Different readers, different texts, different processes : the effects of reader and text properties on text processing

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Title: Different readers, different texts, different processes : the effects of reader and text properties on text processing
Issue Date: 2020-04-30

Chapter 05

Exploring Text-Processing Differences between Paraphrasing and Elaborating Readers: Are their Specific Reading Styles Characterized by Different Eye-Movement Patterns?

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Abstract

In the present study, we explored text-processing differences between two specific subgroups of readers; paraphrasers and elaborators (McMaster, Espin, & van den Broek, 2014; McMaster et al., 2012; Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007). We investigated whether readers that were characterized as low- and high-comprehending paraphrasers and elaborators on the basis of a prior think-aloud experiment (see *Chapter 3*), are also characterized by different eye-movement patterns. We did so by analyzing the eye-movement data we collected of these readers in a prior eye-tracking experiment (see *Chapter 4*) in conjunction with their think-aloud data. In addition, we explored whether the eye-movement patterns of paraphrasers and elaborators show similarities with the eye-movement patterns of subgroups of readers that are distinguished in prior eye-tracking studies (Koornneef & Mulders, 2016; Olson, Kliegle, Davidson, and Foltz, 1985; Rayner, Castelhano, & Yang, 2009; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006). Based on these prior eye-tracking studies on subtypes of readers we used word skipping probability and regression probability as primary eye-movement measures to investigate potential text-processing differences. We hypothesized that paraphrasers would skip fewer words and would look back less often in the text than elaborators. For high-comprehending readers the results indicated that paraphrasers skipped fewer words than elaborators but looked back in the text as often as elaborators. For low-comprehending paraphrasers and elaborators the results did not reveal different eye-movement patterns. Implications of these findings will be discussed.

5.1 Introduction

To successfully comprehend a text, a reader has to construct a coherent mental representation of the meaning of the text (Kintsch, 1988, 1998; Graesser, Singer, & Trabasso, 1994; van den Broek, 1994). This construction of a coherent mental text representation is a complex process involving basic language skills such as word decoding, syntactic parsing, and vocabulary, as well as higher-level cognitive skills related to comprehension such as inference generation, comprehension monitoring, and knowledge of text structure (Cain & Oakhill, 1999; Oakhill, Cain, & Bryant, 2003; Perfetti, Landi, & Oakhill, 2005; van den Broek, Rapp, & Kendeou, 2005).

Readers differ in the extent to which they succeed in constructing a coherent mental text representation. To have an understanding of why some readers are successful comprehenders and others are not, it is vital to get insight into the cognitive processes and strategies in which readers engage during reading. This applies to readers in general, but especially to young readers. This insight can be gained on the basis of different methods. For instance, having readers think out loud or track their eye movements during reading can give insight into their on-line reading process, such as cognitive processes and reading strategies (think-aloud method: Ericsson & Simon, 1993; Pressley & Afflerbach, 1995; eye-tracking method: Boland, 2004; Juhasz & Pollatsek, 2011; Rayner, 1998). Both the think-aloud method and the eye-tracking method have their strengths and limitations and can complement each other in the type of data they generate (Holmqvist et al., 2011; Kaakinen & Hyönä, 2005; Rapp et al., 2007, Walczyk, Marsiglia, Johns, & Bryan, 2004), as will be discussed in the next sections.

5.1.1 Think-aloud method and eye-tracking method

In think-aloud studies, it is common to classify participants' think-aloud responses into different categories of cognitive processing or reading strategies (e.g., Goldman & Saul, 1990b; Magliano, Trabasso, & Graesser, 1999; Linderholm & van den Broek, 2002; McMaster et al., 2012; Rapp et al., 2007). For instance, the reader makes an *inference* when he or she provides an explanation for the content of the current sentence on the basis of background knowledge (*elaborative inference)* or predicts what will come about next in the text *(predictive inference)*. Although having readers think out loud during reading can give insight into their on-line text-processing approach and strategy use, there are limitations to the use of the think-aloud method (Coté, Goldman, & Saul, 1998; Ericsson & Simon, 1980; Rapp et al., 2007). For instance, it requires metacognitive skills from the reader to express his or her thoughts; moreover, the reader only puts into words what he or she is conscious of (Rapp et al., 2007).

Eye tracking can be used to capture both conscious and subconscious moment-to-moment text processing. Moreover, it measures the occurrence and time course very accurately (Rayner, 1998). In eye-tracking studies, it is common to distinguish different cognitive processes or reading strategies on the basis of distinct eye-movement measures (Boland, 2004; Juhasz & Pollatsek, 2011; Rayner, 1998). On the one hand, measures of initial or early processing (e.g., *first fixation and first gaze durations;* see details in Methods section) are used to investigate lower-level processes and skills such as decoding of orthographic information and word identification. On the other hand, later processing measures (e.g., regression rates) are used to investigate integrative text processing (Boland, 2004; Juhasz & Pollatsek, 2011). Eye-movement measures can be informative for the on-line reading process, but conclusive mapping between eye movements and specific cognitive processes is a challenge (Boland, 2004).

So, both the think-aloud method and eye-tracking method have limitations as well as strengths and the methods complement each other in delineating a comprehensive picture of readers' on-line text processing (Holmqvist et al., 2011; Kaakinen & Hyönä, 2005; Rapp et al., 2007; Walczyk et al., 2004). However, to our knowledge, few studies on text processing have combined the methods so far (Holmqvist et al., 2011; Godfroid & Spino, 2015; but see Kaakinen & Hyönä, 2005). In the present study, we wanted to obtain a more in depth picture of the text-processing differences between subgroups of readers in elementary school. And so, the two methods were combined in order to explore whether the different reading profiles of readers as assessed by the think-aloud method are characterized by different eye-movement patterns.

