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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 3 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 4th to 6th grade. Structural equation modeling showed that the bidirectional relation provided the best fitting model. In 5th grade, text reading prosody was related to prior decoding and reading comprehension, whereas in 6th 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.

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. To do so, we compared two unidirectional relations, from text reading prosody to reading comprehension and from reading compression 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. Important to note, 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.

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

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be related to their reading comprehension level (e.g., Berninger et al., 2010; Kim & Wagner, 2015; Kim, Wagner, & Lopez, 2012). Two recent longitudinal studies showed that text reading fluency mediated between, on one hand, word reading and listening comprehension and, on the other hand, reading comprehension (Kim & Wagner, 2015; Kim et al., 2012). The mediating role of 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, both the child's ability to read a text quickly and accurately and the child's ability to read a text with appropriate prosody (i.e., text reading prosody) have 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 were associated, due to the methodological requirements needed to examine this, studies examining the directionality of this relationship are rare. 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 prosody, or a bidirectional relation can exist between these two skills. Evidence for each of these theoretical relations is discussed in the light of the methodological requirements just described.

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 adultlike intonation contour and reading comprehension. It is important to note that 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 adultlike 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 oral reading fluency—measured as speed and accuracy—was correlated with a reading comprehension test by .91, in middle school 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 reading fluency reflected the level of reading comprehension (Fuchs et al., 2001). Another study showed that reading comprehension explained 28% additional variance in reading fluency performance, after word reading 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 oral reading fluency and related to syntactic and semantic processing of sentences (e.g., Koriat et al., 2002; Snedeker & Trueswell, 2003; Snedeker & Yuan, 2008), 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, 1984, 1991).

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, so 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 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 auto-regressive 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 1 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 both 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 & Schwanenflugel, 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 & Wagner, 2015; Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009; Verhoeven & van Leeuwe, 2008, 2009). More important, 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. To compare the three theoretical possibilities regarding the relationship between text reading prosody and reading comprehension, we compared three structural path models: (a) a unidirectional relation from text reading prosody to reading comprehension, (b) a unidirectional relation from reading comprehension to text reading prosody, and (c) a bidirectional relation between text reading prosody and reading comprehension.

Method

Participants

Participants were 99 primary school children (57 girls, 42 boys) from an original sample of 106 participants in fourth grade. The mean age in fourth grade was 9 years, 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 grade to sixth grade. Ninety-six percent of the children had Dutch parents and 4% 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, as Dutch children already read 90% of existing words correctly after only 1 year of formal 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 items (e.g., *laas*), double consonant items (e.g., *stoef*), two-syllable items (e.g., *gluifel*) and multisyllable items (e.g., *waagdoller*). For each list, children had 1 min 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 Chronbach 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 1st 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 it out loud, 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 to 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). Interrater reliability was determined by rater agreement percentages and intraclass correlation coefficients (see Table 1). 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).

Reading comprehension

Two standardized reading comprehension tests for children in intermediate and upper grades were presented to the children in each of the 3 years (Verhoeven & Vermeer, 1993). In the first reading comprehension test (RC1), children read two short stories: one story about the making of bread and

Table 1. Means and standard deviations for raw scores on decoding efficiency, text reading prosody, and reading comprehension.

	4th Grade		5th Grade		6th Grade	
	M	SD	M	SD	M	SD
Decoding efficiency (wpm)						
Decoding CVC	66.22	18.24	78.60	20.88	85.06	20.15
Decoding CCVCC	50.84	18.34	61.73	20.78	68.39	20.65
Decoding two-syllable	31.74	12.50	38.95	14.54	44.57	14.87
Decoding multisyllable	23.36	9.44	28.60	10.56	33.90	11.42
Text reading prosody (max. 16)						
Prosody: turtle & spider	11.70	2.56				
Prosody: cycling holiday	11.35	2.68	12.89	2.21		
Prosody: tiger & squirrel			12.73	2.37	13.76	2.05
Prosody: crane & fox					13.27	2.09
Rater agreement prosody[a]						
Agreement (%)	Exact	Adjacent	Exact	Adjacent	Exact	Adjacent
	43	46	58	36	64	36
Reading comprehension						
RCI (max. 40)	33.17	5.91	36.40	3.50	37.62	3.65
RCII (max. 40)	26.60	4.67	29.74	4.64	31.36	3.73

Note. N = 99. wpm = words per minute; C = consonant; V = vowel; RCI = first reading comprehension test; RCII = second reading comprehension test.
[a]The ICC on the average prosody score was as follows: fourth grade: ICC = .760, $F_{(9, 9)}$ = 6.72, p = .005; fifth grade: ICC = .779, $F_{(9, 9)}$ = 7.66, p = .003; sixth grade: ICC = .829, $F_{(9, 9)}$ = 12.21, p < .001.

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's alpha for both reading comprehension tests: RCI α > .88 and RCII α > .75 (Verhoeven & Vermeer, 1996). In addition, we calculated a sample-based Cronbach's alpha over the data from the 1st year: this was .87 for RCI and RCII taken together (as used for analyses).

