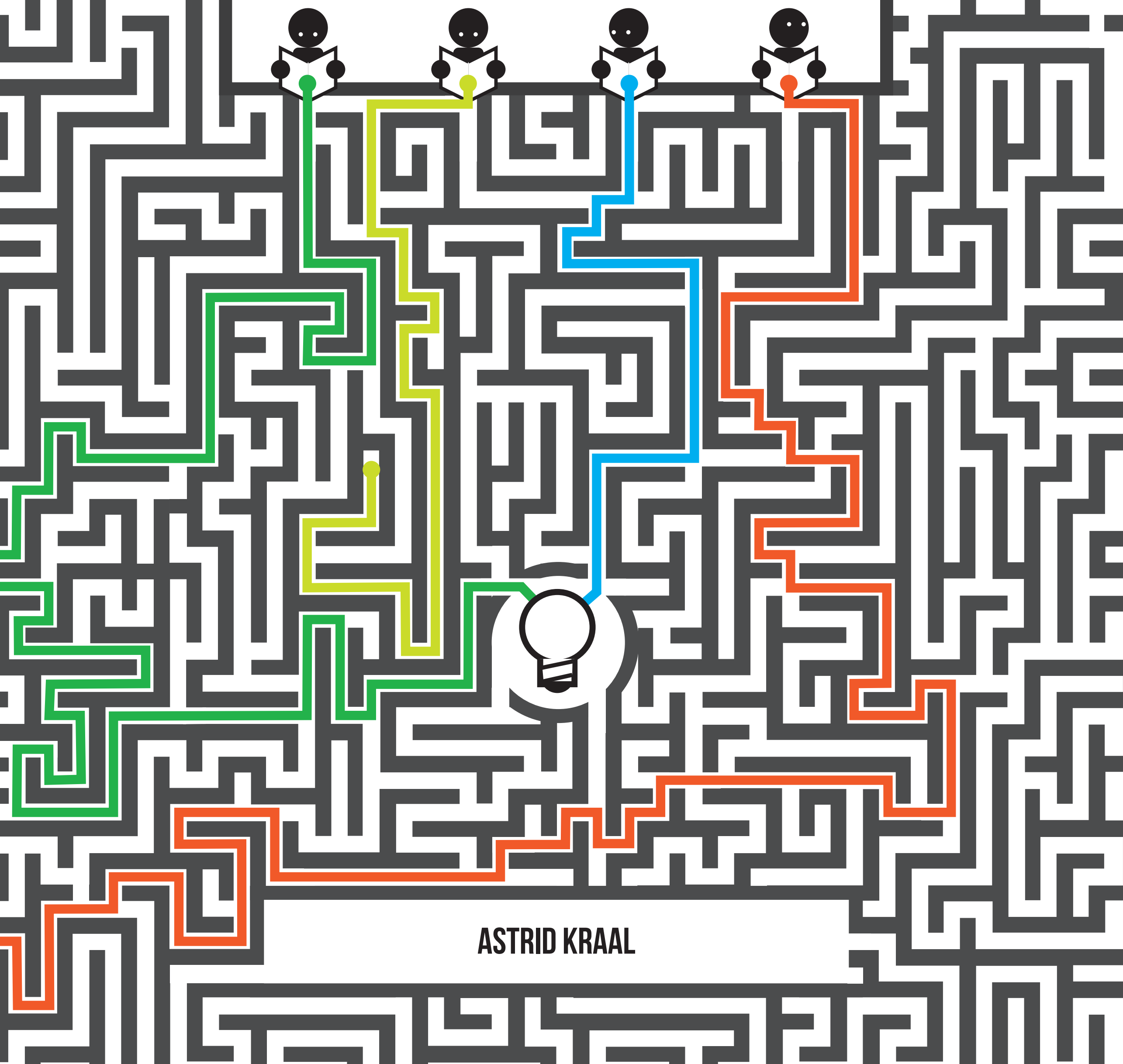
Different readers, different texts, different processes : the effects of reader and text properties on text processing
Kraal, A.

DIFFERENT READERS, DIFFERENT TEXTS, DIFFERENT PROCESSES

THE EFFECTS OF READER AND TEXT PROPERTIES ON TEXT PROCESSING



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Chapter 01

General Introduction

This chapter is based on
Helder, A.*, Kraal, A.*, & van den Broek, P. (2015). De ontwikkeling van begrijpend lezen: Oorzaken van succes en falen vanuit een cognitief perspectief. In D. Schram (Ed.), *Hoe maakbaar is de lezer?* (pp. 59-78). Stichting Lezen: Eburon.