5.1.2 Struggling comprehenders versus good comprehenders

Both the think-aloud method and the eye-tracking method can be used to distinguish between struggling comprehenders and good comprehenders. In addition, the methods can give insight into how the text-processing approaches of struggling and good comprehenders differ, and in which aspects they match. For example, with regard to the think-aloud method, Pressley and Afflerbach (1995) have shown that good readers are goal directed and flexible in their text-processing approach. That is, they adapt their processing approach depending on the text they are reading. Moreover, prior think-aloud studies investigating the text-processing approaches of struggling and good readers revealed that both groups of readers use a variety of strategies, ranging from literal text repetitions to elaborate knowledge-based inferences (Kraal et al., 2018; McMaster et al., 2012, 2014; Rapp et al., 2007), but that struggling readers make more invalid elaborative and predictive inferences than average readers (McMaster et al., 2012) and good readers (Kraal et al., 2018; McMaster et al., 2012). Prior eye-tracking studies (for an overview, see Rayner, 1998) have revealed that struggling as well as beginning readers differ from proficient readers in their eye-movement patterns. That is, in comparison to proficient readers, both struggling and beginning readers make more fixations, longer fixations, shorter saccades, and more regressions during reading. In a study by McMaster et al. (2014) among struggling, average and good readers in Grade 4, eye-tracking results revealed that struggling readers had similar numbers of fixations and regressions as average and good readers, but spent more time on each fixation and on rereading text. Overall, the above indicates that both the think-aloud method and the eye-tracking method, in their own ways, are methods sensitive enough to distinguish between struggling and good comprehenders, based on their text-processing approaches.

5.1.3 Influence of text genre on text-processing approach

To understand children's online reading processes it is important to distinguish between different text genres, e.g., narrative texts versus expository texts, as genre is known to influence the text-processing approach of readers (e.g., Lorch, 2017; McDaniel & Einstein, 1989). Both the think-aloud method and eye-tracking method can give insight into the influence of text genre on children's text-processing approaches. For example, the think-aloud study in *Chapter 3* showed that low- and high-comprehending second-grade readers responded similarly to text genre: Both groups made more text-based and knowledge-based inferences for narrative texts, whereas they made more comments and asked more questions for expository texts. There was one exception: low-comprehending readers made more erroneous knowledge-based inferences for expository texts. These think-aloud results are complemented by the results of an eye-tracking study with these low- and high-comprehending readers (see *Chapter 4*), which revealed that relative to narrative texts, low-comprehending readers responded differently to expository texts than high-comprehending readers did. That is, low-comprehending readers showed an inclination to adopt a less intensive processing approach for expository texts by spending less time on rereading words and -- more speculatively -- by making longer saccades and by skipping more words, whereas high-comprehending readers displayed a more stable processing approach across text genre. These patterns of results suggest that think-aloud and eye-tracking methods complement each other in outlining a complete picture of children's on-line text processing.

5.1.4 Distinct types of readers

Prior studies on on-line text processing have not only differentiated between groups of readers, they have also defined distinct types of readers within a particular, relatively homogeneous group on the basis of differences in on-line text-processing approaches (e.g., Hyönä, Lorch, & Kaakinen, 2002; Koornneef & Mulders, 2016; Kraal et al., 2018; McMaster et al., 2012, 2014; Olson et al., 1985; Rapp et al., 2007; Rayner et al., 2006, 2009). Think-aloud studies among primary and secondary school students have distinguished two distinct types of readers based on their on-line text-processing approach: *paraphrasers* and *elaborators* (Kraal et al., 2018; McMaster et al., 2012, 2014; Rapp et al., 2007). Paraphrasers restrict their text-processing approach mostly to the current text by paraphrasing and restating sentences, and make few text-based and knowledge-based inferences. Elaborators, on the other hand, link their own background knowledge to the information in the text. They make relatively many text-based and knowledge-based inferences and comments on the texts. These distinct types of readers have been distinguished among low-comprehending readers (Kraal et al., 2018; McMaster et al., 2012, 2014; Rapp et al., 2007) as well as among high-comprehending readers (Kraal et al., 2018). To get a more detailed depiction of the text-processing differences between paraphrasers and elaborators, results of think-aloud research can be complemented with research on eye movements.

5.1.5 Prior eye-tracking studies

Prior eye-tracking studies have shown that certain eye-movement measures can reveal differences between subgroups of readers, resulting in the distinction of different types of readers on the basis of eye-movement patterns. For instance, on the basis of the distance and the direction of the saccades that readers make between fixations, Rayner et al. (2006, 2009) have shown that the eye-movement patterns of senior adults differ from the eye-movement patterns of younger adults. That is, senior adults make longer saccades, more frequently skip words, and make more backward saccades (regressions). Rayner et al. interpreted this reading profile as a *proactive* reading profile in which senior readers make frequent guesses about the further course of an ongoing sentence. Therefore, they labeled it a *risky* reading profile. In addition, Koornneef and Mulders (2016) have demonstrated that even among homogeneous groups of adult proficient readers (i.e., university students) eye-movement patterns can differ, resulting in the distinction of subgroups of readers that engage in qualitatively distinct reading strategies. On the basis of saccade distance and regression probability they distinguished *conservative readers* and *proactive readers.* Conservative readers make short saccades and few regressions, whereas proactive readers make long saccades and many regressions. The profile of the proactive readers (Koornneef & Mulders, 2016) is comparable to the risky reading profile (Rayner et al., 2006, 2009). In addition, the subgroups that Koornneef and Mulders (2016) have identified are, in a way, comparable to the two subgroups of poor readers Olson et al. (1985) have identified on the basis of between-words regressive eye movements and progressive word skipping eye movements; *plodding* and *exploring readers*. Plodders, on the one hand, move forward with relatively short saccades and with few regressions between words or skipping over words. Explorers, on the other hand, often skip words, make fewer intra-word progressive movements, and make relatively more regressions to previous words.