Procedure

All assessments were carried out during school hours. Data collection took place in the spring of 3 consecutive years. The tests to assess reading comprehension were administered groupwise 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 administrated 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 article) 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 articles, where we examined cross-sectional relationships between text reading prosody and reading comprehension Veenendaal et al., 2014, 2015).

Data analysis

The text reading prosody, decoding efficiency, and reading comprehension data were converted into averaged *z* scores. Structural path modeling was used to analyze the data, using LISREL software

(version 8.80; Jöreskog & Sörborn, 1996) and maximum likelihood estimation. We first 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 GFI (AGFI), the normed fit index (NFI), the comparative fit index (CFI) and the root mean square error of approximation (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.

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.

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 grades. The results of the interrater reliability analysis of the text reading prosody assessment can also be found in Table 1.

Development in each skill over the 3 years was examined by means of a repeated measures analysis of variance, with time (performance on task over the three grades) as the within-subjects variable and school as the between-subjects factor, in order to account for the nested data structure of children within different schools. Greenhouse–Geisser corrections were applied as the data violated the assumption of sphericity.

There was a main effect of time on the decoding task, $F(1.76, 166.86) = 290.55$, $p < .001$, partial $\eta^2 = .75$; on text reading prosody, $F(1.87, 177.31) = 98.28$, $p < .001$, partial $\eta^2 = .51$; and on reading comprehension, $F(1.58, 150.36) = 102.32$, $p < .001$, partial $\eta^2 = .52$. Post hoc tests (Bonferroni) revealed that the scores between the time points, from fourth to fifth grade ($p < .001$) and from fifth to sixth grade ($p < .001$), increased significantly for all measures. There was no main effect of school on decoding efficiency, $F(3, 95) = 0.68$, $p = .566$, partial $\eta^2 = .02$; on text reading prosody, $F(3, 95) = 2.62$, $p < .056$, partial $\eta^2 = .08$; and on reading comprehension, $F(3, 95) = 2.66$, $p = .053$, partial $\eta^2 = .08$. Further, no interactions were found between school and time on decoding efficiency, $F(5.27, 166.86) = 2.21$, $p = .053$, partial $\eta^2 = .07$; text reading prosody, $F(5.60, 177.31) = 1.57$, $p = .165$, partial $\eta^2 = .05$; and reading comprehension, $F(4.75, 150.36) = 0.85$, $p = .514$, partial $\eta^2 = .03$.

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 ($r = .36$, $p < .001$). 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 a strong correlation between text reading prosody in fifth grade and reading comprehension in sixth grade ($r = .57$, $p < .001$).

Table 2. Bivariate correlations between averaged z scores of decoding efficiency, text reading prosody, and reading comprehension in fourth, fifth, and sixth grades.

	Dec 4th	Dec 5th	Dec 6th	Pros 4th	Pros 5th	Pros 6th	RC 4th	RC 5th	RC 6th
Dec 4th	—								
Dec 5th	.93***	—							
Dec 6th	.90***	.95***	—						
Pros 4th	.58***	.58***	.56***	—					
Pros 5th	.59***	.60**	.56***	.83***	—				
Pros 6th	.63***	.65***	.64***	.80***	.85***	—			
RC 4th	.12	.13	.13	.39***	.44***	.39***	—		
RC 5th	.23*	.25*	.26*	.32**	.39***	.43***	.68***	—	
RC 6th	.39***	.36***	.35***	.51***	.57***	.60***	.61***	.75***	—

Note. $N = 99$. Dec = decoding efficiency; Pros = text reading prosody; RC = reading comprehension.
*$p < .05$. **$p < .01$. ***$p < .001$.

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: $\chi^2(18, N = 99) = 30.09$, $p = .018$, RMSEA = .08, GFI = .94, NFI = .97, CFI = .99, AGFI = .84.