**shared first authorship*

1.1 Introduction

Reading comprehension is a complex skill, in which readers use various cognitive processes. Comprehension of a text involves the construction of a mental representation of the meaning of the text. To understand what they are reading, readers need to employ both basic language skills and comprehension skills. A distinction can be made between cognitive processes for basic language skills and cognitive processes for comprehension skills (e.g., Gough & Tunmer, 1986; Hoover & Gough, 1990; Kendeou, van den Broek, Helder, & Karlsson, 2014). The former involve processes that relate to decoding text, for example phonemic awareness and the linking of sounds to characters, whereas the latter involve processes related to understanding the information in a text. Examples of comprehension skills include making connections, noting a disruption of understanding, and being aware of text structures (e.g., Cain & Oakhill, 2007; Helder, van den Broek, Van Leijenhorst, & Beker, 2013; van den Broek & Espin, 2012). Many of these comprehension skills apply not only to written text but also, for example, to understanding films, presentations, and the like.

1.2 Basic language skills and comprehension skills

Both basic language skills and comprehension skills are important for reading comprehension. During the first years of primary education, a relatively high degree of attention is paid to the automation of basic language skills. When students start learning to read, converting characters into sounds and words makes large demands on their limited cognitive capacity. If all goes well these basic language skills are automated on average halfway through primary school, making more cognitive capacity available for students to apply comprehension skills (De Jong & Van der Leij, 2002; Kendeou, Papadopoulos, & Spanoudis, 2012; Perfetti & Hart, 2002). At the same time, the cognitive capacity of children increases, especially during primary school, and continues to increase well into adolescence (Huizinga, Dolan, & Van der Molen, 2006; Luna, Garver, Urban, Lazar, & Sweeney, 2004). The amount of cognitive capacity available is related to a child's reading comprehension level: more cognitive capacity leaves more room for comprehension. However, the fact that more capacity is available does not necessarily mean that texts that are decoded correctly are actually well understood. Comprehension skills play an important role here.

Much less is known about the development of comprehension skills than about the development of basic language skills. Nevertheless, a number of conclusions relevant to education can be drawn, including conclusions from longitudinal studies, whereby the same tests are carried out in the same group of children in successive years (Kendeou, Bohn-Gettler, White, & van den Broek, 2008; Kendeou, van den Broek, White, Lynch, 2009; Oakhill & Cain, 2011). First, it emerges that the development of comprehension skills starts at a young age. Even before children receive formal reading instruction, they are capable of making connections between events in stories that they see or hear. Second, it emerges that comprehension skills develop relatively independently of basic language skills. So, if a child is not good at decoding a text, this does not necessarily mean that he/she is unable to understand the content of the text –and vice versa. Third, it turns out that individual differences in comprehension skills at a younger age predict reading comprehension level later in life, independently of basic language skills.

1.3 From comprehending narrative texts to comprehending expository texts

The relationship between the amount of attention devoted to basic language skills and comprehension skills changes during the primary school years. Generally, in kindergarten equal attention is paid to basic language skills and comprehension skills. In Grade 1 and Grade 2 some attention is paid to comprehension skills, but the emphasis is on basic language skills. From Grade 3 on, there is more attention for comprehension skills. In primary schools in the Netherlands, reading comprehension becomes a subject in its own right. There is a shift from "learning to read", to "reading to learn" (Chall, 1996, Chall, Jacobs, & Baldwin, 1990). At the same time, there is a shift from the use of narrative texts to the use of expository texts in education. These texts differ in the ways they are organized, the causal coherence of information, the vocabulary, and the presence of a central character (Wolfe, 2005). For most children, expository texts are more difficult to comprehend than narrative texts (Best, Floyd, & McNamara, 2008). Adequate comprehension of expository texts is crucial, however. In the final years of primary school, children are expected to learn and apply information from expository texts in history, geography, and biology books in other contexts (Allington & Johnston, 2002). This is also expected of them in most forms of further education.