5.1.6 The present study

Prior think-aloud studies have shown differences in the text-processing patterns of paraphrasers and elaborators. In addition, prior eye-tracking studies have shown that certain eye-movement measures reveal differences in the text-processing patterns of readers. The goal of the present study is to delineate a more comprehensive picture of the text-processing approaches of paraphrasers and elaborators. Therefore, we explored whether the reading profiles of paraphrasers and elaborators as assessed by a think-aloud protocol are characterized by different eye-movement patterns as assessed by eye-movement measures. In a study we conducted previously (see *Chapter 3*), we asked participants to think out loud as they read expository texts and narrative texts for comprehension. In another study we conducted previously with the same participants (see *Chapter 4*), we recorded their eye movements as they read expository texts and narrative texts for comprehension. In the present study, we aimed to answer the question whether the text-processing patterns of second-grade low- and high-comprehending paraphrasers and elaborators are characterized by different eye-movement patterns by analyzing the data of the previous studies (*Chapters 3* and *4*) in conjunction. We also explored the effect of text genre on the eye-movement patterns. Additionally, we explored whether the reading profiles of paraphrasers and elaborators show similarities with the reading styles of subgroups of readers that are distinguished in prior eye-tracking studies (Koornneef & Mulders, 2016; Olson et al., 1985; Rayner et al., 2006, 2009).

Based on prior eye-tracking studies on subgroups of readers by Olson et al. (1985), Rayner et al. (2006, 2009) and Koornneef and Mulders (2016), we tested hypotheses regarding *word skipping probability* and *regression probability*. Since paraphrasers restrict their text-processing approach mostly to the present text by paraphrasing and restating sentences and elaborators link their background knowledge to the text by making relatively many text-based and knowledge-based inferences and comments on the text (Kraal et al., 2018; McMaster et al., 2012, 2014; Rapp et al., 2007), we hypothesized that paraphrasers, in comparison to elaborators, would skip fewer words (as measured by *first-pass word skipping probability*) and would look back less often in the text (as measured by *first-pass regression probability*). We further explored the text-processing approaches of elaborators and paraphrasers in relation to other reading measures. In addition, given that readers have been found to process different text genres differently (e.g., Lorch, 2017; McDaniel & Einstein, 1989), we explored the effect of text genre (expository and narrative texts) on the eye-movement patterns of low- and high-comprehending paraphrasers and elaborators.

5.2 Method

5.2.1 Participants

The study included 75 second-grade pupils (45 girls; mean age 7.48; range 7.0-8.0) from nineteen classes of nine public elementary schools in the Netherlands, ranging from rural to inner-city schools. They were a subset of the participants from the think-aloud study (see *Chapter 3*). Inclusion criteria for that study were: (1) average or above-average scores on a non-verbal intelligence test (*Raven's progressive matrices*, Raven, Raven, & Court, 1998); (2) average or above-average scores on a Dutch standardized test for word reading ability (*Drie-Minuten-Test* [Three-Minutes-Test], Cito, 2009); (3) no diagnosed behavioral and/or attention problems; (4) a score either above the 75th percentile or below the 50th percentile on a Dutch standardized test for reading comprehension (*LOVS Begrijpend Lezen Groep 3* [Reading comprehension test for Grade 1], Cito, 2006). An additional inclusion criterion for the present study was that the children had participated in the eye-tracking study (see *Chapter 4*). This resulted in the inclusion of 23 low- and 52 high-comprehending readers.

5.2.2 Measures and materials

Reading Profiles based on Think-aloud Responses. In the prior think-aloud study (*Chapter 3*), participants were asked to think out loud as they read two expository texts and two narrative texts for comprehension. The four experimental texts were matched on readability and length, using an algorithm that calculates text difficulty at the level of conceptual readability (P-CLIB version 3.0, Evers, 2008). See Table 5.1 for details on text features of the experimental texts. Text comprehension was assessed by posing five questions after each text (two questions eliciting literal information, two questions requiring a text-based inference, and one knowledge-based question requiring a gap-filling inference between the reader's background knowledge and the information in the text (Cain & Oakhill, 1999). The participants read the texts aloud in a sentence-by-sentence manner while thinking out loud after each sentence. Think-aloud responses were audio-recorded and later transcribed and parsed into idea units. After this initial parsing procedure the idea units were coded into eight categories using coding sheets based on guidelines by Linderholm and van den Broek (2002), McMaster et al. (2012), and Rapp et al. (2007), (for details, see *Chapter 3*). Using cluster analyses, the children were differentiated on the basis of their patterns of think-aloud responses (Ward & Hook, 1963). This analysis revealed similar subgroups within the groups of low- and high-comprehending readers. Subsequently, a multivariate RM-ANOVA analysis was conducted to further define the subgroups (for details, see Chapter 3). The subgroups were classified as high-comprehending paraphrasers (N = 25), high-comprehending elaborators (N = 27), low-comprehending paraphrasers (N = 9), and low-comprehending elaborators (N = 14). The think-aloud experiment was conducted in individual sessions that lasted 45 to 60 minutes, and took place at the schools of the participants, (for details on the procedure, see *Chapter 3*).

Table 5.1 Text features of narrative and expository experimental texts of the think-aloud study and the eye-tracking study based on P-CLIB, version 3.0 (Evers, 2008)

	Think-aloud study		Eye-tracking study	
	Narrative	*Expository*	*Narrative*	*Expository*
Average no. of sentences	23	22	19	19
Average no. of words/text	152	149	121	122
Average no. of types/text[1]	99	83	78	69
Average no. of letters/text	635	656	500	524
Average no. of words/sentence	6.5	6.8	6.4	6.4
Average no. letters/word	4.2	4.4	4.1	4.3
Average % of frequent words	79.2	81.2	89	75.5
Average type-token ratio	0.65	0.56	0.64	0.56
Average CLIB (Grade level)	CLIB-4[2]	CLIB-4[2]	CLIB-4[2]	CLIB-5[2]

[1]No. of types/text represents the number of distinct words in a text.
[2]CLIB-4 is the equivalent of the text-difficulty level for Grade 2 and CLIB-5 for Grade 3.