The proportion of explained variance in text reading prosody was $R^2 = .75$, and the explained variance in reading comprehension was $R^2 = .63$, in sixth grade. This first path model shows that, similar to decoding efficiency and reading comprehension, the strongest predictor for text reading prosody was text reading prosody 1 year earlier (the autoregressive effect). Regarding the direction of the relation between text reading prosody and comprehension, text reading prosody in fifth grade was significantly related to reading comprehension in sixth grade. No significant relation between text reading prosody and reading comprehension was found in the transition from fourth and fifth grade. Regarding the relation with decoding efficiency, decoding was significantly related 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 as follows: $\chi^2(18, N = 99) = 32.64$, $p = .018$, RMSEA = .09, GFI = .93, NFI = .97, CFI = .98, AGFI = .83. The proportion of explained variance in sixth grade in text reading prosody was $R^2 = .75$ and in reading comprehension was $R^2 = .59$. The second path model (ii) shows that reading comprehension was significantly related to text reading prosody 1 year later, in fifth as well as sixth grade. In this path model, decoding efficiency related 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 $\chi^2(16, N = 99) = 20.44$, $p = .20$, RMSEA = .05, GFI = .96, NFI = .98, CFI = 1 .00, AGFI = .88. The proportion of explained variance was $R^2 = .76$ in text reading prosody and $R^2 = .65$ in reading comprehension, in sixth grade. The third path model (iii) shows that reading comprehension was significantly related to text reading prosody from fourth grade to fifth grade, whereas text reading prosody was significantly related to reading comprehension from fifth grade 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 related to text reading prosody in both years, but only to reading comprehension from fourth grade to fifth grade.
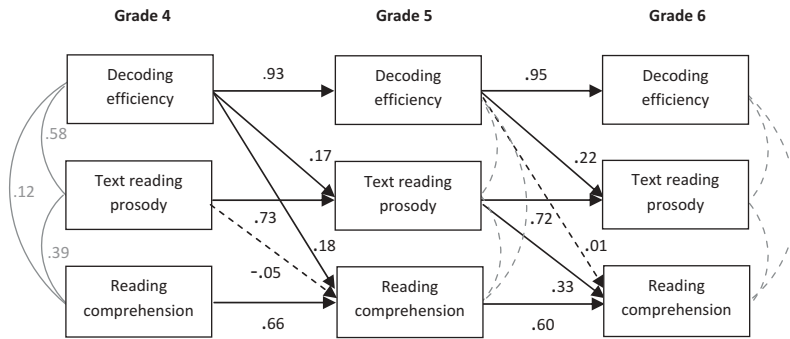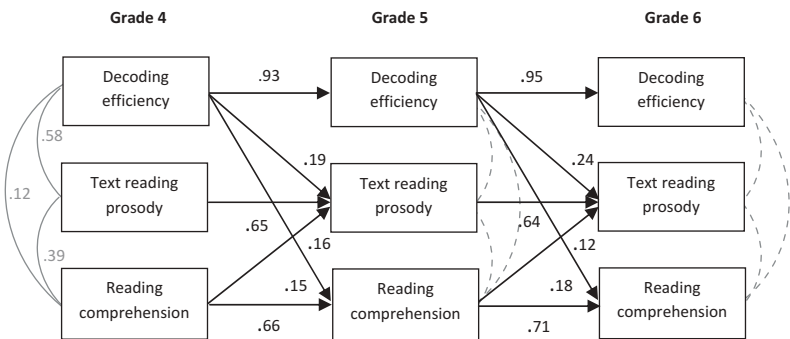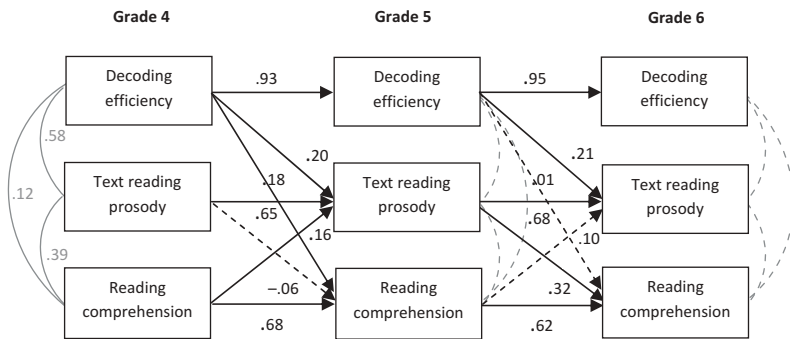
Figure 1. The direction of the relation between text reading prosody and reading comprehension.

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 to a lesser degree, 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. Of importance, we took into account auto-regressive 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 therefore 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 is dependent on grade level. It was shown that besides decoding efficiency, reading comprehension contributed to text reading prosody from fourth grade to fifth grade. This means that decoding efficiency in itself was not enough for text reading prosody to develop. Of interest, our data showed that a relation from text reading prosody to reading comprehension appeared only in the upper grades, from fifth grade to sixth grade. The results therefore suggest that text reading prosody needed to become stably developed before it started to facilitate reading comprehension 1 year later.

The reciprocal relation between reading comprehension and text reading prosody can be related to interactive theories of reading (Rumelhart, 1994; Stanovich, 1991, 1984). 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 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 is 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 (Fodor, 1998, 2002; Stolterfoht, Friederici, Alter, & Steube, 2007). Fodor (1998, 2002) 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 take place only 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 retell 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 grade to second grade and an early adultlike 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 relation between text reading prosody and reading comprehension over a longer period. The results showed, first, that text reading prosody and reading comprehension were related in the 1st year of assessment (as shown by the covariances in Grade 4). In addition, the results showed that this relation is dependent on grade level—and therefore on the reading level of children—when measured over

3 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 until now largely unknown. The result 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, and in 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 or not text reading prosody was included in the model. 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 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 advanced Dutch 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. First, text reading prosody has been measured by use of a rating scale. Even though interrater 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 ($r = .75–.90$, $p < .001$). Second, 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 make use of a latent variable approach for the two different texts used to assess text reading prosody and the two reading comprehension tasks, or 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. Last, the relatively small sample limited us in precisely capturing individual differences in reading skills over time or any potential effects of school membership. Therefore, it is recommended that future research would examine development in text reading prosody more closely by including more schools and more participants and by performing multilevel modeling.

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 comprehension. 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.

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