1.4 Same text, different mental text representations

Although a text has the same title, sentences, words, and layout for each reader, the mental representations that readers construct differ. These depend, among other things, on the cognitive processes that the reader uses during reading. While reading, things can go 'wrong' in the reader's mind. For example, low-comprehending readers may find it difficult to recognize certain connections in the text, to make relevant connections at the right moments, or to integrate the information in the text with his or her background knowledge (Perfetti, Landi, & Oakhill, 2005; Yuill & Oakhill, 1991). This leads to a less coherent mental text representation, which in turn leads to superficial processing of the content and less-than-optimal understanding of the text (Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007; van den Broek et al., 2006). Research by Karlsson et al. (2018), McMaster et al. (2012) and Rapp et al. (2007) has revealed two distinct subtypes of struggling readers with their own characteristic reading style: paraphrasers and elaborators. Paraphrasers typically construct a limited mental representation that mainly reflects the literal meaning of the text, whereas elaborators attempt to enrich their mental representation by generating elaborative and predictive inferences, often unsuccessfully (Rapp et al., 2007).

1.5 Different research methods to investigate cognitive processes

Cognitive processes can be investigated in various ways, using varying research methods. In doing so, we differentiate between methods to investigate what the reader has stored in his/her mental representation of the text *after* reading, and methods to investigate what occurs in the mind of the reader *during* reading. For instance, *after* reading, readers can be asked about the content of the text – the main topic and/or details – or about what they remember of the text. These are ways to find out what is stored in the mental representation that the reader has built up after reading a text. *During* reading, on the other hand, a reader can be prompted to express his/her thoughts after reading each sentence (think-aloud method). Another, more indirect way to investigate the underlying cognitive processes during reading is to measure reading times and/or eye movements. Each research method has its own strengths and weaknesses. For example, some methods only reveal the reader’s conscious thoughts (e.g., asking questions, think-aloud method), whereas other methods measure unconscious processes that are more difficult to interpret (e.g., reading times, eye movements). By using a combination of research techniques, we can gain different kinds of insight into how readers comprehend what they read.

1.6 Effect of text layout on text processing

How well a reader comprehends a text does not solely depend on characteristics of the reader. Text characteristics also have an impact on readers' text-processing approaches and their construction of a mental representation of the meaning of the text. In text-orientated approaches it is common belief that beginning readers will benefit from an easy text, in which words are easily recognized and decoded and sentences are easily parsed, because this should facilitate the construction of a qualitatively good mental representation of the text. Therefore, texts for beginning readers often are written in a large font, with increased spacing between letters, words, and lines (e.g., Zorzi et al., 2012). Moreover, infrequent words and sentences with subordinating clauses are avoided, sentences are generally short and to avoid line-breaks in the middle of a sentence texts are presented in a fragmented layout in which each sentence is presented on a new line (Land, 2009).

The idea behind these adaptations in the text layout is that they optimize the eye movements and basic decoding processes during reading, and possibly free up cognitive resources for higher-order comprehension processes such as comprehension monitoring and inference generating (cf., Schneps, Thomson, Chen, et al., 2013; Schneps, Thomson, Chen, Sonnert, & Pomplun, 2013). In other words, the visuo-spatial features of a text can effect reading in several ways, ranging from reducing the cognitive load of basic decoding and eye-movement processes to probing higher-order integration processes. By varying the layout of texts, we can explore whether and why beginning readers may benefit from a specific layout. And, by examining readers with different reading skills we can explore whether and how individual differences in reading skills constrain the efficacy of the layout of a text.

1.7 Outline of this dissertation

Although comprehension differences between children have been observed, little attention has been paid to on-line text processing. Moreover, the processing of narrative texts and expository texts has often been studied in isolation. The central aim of this dissertation is to gain insight into the on-line text processing of young low- and high-comprehending children as they read expository and narrative texts for comprehension, by using a variety of on-line research methods. An additional aim is to gain insight into distinct reading profiles. The second aim of this dissertation is to gain insight into the effect of different forms of text layout on the text comprehension and reading speed of young children as they read expository and narrative texts for comprehension. The dissertation consists of three sections.

The first section of this dissertation consists of a theoretical chapter (**Chapter 2**). This chapter reviews research on sources of individual differences in reading comprehension abilities. First, I discuss what text comprehension is and what cognitive processes occur during reading for comprehension. Then, I highlight sources of individual differences in executing these processes. Finally, I discuss the development of the skills and abilities required for successful reading comprehension.