Eye-tracking experiment. In the prior eye-tracking study (*Chapter 4*), the children read two expository texts and two narrative texts for comprehension while their eye movements were tracked with an Eyelink 1000 setup (SR Research), sampling at a rate of 500 Hz. The experimental texts were matched on readability and length, comparable to the texts used in the think-aloud experiment, see Table 5.1. The texts were presented in their entirety (one sentence per line) without title, with double spacing between the lines. The children read the texts silently in a self-paced manner, while their heads rested on a chin rest. After reading each text, the children removed their head from the chin rest and orally answered six comprehension questions (two questions eliciting literal information, three questions requiring a text-based inference, and one knowledge-based question requiring a gap-filling inference between the reader's background knowledge and the information in the text, Cain & Oakhill, 1999). The eye-tracking experiment was conducted in individual sessions that lasted 45 to 60 minutes, and took place at the schools of the participants, (for details on the procedure, see *Chapter 4*).

Eye-movement measures. In the prior eye-tracking study, the eye movements were analysed to investigate on-line text processing of low- and high-comprehending second-grade readers as they read narrative and expository texts. In the present study, the eye-tracking data are used to explore unique processing patterns by subgroups of readers with different reading profiles and skill in reading comprehension (low-comprehending paraphrasers vs. low-comprehending elaborators, and high-comprehending paraphrases vs. high-comprehending elaborators) for different types of texts (narratives vs. expository texts). In order to do this, several measures were derived from the eye-tracking data. Based on prior eye-tracking research on processing patterns of subgroups of readers (Koornneef & Mulders, 2016; Olson et al., 1985; Rayner et al., 2006, 2009), the primary measures consisted of *first-pass regression probability* (based on the ratio of progressive and regressive saccades during first pass) and *first-pass word skipping probability* (the probability that a word is skipped during first pass) (Juhasz & Pollatsek, 2011). In addition, a number of eye-tracking measures were computed in an exploratory manner. These measures include coarse measures of processing strategies (see, e.g., Juhasz & Pollatsek, 2011), such as *full text reading times* and *full text fixation counts*. They also include several finer-grained reading measures for each individual word of a text (e.g., Juhasz & Pollatsek, 2011), namely *first fixation duration* (the duration of the first fixation on a word during first pass), *first gaze duration* (the sum of all fixation durations for a word during first pass before the reader either moves on or looks back into the text), *right-bounded duration* (the sum of all fixation durations of a word during first pass before the reader moves on progressively), *total fixation duration* (the sum of all fixation durations for a word), *second-pass fixation duration* (the sum of all second-pass fixation durations for a word, i.e., computed by subtracting the right-bounded duration from the total fixation duration), and *saccade amplitude* (the amplitude of progressive first-pass saccades in degree of visual angle; Juhasz & Pollatsek, 2011).

Test battery

A test battery assessing participants' general cognitive and language-related proficiencies was administered in a prior study (for details, see *Chapter 3*). Only tests relevant to the present study are described here.

Non-verbal intelligence (selection criterion). Raven's Standard Progressive Matrices (Raven et al., 1998) were used as a measure for non-verbal intelligence and abstract reasoning. Reported scores are raw scores. The scores of the participants ranged from 15 to 49, reflecting average to high non-verbal intelligence (range of possible scores: 0-60).

Word-reading ability (selection criterion). A Dutch standardized test (*Drie-Minuten-Toets* [Three-Minutes-Test], Cito, 2009) was used to assess word decoding skills. The test had been administered at the end of Grade 1. Reported scores are skill scores. The scores of the participants ranged from 35 to 85, reflecting above average to very high word-reading ability (range of possible scores: 0-148).

Reading comprehension (selection and classification criterion). A Dutch standardized test (*LOVS Begrijpend Lezen Groep 3* [Reading Comprehension Test Grade 1], Cito, 2006) was used to assess reading comprehension. The test consists of an initial module for all children, an easier follow-up module for weak comprehenders, and a more difficult follow-up module for average and good comprehenders. Reported scores are skill scores. The scores of the participants ranged from -30 to 34, reflecting very low to very high reading-comprehension ability (range of possible scores for easier follow-up module: -87 to 48; range of possible scores for more difficult follow-up module: -81 to 60).

Listening comprehension. A standardized Dutch test was used to assess listening comprehension (*LOVS Begrijpend Luisteren Groep 3* [Listening Comprehension Grade 1], Cito, 2011). Reported scores are skill scores. The scores of the participants ranged from 34 to 83, reflecting the full range of listening-comprehension ability (range of possible scores: 0-113).

Vocabulary knowledge. The Peabody Picture Vocabulary Test-III-NL (Schlichting, 2005) was used as a standardized measure to assess receptive vocabulary in Dutch. Reported scores are raw scores. The scores of the participants ranged from 22 to 52 (range of possible scores: 0-60).

Inference making. A translated version of the Inference and Integration Task (Cain & Oakhill, 1999) was used to assess inference-making skills. Reported scores are raw scores. The scores of the participants ranged from 7.5 to 17 (range of possible scores: 0-18).

Verbal working memory. We translated the Sentence Span Measure (Swanson, Cochran, & Ewers, 1989), and adapted it (for details, see Chapter 3) to assess verbal working-memory capacity. Reported scores are the scores for number of words correctly remembered plus comprehension questions correctly answered. The scores of the participants ranged from 1 to 16 (range of possible scores: 0-30).

