact that Ludo appreciated and stimulated my independent attitude was very important to me, and over the years I felt more and more in control over my own project. Ludo’s enthusiasm for my research topic and his far-reaching knowledge of the field of literacy made the design of my studies and my publications stronger. I would like to thank Ludo for giving me the confidence to have completed this journey successfully.

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Another important part of my PhD project has been the contact with my fellow PhD students. The composition of this group has changed enormously from 2011 to 2015, but one thing stayed the same: I always enjoyed the interaction, the lunches together and the sharing of ideas and experiences. I will not mention any names out of fear for forgetting anyone, but I would like to thank all my colleagues, old and new alike, for their pleasant company. A few colleagues I saw outside of work as well and these I will mention by name. The first of these has to be Roy Vink, my roomy for four years. I could not have wished for a better roommate and I will not quickly forget our intense discussions about ‘life, the universe and everything’, usually, wearing our coats and standing on the doorstep about to leave for home. Good memories!! Another colleague I would like to mention is Kim Cordewener. I feel I can write a book about all the things we talked about and all the experiences we shared together, through good times and bad (but don’t worry, I won’t!). You were always there to lend a listening ear and your heart-warming interest and care for other people distinguishes you. Roy and Kim, I hope to keep seeing both of you in the future.

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provide me with company, food and a bed during the months of testing in ‘the Achterhoek’, or to listen to sound samples of children reading stories, or to try out test batteries to see how long they would take, you have all played a part in my studies. For me, it was a great experience to be able to share my experiences with you and to be so close to you all again. Mum, dad, Anne, Rosie, Graeme and the girls, thank you so much for all your enthusiasm and your support!

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Nathalie Veenendaal was born in Arnhem on the 26th January 1969. She obtained her bachelor’s degree in psychology in 2003, at the Open University in Edinburgh, Scotland. After her bachelor’s she worked as a research assistant at the Infancy Studies Laboratory of Rutgers University, Newark, USA. Subsequently, Nathalie did a Master of Cognitive Science Degree at the University of Bordeaux II (Victor Segalen) in Bordeaux, France. For her master’s thesis she investigated the use and understanding of English speech prosody in French adults at the Imagerie Moléculaire et Fonctionnelle (IMF), under the supervision of Isabelle Hesling. Nathalie went on to do a Research Master of Behavioural Science Degree at the Behavioural Science Institute of the Radboud University in Nijmegen. For her thesis she conducted a study to investigate the relation between text reading fluency and reading comprehension in fourth grade primary school children. In 2011 Nathalie started her PhD, under the supervision of Ludo Verhoeven and Margriet Groen. During her PhD she continued her research into the relation between text reading fluency and reading comprehension, and started to focus more on the ‘prosody aspect’ of text reading fluency. Nathalie twice presented her work at the annual meetings of the Society for the Scientific Study in Reading (2014, 2015). She also organised a symposium on methods in ERPs (Event Related Potentials) and on ‘Prosody in Spoken and Written Modality’. During her PhD Nathalie taught several courses to bachelor’s students in Pedagogical and Educational Sciences, and she supervised bachelor’s and master’s students in writing their theses. In January 2015 Nathalie obtained the University Teaching Qualification (BKO certificate). Nathalie currently works at the Educational Development and Training group of the Centre for Teaching and Learning (faculty of Social Sciences) at the University of Utrecht. Here she works as a consultant and she provides training for teachers about aspects of internationalisation, such as Content and Language Integrated Learning and Teaching in the International Classroom.
Publications
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