The second section of this dissertation consists of four empirical studies (**Chapters 3-6**). The aim of the study described in **Chapter 3** was to investigate the on-line comprehension processes and strategy use of second-grade low- and high-comprehending readers when reading expository and narrative texts for comprehension; this was investigated by using a think-aloud protocol. An additional aim was to investigate whether the distinction of two types of struggling readers, -- *paraphrasers* and *elaborators* (McMaster et al., 2012; Rapp et al., 2007) -- already exists at a young age, and whether this distinction also applies to high-comprehending readers. To assess the quality of their after-reading mental text representation, the participants answered literal and inferential comprehension questions. In addition, to determine possible factors contributing to comprehension differences, they completed a test battery assessing general cognitive and language-related proficiencies. In **Chapter 4** the on-line text processing of second-grade low- and high comprehending readers was investigated by tracking their eye movements as they read expository and narrative texts for comprehension. After reading, the participants answered literal and inferential comprehension questions to determine the quality of their mental text representation. We hypothesized that our participants needed to adapt their reading approach to obtain a proper understanding of expository texts, because young readers are known to have greater difficulty processing expository texts than narrative texts (Best et al., 2008), and that high-comprehending readers would adjust their reading approach more easily to the text than low-comprehending readers (Duke & Pearson, 2002; Rapp et al., 2007). In **Chapter 5** we investigated whether subgroups of readers that were characterized as low-comprehending and high-comprehending paraphrasers and elaborators on the basis of the think-aloud study described in *Chapter 3*, were also characterized by different eye-movement patterns. We did so by analyzing the data of the eye-tracking study described in *Chapter 4* and the think-aloud study (*Chapter 3*). 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 showed similarities with eye-movement patterns of subgroups of readers that are distinguished in eye-tracking studies by others. **Chapter 6** concerns a study on text layout in which we explored the idea that the visuo-spatial properties of segmented layouts support beginning readers by reducing the demands of basic eye-movement processes. We examined whether young, beginning readers either benefit or experience drawbacks from segmented texts. We also explored *why* beginning readers may benefit from a specific layout. In addition, we wanted to gain more insight into whether and how individual differences in reading skills constrain the efficacy of the layout of a text. A series of four self-paced reading experiments with different text layouts was conducted to assess the effect on the text comprehension and reading speed of second- and third-grade pupils. In each experiment, participants read several narrative and expository texts with different layouts. The reading times for the texts were recorded and after reading each text, participants answered literal and inferential comprehension questions to assess the quality of their after-reading mental text representation.

In the studies described in *Chapters 3-5*, we defined low-comprehending readers as readers who have difficulty comprehending connected text despite having age-appropriate technical reading skills (cf., Cain & Oakhill, 2007; Nation, 2005), with the addition that their intelligence is normally developed and that they don't have diagnosed behavioral problems. In *Chapter 6*, two Dutch standardized tests for reading comprehension and decoding proficiency were used as continuous variables for reading-comprehension skills and word-decoding skills, respectively.

In **Chapter 7,** the third and final section of this dissertation, the results and conclusions from the empirical studies are summarized and discussed in a broader context, and recommendations are given for educational practice.

Chapter 02

Individual Differences in Reading Comprehension

This chapter is based on

Van den Broek, P., Mouw, J., & Kraal, A. (2016). Individual differences in reading comprehension. In P. Afflerbach (Ed.), *Handbook of individual differences in reading: Reader, text, and context* (pp. 138-150). New York: Routledge. doi:10.4324/9780203075562.

Available online via: https://www.routledge.com/Handbook-of-Individual-Differences-in-Reading-Reader-Text-and-Context/Afflerbach/p/book/9780415658881

and

Helder, A.*, Kraal, A.*, & van den Broek, P. (2015). De ontwikkeling van begrijpend lezen: Oorzaken van succes en falen vanuit een cognitief perspectief. In D. Schram (Ed.), *Hoe maakbaar is de lezer?* (pp. 59-78). Stichting Lezen: Eburon.

**shared first authorship*

2.1 Introduction

People read texts for many different purposes, for example, for pleasure, to learn for school, to understand phenomena, or to obtain instructions. For all of these purposes, it is essential that the reader *comprehends* the text. However, individuals differ tremendously in their ability to do so and, hence, in their ability to attain their purposes. Comprehension of a text can be defined in various ways. It may refer to the ability to reproduce (parts of) the text, the ability to analyze the information in the text, the ability to use or apply the information, as well as a range of other abilities. For example, Bloom's taxonomy of learning objectives describes levels of processing of texts and other learning materials that range from memory for the text to critical evaluation and even the production of information (Airasian et al., 2001; Bloom, 1956). Likewise, the PISA reports define *Reading Literacy* as "Reading literacy is understanding, using, evaluating, reflecting on and engaging with texts in order to achieve one's goals, to develop one's knowledge and potential and to participate in society" (PISA report, OECD, 2017, p. 51). In these conceptualizations, a crucial step in comprehending a text is that the reader first creates a mental representation of the meaning of the text. Individual differences in the representation of a text reverberate through all other comprehension-related activities. This chapter discusses sources of individual differences in reading comprehension abilities, with focus on the meaning-representation aspects of comprehension.