5.3 Results

5.3.1 Test battery

Data of one high-comprehending paraphraser was missing on the test for verbal working memory. Fourteen participants (2 low-comprehending elaborators, 6 high-comprehending elaborators and 6 high-comprehending paraphrasers) only completed the initial part of the reading comprehension test. A MANOVA was performed with Reading Proficiency as a between-participants factor and the scores for the cognitive and language-related tasks in the test battery as dependent measures. The MANOVA showed that high-comprehending readers performed better on the test battery than did low-comprehending readers ($F(7,52) = 25.58$, $p < .001$). Univariate ANOVAs revealed that this contrast between groups was reliable for all cognitive and language-related tasks (*p*s < .01; see Table 5.2). In addition, two MANOVAs with the between-participants factor Think-Aloud Reading Profile (paraphrasers vs. elaborators) were performed for the groups of high- and low-comprehending readers separately. In the group of high-comprehending readers, paraphrasers and elaborators showed no differences in performance on the tasks employed in the test battery ($F(7,31) = 1.14$, $p = .36$). In the group of low-comprehending readers, the performance of paraphrasers and elaborators did show a difference ($F(7,13) = 11.88$, $p < .001$). Namely, low-comprehending elaborators performed better than low-comprehending paraphrasers on the tests for reading comprehension (elaborators: M = -5.58, SD = 3.29; paraphrasers: M = -11.56, SD = 8.72), ($F(1,19) = 4.79$, $p < .05$) and verbal working memory (elaborators: M = 3.21, SD = 1.12; paraphrasers M = 2.0, SD = 0.87), ($F(1,19) = 6.14$, $p < .05$), and low-comprehending paraphrasers (M = 51.67, SD = 10.17) performed better than low-comprehending elaborators (M = 43.57, SD = 8.20) on the test for word-reading ability ($F(1,19) = 10.77$, $p < .01$).

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Table 5.2 Mean scores (and standard deviations) of low- and high-comprehending paraphrasers and elaborators on tasks in the test battery.

	Low-comprehending paraphrasers	Low-comprehending elaborators	High-comprehending paraphrasers	High-comprehending elaborators
Measure	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Reading comprehension	-11.56 (8.72)	-5.58 (3.29)	16.21 (7.08)	21.14 (7.66)
Word-reading ability	51.67 (10.17)	43.57 (8.20)	52.96 (13.00)	55.78 (12.13)
Non-verbal intelligence	29.78 (8.01)	26.14 (6.87)	35.28 (6.47)	36.52 (6.13)
Listening comprehension	49.00 (8.83)	48.57 (9.53)	59.68 (6.85)	62.00 (9.16)
Vocabulary	29.89 (6.23)	34.71 (5.72)	41.32 (5.78)	42.67 (6.56)
Inference making	11.06 (2.34)	13.21 (2.06)	14.68 (1.17)	14.72 (1.69)
Verbal working memory	2.00 (0.87)	3.21 (1.12)	5.00 (2.50)	6.52 (3.87)

5.3.2 Comprehension measures

The mean values of the accuracy scores of the comprehension questions as a function of Text Genre, Question Type (literal, text-based, and knowledge-based questions), Reading Proficiency and Think-Aloud Reading Profile are reported. A mixed-effects logistic regression model was fitted on the data with the R package LME4. First, a model was fitted that included the fixed factors Text Genre, Reading Proficiency, and Question Type, as well as the interactions between these factors. Participants and questions were included as crossed random effects (Baayen, Davidson, & Bates, 2008; cf. Barr, Levy, Scheepers, & Tily, 2013, and Bates, Kliegle, Vasishth, & Baayen, 2015, for discussion). Because this model did not converge, models were fitted for each type of question separately (i.e., these models included the fixed factors Text Genre and Reading Proficiency, their interaction, and random effects of participants and questions).

Literal Questions. The analyses for the low-comprehending readers revealed a main effect of Text Genre ($\chi2(1) = 19.5$, $p < .001$). Low-comprehending elaborators and paraphrasers obtained higher accuracy scores for narrative texts (elaborators: M = 0.88, SD = 0.33; paraphrasers: M = 0.82, SD = 0.39) than for expository texts (elaborators: M = 0.38, SD = 0.49; paraphrasers: M = 0.22, SD = 0.42), (elaborators: b = 3.17, SE = 0.84, z = 3.79; paraphrasers: b = 3.53, SE = 0.91, z = 3.86).

The analyses for the high-comprehending readers revealed a main effect of Text Genre ($\chi2(1) = 6.49$, $p < .05$). High-comprehending elaborators and paraphrasers obtained higher accuracy scores for narrative texts (elaborators: M = 0.95, SD = 0.21; paraphrasers: M = 0.92, SD = 0.27) than for expository texts (elaborators: M = 0.59, SD = 0.49; paraphrasers: M = 0.61, SD = 0.49), (elaborators: b = 3.45, SE = 1.25, z = 2.76; paraphrasers: b = 2.64, SE = 1.21, z = 2.18).

The analyses revealed no interaction effects neither for low- nor for high-comprehending readers.

Text-based Questions. The analyses for the low-comprehending readers revealed a main effect of Text Genre ($\chi2(1) = 9.38$, $p < .01$). Low-comprehending elaborators and paraphrasers obtained higher accuracy scores for narrative texts (elaborators: M = 0.50, SD = 0.50; paraphrasers: M = 0.57, SD = 0.50) than for expository texts (elaborators: M = 0.29, SD = 0.45; paraphrasers: M = 0.17, SD = 0.38), (elaborators: b = 0.98, SE = 0.47, z = 2.08; paraphrasers: b = 2.02, SE =0.59, z = 3.46).