2.2 Comprehension: Inferences and the construction of a coherent representation

Comprehension of a text involves the construction of a mental representation of the meaning of the text. To understand individual differences in reading comprehension, it is useful to consider both the *product* of reading, the mental representation, and the *process* by which such a representation is constructed. The Landscape Model of Reading Comprehension (Helder, van den Broek, Van Leijenhorst, & Beker, 2013; van den Broek, Risden, Fletcher, & Thurlow, 1996) captures both product and process in an integrative account of reading comprehension, by combining research findings from many investigators. We summarize the model here.

2.2.1 The reader's representation of a text

With regard to the product of reading, in a successful representation the reader combines parts from the text with information from background knowledge that he or she has recruited during reading. Together, these elements do not simply form a list –a crucial aspect of text comprehension is that the elements in the mental representation are interconnected by means of meaningful relations, thereby resulting in a *coherent* representation (Coté, Goldman, & Saul, 1998; Graesser & Clark, 1985; Kintsch & Van Dijk, 1978; McNamara, E. Kintsch, Bulter Songer, & W. Kintsch, 1996; Trabasso, Secco, & van den Broek, 1984). Meaningful relations occur between individual text and background knowledge elements but also between larger text units, such as paragraphs, sections, and chapters. For example, textbooks may elaborate on a newly introduced concept by explaining components of the concept in separate paragraphs. To grasp the concept, the reader must recognize the relations between the components across paragraphs. This will be explained on the basis of an example represented in Table 2.1 and Figure 2.1 (from Trabasso, Secco, & van den Broek, 1984).

Table 2.1 Text elements of the Epaminondas Story (Trabasso, Secco, & van den Broek, 1984)

Epaminondas	
1.	Once there was a little boy,
2.	who lived in a hot country.
3.	One day his mother told him to take some cake to his grandmother.
4.	She wanted him to hold it carefully
5.	so it wouldn't break into crumbs.
6.	The little boy put the cake in a leaf under his arm
7.	and carried it to his grandmother's.
8.	When he got there
9.	the cake had crumbled into tiny pieces.
10.	His grandmother told him he was a silly boy
11.	and that he should have carried the cake on top of his head
12.	so it wouldn't break.
13.	Then she gave him a pat of butter to take back to his mother's house.
14.	The little boy wanted to be very careful with the butter
15.	so he put it on top of his head
16.	and carried it home.
17.	The sun was shining hard
18.	and when he got home
19.	the butter had melted.
20.	His mother told him he was a silly boy
21.	and that he should have put the butter in a leaf
22.	So that it would have gotten home safe and sound.

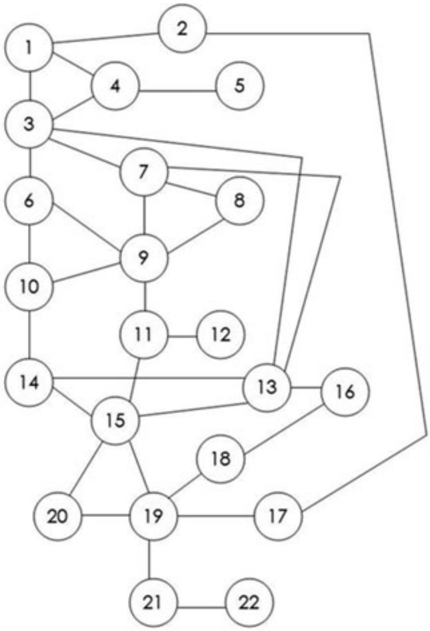

Figure 2.1. Example of a possible mental text representation of the Epaminondas story. The numbers in the circles correspond with the numbers of the text elements in Table 2.1. The lines represent the connections that the reader can make between these text elements. Connections that the reader can make with his/her background knowledge are not represented in Figure 2.1 (from Trabasso, Secco, & van den Broek, 1984).