The analyses for the high-comprehending readers revealed a main effect of Text Genre ($\chi 2(1) = 6.47$, $p < .05$). High-comprehending elaborators and paraphrasers obtained higher accuracy scores for narrative texts (elaborators: M = 0.77, SD = 0.43; paraphrasers: M = 0.77, SD = 0.42) than for expository texts (elaborators: M = 0.59, SD = 0.49; paraphrasers: M = 0.53, SD = 0.50), (elaborators: b = 1.01, SE = 0.49, z = 2.05; paraphrasers: b = 3.17, SE = 0.84, z = 3.79).

The analyses revealed no interaction effects neither for low- nor for high-comprehending readers.

Knowledge-based Questions. The analyses revealed no main or interaction effects neither for low- nor for high-comprehending readers.

5.3.3 Eye-movement measures

Tables 5.3 and 5.4 report the mean values (and their standard deviations –when applicable) of the primary and secondary eye-movement measures as a function of Reading Proficiency (high- vs. low-comprehending readers), Think-Aloud Reading Profile (elaborator vs. paraphraser) and Text Genre (expository vs. narrative texts). Mixed-effects logistic regression models were fitted for the two main (categorical) dependent measures (i.e., *first-pass regression probability* and *first-pass word skipping probability*). Mixed-effects linear regression models were fitted for the continuous eye-movement measures –with the response variable log-transformed to correct for right skewness. The models were conducted with the statistical software R (version 3.3.3.) using the package LME4 (version. 1.1-12). Separate analyses were conducted for the low-and high-comprehending readers. For each dependent variable a model was constructed that included the fixed factors Think-Aloud Reading Profile and Text Genre, as well as the interaction of these factors. Participants and texts were included as crossed random effects. Wald chi-square testing (Type II) –as implemented in the R package Car (version 2.1-4)– was applied to detect significant main and interaction effects. Relevant fixed-effects estimates and the associated t-values (for the continuous dependent variables) and z-values (for the categorical dependent variables) will be reported. Statistical significance at approximately the .05 level is indicated by z- and t-values of ≥ 1.96 or ≤ -1.96. The initial reference category was the group of paraphrasers reading an expository text. To obtain fixed-effects estimates and the associated statistics for all relevant simple effects, the reference category of the models was adjusted accordingly.

Primary analyses

First-pass regression probability. The analyses for the low-comprehending readers revealed a main effect of Text Genre ($\chi 2(1) = 6.05$, $p < .05$). This effect was caused by low-comprehending paraphrasers, who displayed a higher regression probability in narrative texts (M = 0.21) than in expository texts (M = 0.18), (b = 0.18, SE = 0.092, z = 1.98). The analyses revealed no significant main and interaction effects for high-comprehending readers.

First-pass word skipping probability. The analyses for the low-comprehending readers revealed a main effect of Text Genre ($\chi 2(1) = 5.32$, $p < .05$). This effect was caused by low-comprehending paraphrasers, who displayed a lower skipping rate in narrative texts (M = 0.25) than in expository texts (M = 0.32), (b = -0.24, SE = 0.083, z = -2.91). The analyses for the high-comprehending readers revealed a main effect of Think-Aloud Reading Profile ($\chi 2(1) = 6.75$, $p < .01$). High-comprehending paraphrasers (M = 0.28) displayed lower skipping rates than did high-comprehending elaborators (M = 0.37) in expository texts (b = -0.42, SE = 0.15, z = -2.74). Similarly, in narrative texts (b = -0.36, SE = 0.15, z = -2.38), high-comprehending paraphrasers (M = 0.30) displayed lower skipping rates than did high-comprehending elaborators (M = 0.38).

Table 5.3 Mean values of the primary eye-movement measures as a function of Reading Proficiency, Think-Aloud Reading Profile and Text Genre.

	Low-comprehending paraphrasers	Low-comprehending elaborators	High-comprehending paraphrasers	High-comprehending elaborators
Measure and text genre	*M*	*M*	*M*	*M*
Regression probability				
narrative	.21	.23	.24	.27
expository	.18	.21	.24	.25
Word skipping probability				
narrative	.25	.30	.30	.38
expository	.32	.31	.28	.37

Exploratory analyses

Full text reading time and Full text fixation count. The analyses revealed no significant main or interaction effects, neither for the analyses of low-comprehending readers nor for the analyses of high-comprehending readers.

First fixation duration. The analyses revealed no significant main or interaction effects for low-comprehending readers. The analyses for the high-comprehending readers revealed a main effect of Think-Aloud Reading Profile ($\chi2(1) = 4.98$ $p < .05$). High-comprehending paraphrasers (M = 293, SD = 149) displayed longer first fixation durations than did high-comprehending elaborators (M = 277, SD = 148) in expository texts (b = 0.076, SE = 0.035, t = 2.16). Likewise, in narrative texts (b = 0.079, SE = 0.035, t = 2.22), high-comprehending paraphrasers (M = 294, SD = 170) displayed longer first fixation durations than did high-comprehending elaborators (M = 274, SD = 139).

First gaze duration. The analyses revealed no significant main or interaction effects for low-comprehending readers. The analyses for the high-comprehending readers revealed a main effect of Text Genre ($\chi2(1) = 5.12$ $p < .05$). This effect was caused by high-comprehending elaborators, who displayed shorter first gaze durations for narrative texts (M = 363, SD = 241) than for expository texts (M = 377, SD = 262), (b = -0.040, SE = 0.018, t = -2.24).

Right-bounded duration. The analyses revealed no significant main or interaction effects for low-comprehending readers. The analyses for the high-comprehending readers revealed a main effect of Text Genre ($\chi2(1) = 6.21$, $p < .05$). High-comprehending elaborators and high-comprehending paraphrasers displayed shorter right-bounded durations for narrative texts (elaborators: M = 427, SD = 314; paraphrasers: M = 437, SD = 289) than for expository texts (elaborators: M = 451, SD = 367; paraphrasers: M = 469, SD = 334), (elaborators: b = -0.050, SE = 0.022, t = -2.26; paraphrasers: b = -0.051, SE = 0.022, t = -2.33).