There are various kinds of meaningful relations that provide coherence to texts. For most texts, the most crucial relations are *referential* relations, and *causal* and *logical* relations (van den Broek, 1994; van den Broek, Helder, & Van Leijenhorst, 2013). The line between text elements 3 and 1 (see Figure 2.1) is an example of a referential relation; the words ‘his’ and ‘him’ refer to the boy who is introduced in text element 1 (see Table 2.1). The line between text elements 19 and 17 is an example of a causal relation; the fact that the butter had melted (text element 19) is a result of the bright shining sun in text element 17. To make this causal relation, the reader the reader has to use his/her background knowledge. That is, the reader has to realize that the sun is hot is that butter melts when it is hot. Causal relations are often not explicitly mentioned in the text, as in this example, but can only be made if the reader addresses his/her background knowledge. These kinds of relations can be made between successive parts of the text, but also between parts of text that are further apart. An example of a relation between text elements that are further apart is the relation between text element 2 (warm country) and text element 17 (sun was shining very brightly) in the Epaminondas story. Other types of relations, such as spatial, emotional, and temporal, may also contribute to the overall coherence of the representation of the text.

The elements from the text and from background knowledge, together with their relations, form a network of interconnected and mutually dependent events and facts. Some events and facts feature prominently in the network by having many connections to other parts of the representation. In the text in Table 2.1, for example, text element 9 (that the cake was crumbled) with five connections to other text elements is more important for the structure of the text than text element 8 (that the boy arrived at his grandmother's house) with two connections. Highly connected elements are *structurally central* to the meaningful representation of the text. Proficient readers tend to judge these elements as more important, and remember or include them in summaries of the text more often than elements with few connections (Graesser & Clark, 1985; Trabasso & van den Broek, 1985). Building a coherent mental representation of a text is therefore essential for successful reading comprehension; it is the basis for learning and application of knowledge. Struggling comprehenders may fail to identify all important relations and, as a result, arrive at an impoverished representation and compromised ability to utilize the textual information. This is because readers draw on their representation when they perform tasks based on their reading. These tasks include experimental tasks such as recall or judgments tasks, but also everyday life tasks such as retelling to others what they have read, applying the knowledge gained from reading, and comparing information across multiple texts or multiple media.

2.2.2 Comprehension processes: Inferring relations

The construction of a mental representation of the text is the result of a rich set of coherence-building processes by which the reader identifies relations between textual elements and between elements and his or her background knowledge. The study of these processes is not only theoretically interesting, but also has profound implications for educational practice. The processes are the mechanisms by which representations are constructed and, therefore, determine success and failure of comprehension. To be effective, interventions aimed at improving comprehension must impact the processes that take place *during* reading.

There are several factors that limit a reader's ability to identify the relations in a text. One major factor is that most semantic relations are not explicitly marked in the text and, therefore, need to be inferred by the reader. For example, texts frequently have sentence pairs such as “The inhabitants suffer from frequent torrential rain falls. Farming is a challenge”, in which the causal relation between the two facts is not explicitly stated. To comprehend, the reader must *infer* the relation. A second major factor is the fact that readers have limited attentional or working-memory capacities and, therefore, can only maintain a subset of all potentially relevant events and facts from the text as they proceed to subsequent sentences. The likelihood that the relation between two events or facts will indeed be recognized by the reader is increased when the two are presented closely together in the text or when the earlier event/fact is repeated. A third limiting factor is that, even when a semantic relation is marked and working memory is not overextended, the background knowledge necessary for the inference may be lacking (in the above example: Repeated heavy rain fall may wash crops off farmland). We will return to these and other limitations in the next section.

As a reader progresses through a text, each new sentence elicits a new reading cycle with automatic processes and, possibly, strategic processes. With respect to the *automatic* processes, the concepts in the sentence trigger a passive, spread-of-activation process that activates additional concepts from the reader’s memory for the preceding sentences and from his or her general background knowledge. The latter involves individual facts and events, but also the ‘filling in’ of conceptual gaps through activation of schemes or scripts (Anderson & Pearson, 1984). These activations are ‘for free’ in that they do not require effort or conscious processing by the reader. Together with concepts, events, and facts processed in the preceding reading cycle and those in the currently read sentence, these activated concepts allow the reader to make coherence-building (and other) inferences (Helder et al., 2013; van den Broek, Risden, et al., 1996).

In addition to the automatic processes, a reader may engage in *strategic,* coherence-based processes. These processes are initiated by the reader to establish coherence. They may involve the preceding text (such as looking back or searching in memory for information from the preceding text), background knowledge (e.g., searching for an explanation for an event or fact), or other sources of information altogether (e.g., internet, other texts). Strategic processes are acquired through experience or instruction, and some may become relatively automatized as a child becomes proficient in reading. Readers differ in their ‘toolbox’ of strategic processes. The strategic processes enable inference making beyond those already available through the automatic processes.