Total fixation duration. The analyses revealed no significant main or interaction effects for low-comprehending readers. The analyses for the high-comprehending readers revealed a main effect of Text Genre ($\chi2(1) = 5.81$, $p < .05$). This effect was caused by high-comprehending paraphrasers, who displayed shorter total fixation durations for narrative texts (M = 493, SD = 335) than for expository texts (M = 528, SD = 384), (b = -0.050, SE = 0.020, t = -2.55).

Second-pass fixation duration. The analyses revealed no significant main or interaction effects neither for low- nor for high-comprehending readers.

Saccade amplitude. The analyses for the low-comprehending readers revealed a main effect of Text Genre ($\chi2(1) = 4.91$, $p < .05$). Low-comprehending readers displayed shorter saccades for narrative texts than for expository texts (b = -0.038, SE = 0.017, t = -2.22). No significant effects were observed for high-comprehending readers.

Table 5.4 Mean values (and standard deviations) of the secondary eye-movement measures as a function of Reading Proficiency, Think-Aloud Reading Profile and Text Genre.

	Low-comprehend. paraphrasers	Low-comprehend. elaborators	High-comprehend. paraphrasers	High-comprehend. elaborators
Measure and text genre	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Full text reading time[1]				
narrative	57.8 (10.3)	57.0 (10.1)	50.8 (12.7)	48.6 (16.1)
expository	53.5 (8.8)	56.9 (10.2)	53.9 (15.4)	48.5 (15.0)
Full text fixation count				
narrative	185 (26)	190 (33)	174 (37)	176 (40)
expository	172 (24)	188 (33)	185 (44)	177 (39)
First fixation duration[2]				
narrative	315 (168)	305 (150)	294 (170)	274 (139)
expository	319 (167)	307 (152)	293 (149)	277 (148)
First gaze duration[2]				
narrative	419 (255)	404 (262)	375 (245)	363 (241)
expository	445 (297)	422 (287)	392 (266)	377 (262)
Right-bounded duration[2]				
narrative	485 (300)	474 (315)	437 (289)	427 (314)
expository	507 (340)	494 (335)	469 (334)	451 (367)
Total fixation duration[2]				
narrative	543 (355)	546 (382)	493 (335)	486 (371)
expository	548 (396)	554 (392)	528 (384)	508 (414)
Second-pass fix. duration[2]				
narrative	440.0 (276.4)	456.0 (355.2)	475.5 (538.2)	417.8 (304.8)
expository	463.9 (356.0)	399.9 (261.2)	440.8 (334.6)	433.9 (315.7)
Saccade amplitude[3]				
narrative	2.08 (1.99)	2.15 (2.03)	2.24 (1.85)	2.30 (1.87)
expository	2.17 (2.12)	2.24 (2.09)	2.28 (1.88)	2.31 (1.89)

[1] in seconds, [2] in milliseconds, [3] in degrees of visual angle

5.4 Discussion

In the present study we investigated whether readers that were characterized as low- and high-comprehending paraphrasers and elaborators on the basis of a think-aloud experiment (see *Chapter 3*), are also characterized by different eye-movement patterns. We did so by analyzing the data of a prior eye-tracking experiment (*Chapter 4*) and think-aloud experiment (*Chapter 3*) in conjunction. We predicted that paraphrasers would skip fewer words (as measured by first-pass word skipping probability) and would look back less often in the text (as measured by first-pass regression probability) than elaborators. In addition, we explored the text-processing approaches of elaborators and paraphrasers in relation to other reading eye-movement measures. In doing so, we also explored the effect of text genre on the eye-movement patterns. In addition, we explored whether the eye-movement patterns of paraphrasers and elaborators show similarities with eye-movement patterns of subgroups of readers that are distinguished in prior eye-tracking studies by Koornneef and Mulders (2016), Olson et al. (1985), and Rayner et al., 2006, 2009).

5.4.1 Reading profiles of high-comprehending readers

The reading profiles of high-comprehending elaborators and paraphrasers were partly characterized by different eye-movement patterns as hypothesized: High-comprehending elaborators skipped more words than high-comprehending paraphrasers did, but contrary to our hypotheses, they did not make more regressions. A possible explanation for the latter result is that the experimental texts that were used to record the eye-movements of the participants did not elicit the making of regressions because they did not demand much cognitive effort or because they did not contain unexpected turns. The experimental texts were age appropriate, but possibly not challenging enough for high-comprehending readers. Readers perform optimally with texts that are appropriate but somewhat challenging to their skill level, whereas reading motivation declines when the text is considered too simple (van den Broek, 2010). Perhaps more challenging texts would stimulate high-comprehending elaborators to make more regressions in comparison to high-comprehending paraphrasers.

In addition to skipping more words, high-comprehending elaborators displayed shorter first-fixation durations than high-comprehending paraphrasers in both narrative and expository texts. This invites the conclusion that the elaborators were faster and perhaps more efficient readers than the paraphrasers. However, their performance on other measures suggests they were not better (or worse) readers than paraphrasers: high-comprehending elaborators and paraphrasers did not differ in their scores on the test-battery tests for technical reading skills and reading comprehension skills. Moreover, despite having differing eye-movement patterns, they had equally good mental text representations of both narrative and expository texts, as measured by comprehension questions. So, for these distinct subgroups of high-comprehending readers –at least in Grade 2, before they have had formal instruction in reading comprehension- their different text-processing approaches do not lead to mental text representations of different quality. Therefore, one approach is not qualitatively better than the other approach, at least not in the context of and with the materials used in this study. It is possible that under different reading circumstances or with other texts, the different texts processing approaches will lead to differences in reading comprehension.

5.4.2 Reading profiles of low-comprehending readers

For low-comprehending readers the results regarding word-skipping probability and regression probability did not reveal differences between the eye-movement patterns of elaborators and paraphrasers. This finding is not as hypothesized. The fact that the subgroups of low-comprehending readers differed in terms of reading style in the think-aloud experiment but not in the eye-tracking experiment may reflect a difference between the two research methods. The think-aloud method tends to stimulate active use of strategies during reading (Chi, de Leeuw, Chiu, & LaVancher, 1994; Coté et al., 1998). In fact, the think-aloud method has been proposed as a method to stimulate children to apply strategies during reading (Trabasso & Magliano, 1996) and prior research has pointed out that readers read with more attentional focus and think longer about what they are reading when they are asked to think aloud during reading (e.g., Chi et al., 1994; Schunk & Rice, 1985). Then, the subgroups of low-comprehending paraphrasers and elaborators might be a result of the think-aloud method and do not differ from each other when they read a text more naturally, in its entirety and silently (cf., McMaster et al., 2012). However, another possible -and perhaps more likely- explanation for the lack of difference in eye-movement patterns of low-comprehending paraphrasers and elaborators is the small sample size in comparison to the sample size of the high-comprehending paraphrasers and elaborators. Therefore, more (eye-tracking) research with a bigger sample size of low-comprehending paraphrasers and elaborators is needed.

5.4.3 Effect of text-genre

In general, the subgroups of readers demonstrated similar eye-movement patterns for narrative and expository texts on the primary eye-movement measures, – regression probability and word-skipping probability-, indicating that they did not adapt their eye movements to text genre. However, low-comprehending paraphrasers were an exception; they made more regressions when reading narrative than when reading expository texts, and skipped fewer words when reading narrative than when reading expository texts. It therefore appears that low-comprehending paraphrasers adapted their reading style to text genre more than the other subgroups of readers, yet in an unexpected direction. In case of an adaptation, one would expect a more precise reading style for expository texts than for narrative texts, because, for weak comprehenders in particular, expository texts are a bigger processing challenge than narrative texts (see e.g., Coté et al., 1998; Lorch, 2017; Oakhill, Cain, & Elbro, 2014; Williams, Hall, & Lauer, 2004). An interesting question for future research is what drove low-comprehending paraphrasers to make these adaptations. The results on the cognitive tasks of the test battery suggest that technical reading skills were not at fault (among low-comprehending readers, paraphrasers were better technical readers than elaborators), but working-memory capacity and general comprehension skills may have been (as low-comprehending paraphrasers scored lower than low-comprehending elaborators on the tests for verbal working-memory capacity and reading comprehension skills).

5.4.4 Correspondence of reading styles of paraphrasers and elaborators with conservative and proactive reading styles

Given that both think-aloud studies and eye-tracking studies have distinguished subgroups of readers - *paraphrasers* versus *elaborators* (McMaster et al., 2012, 2014; Rapp et al., 2007), and *plodders* or *conservative readers* versus *explorers* or *risky readers* or *proactive readers* respectively (Koornneef & Mulders, 2016; Olson et al., 1985; Rayner et al., 2006, 2009) -, we explored whether these subgroups have common ground. For high-comprehending readers this seemed to apply to some extent; High-comprehending elaborators skipped more words than high-comprehending paraphrasers, displaying a somewhat more exploring or proactive reading style than high-comprehending paraphrasers. However, on the basis of our results, we cannot conclude that the reading styles of high-comprehending paraphrasers and elaborators haven common ground with the subgroups of readers that Olson et al. (1985), Rayner et al. (2006, 2009), and Koornneef and Mulders (2016) distinguished.

The eye-movement patterns of low-comprehending paraphrasers and elaborators did not differ from each other and were not associated with the reading styles as distinguished in prior eye-tracking studies by Olson et al. (1985), Rayner et al. (2006, 2009), and Koornneef and Mulders (2016). More research with a larger sample size is needed to elucidate these findings.

5.4.5 Conclusion

Low-comprehending paraphrasers and elaborators engaged in similar eye-movement patterns regarding *word-skipping probability* and *regression probability*. Their patterns differed from those of the subgroups of high-comprehending readers and did not match with the reading styles distinguished in prior eye-tracking studies by Olson et al. (1985), Rayner et al. (2006, 2009), and Koornneef and Mulders (2016). The fact that subgroups of low-comprehending readers who were clearly distinguished as two subgroups with different reading styles in a think-aloud experiment did not reveal different eye-movement patterns in an eye-tracking experiment is possibly a result of the think-aloud method, because it is presumed to stimulate the use of strategies (Chi et al.,1994; Coté et al., 1998). What is more, the texts in the think-aloud experiment were presented in a sentence-by-sentence manner and were read aloud -- characteristic of beginning reading (Chall, 1983) --, whereas the texts in the eye-tracking experiment were presented in their entirety and were read silently. Therefore, it is unlikely that the children, low-comprehenders in particular, automatically engaged in comprehension monitoring and other metacognitive processes in the eye-tracking experiment. However, and possibly more likely, the lack of difference in eye-movement patterns can be the result of small sample size.

High-comprehending elaborators skipped more words than high-comprehending paraphrasers, but they did not reveal different eye-movement patterns regarding regression probability. The different word-skipping behavior could not be attributed to differences in any of the (cognitive) skills that were assessed in the test battery, because high-comprehending elaborators and paraphrasers scored equally good on these tests. Possibly, experimental texts that are cognitively more challenging, for instance texts with unexpected turns, will reveal differences in regressive eye-movements of high-comprehending elaborators and paraphrasers as well. And, if so, their eye-movement patterns may possibly be more in line with the reading styles of the subtypes of readers that have been distinguished in other eye-tracking studies. Future research could give insight into these issues.