The degree to which a reader will engage in strategic processes, in addition to the automatic ones, is to a large extent determined by the reader's *standards of coherence*: For each reading situation (i.e., reading a particular text in a particular context), a reader implicitly or explicitly adopts a set of standards of coherence (McCrudden & Schraw, 2007; van den Broek, Bohn-Gettler, Kendeou, Carlson, & White, 2011a). These standards reflect the type (e.g., causal, referential, temporal, etc.) and strength of coherence the reader considers desirable. Standards of coherence have a family resemblance to comprehension monitoring, but an important difference is that standards often are implicit and operate without the reader's conscious awareness. A reader's standards depend on the reading situation (e.g., the reading task, instructions, presence of competing tasks), on the reader (e.g., reading goals, motivation, reading skills), and on the text (e.g., text genre, presence of text signals such as headers and connectives, and perceived source credibility; see van den Broek, Risden et al., 1996, van den Broek, Bohn-Gettler et al., 2011a, for reviews).

Thus, the reader is likely to draw on the coherence-building strategic processes in his or her repertoire when the automatic processes described above do not establish sufficient coherence between a newly read sentence and the reader's representation of the preceding text to meet the reader's standards. This is particularly likely when the text is difficult or when the reader has a particularly challenging goal for reading.

As the reader proceeds through the text, every new sentence elicits anew a combination of automatic and, possibly, strategic processes. The combinations change as a function of the properties of each newly read sentence and, thereby, create an unfolding landscape of inferential processes and fluctuating activations of concepts, events, and facts. Thus, the reading process is dynamic, with different combinations of processes taking place at different moments during reading, much like a cross-country runner whose body adjusts with every step to the unique combination of properties of the ground he is running on.

The reading process is dynamic in the sense that comprehension of a sentence and the gradual emergence of a mental representation continually interact with each other as the reader moves through the text. As each newly read sentence is processed and comprehended, the meaning derived from the sentence modifies the representation the reader has built of the text read so far. In turn, as we have seen, the representation built so far influences the processing of the next sentence. This reciprocal processing of sentence and text continues until the reader has finished reading the entire text.

2.3 Individual differences in inference generation and comprehension

The summary of the processes and products of comprehending a text in the preceding section provides a description of the modal reader but in reality individuals differ considerably in the extent to which they execute the various processes and, hence, in the representation they have created by the time their reading is completed. The sources of individual variation roughly fall into three categories: *general cognitive* factors, *comprehension* factors, and *text-specific* factors (for detailed reviews see Cain & Oakhill, 2007; Helder et al., 2013; van den Broek & Espin, 2012).

2.3.1 General cognitive factors

As described, reading comprehension depends on a complex set of interacting processes. Not surprisingly, several general cognitive factors have been found to influence an individual's comprehension abilities and, hence, to cause individual differences. An important factor in determining a reader's ability to arrive at correct and deep understanding is his or her *background knowledge* about the information presented in the text. The inferential processes that allow a reader to identify semantic relations draw heavily on his/her prior knowledge. This is the case for both automatic and strategic processes. As a result, differences in background knowledge strongly influence the reader's comprehension and representation of a text: generally, the more knowledge the reader possesses on topics in the text, the richer and more interconnected his or her representation will be (Anderson & Pitchert, 1978; McNamara et al., 1996; Voss, Vesonder, & Spilich, 1980). In addition to the amount and depth of a reader's knowledge, the accuracy of knowledge plays an important role. For example, misconceptions influence the representation of a text just as accurate knowledge does (e.g., Dole & Smith, 1989; Kendeou & van den Broek, 2005; Mason, Gava, & Boldrin, 2008).

A second important source of individual differences concerns *working memory*. Differences in the capacity and efficacy of working memory have been found to affect comprehension in adults (Just & Carpenter, 1992; Linderholm & van den Broek, 2002; Virtue, van den Broek, & Linderholm, 2006; Whitney, Ritchie, & Matthew, 1991) as well as children (Cain & Oakhill, 2007; Reynolds, Cho, & Hutchinson, 2016). A greater working memory facilitates the maintenance and processing of more information from the text and background knowledge, thus supporting the generation of inferences and construction of a coherent representation. Working memory is one component of the broader class of *executive functions,* which include *inhibition, shifting*, and *updating* (Miyaki et al., 2000). These generally concern the individual's ability to effectively *allocate attention,* thereby influencing the content of working memory. Although these have received less attention from researchers than working memory, they too have been found to affect comprehension of text (e.g., Sesma, Mahone, Levine, Eason, & Cutting, 2009).

2.3.2 General comprehension skills

Individual differences occur in the execution of comprehension processes that occur in all modalities including, but not limited to, reading. One important individual difference pertains to one's *standards of coherence*. Individuals may differ systematically in the type and degree of coherence they maintain while reading texts or processing information in other modalities (van den Broek, White, Kendeou, & Carlson, 2009). They may also differ in their ability to adjust their standards to fit the particular (reading) situation. For example, readers with weak comprehension adjust their reading processes less effectively to variations in reading goals than do good comprehenders (Cain & Oakhill, 2007; Linderholm & van den Broek, 2002).

A second important source of individual differences in comprehension skills concerns the degree to which individuals allocate attention to information that is important for the semantic structure of the text. Differences in this *sensitivity to structural centrality* result in differences in what information is selected from new text input for further processing.

A third source of individual differences in comprehension concerns *inferential skills*. The information that is available to the reader at a particular point in reading needs to be connected by the reader by constructing, actively or passively, a particular semantic relation. Differences in the ability to do so also have been studied mostly in the context of children. We discuss these in the context of text processing in the following subsection.

2.3.3 Text-specific skills

The processes described in the preceding section apply to all comprehension contexts, whether in reading, listening, or another medium. There also are cognitive factors that are particular to the reading context. One concerns the reader's knowledge about *text genres*. Different genres are structured around different types of coherence relations. The reader's ability to adjust his or her reading to the genre of a text influences the depth of knowledge gained from reading (Oakhill & Cain, 2011).

A second source of individual differences pertains to a reader's knowledge of and ability to process *textual cues*. Texts contains 'instructions for processing' such as headers for (sub)sections and connectives that promote the reader to engage in particular semantic processing (Lemarié, Lorch, Eyrolle, & Virbel, 2008). Through experience and instruction developing readers acquire knowledge of these and other semantic cues. Together these cues also contribute to a reader's skill in recognizing the broader structure within a text. For example, in expository texts headers that signal (sub)sections may create a hierarchical organization to parts of the text (Lorch, 1989; Lorch, Lemarié, & Grant, 2011; Surber & Schroeder, 2007). Likewise, connectives (e.g., *and*, *so*, *because*, *however*, *meanwhile*) provide the reader with processing instructions, guiding and helping the reader to connect different parts of the text, inducing inferential processing (Sanders, Land, & Mulder, 2007; Van Silfhout, Evers-Vermeul, & Sanders, 2015).

A third source of individual differences in text-specific factors concerns *inference-making* skills. Although these skills apply to any comprehension situation, their implementation may be partially specific to the reading context. For example, evidence from eye-tracking and think-aloud studies show that poorly comprehending readers often engage in suboptimal inferential processing during reading (Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007; see also Oakhill & Cain, 2011). Interestingly, it appears that these poorly comprehending readers fall into at least two distinct subgroups (McMaster et al., 2012): those who generate relatively few inferences that connect text elements and those who *do* generate such inferences but often to irrelevant information. A second example of individual differences in inference-making skills concerns differences in reading-specific strategies that a reader may have available to establish coherence when reading a text, such as knowledge about when and how to reread, how to interpret a table of contents, and so on.

A fourth source of individual differences concerns variation in *motivation for reading*. The amount of motivation that a reader brings to a reading situation determines how much mental energy he or she is willing to expend, his or her standards of coherence, and so on. Motivation can be intrinsic (Clinton & van den Broek, 2012; Guthrie & Wigfield, 2000; Wang & Guthrie, 2004) or extrinsic (dependent on incentives; e.g., Konheim-Kalkstein & van den Broek, 2008). Intrinsic motivation for reading revolves around reading for enjoyment and for interest

(Guthrie & Wigfield, 2000). It has been found to lead to both higher exposure (more frequent reading) and higher reading performance (Baker & Wigfield, 1999). With regard to processing, it leads to more frequent use of (adequate) strategies and deeper level learning (Schiefele, 1999).The role of extrinsic motivation for reading has been investigated less extensively. The results are mixed. For example, presenting student readers with incentives to read a text has been found to improve comprehension, at least in immediate tests (Konheim-Kalkstein & van den Broek, 2008). But the effect of external reinforcement may be detrimental in the long run: Becker, McElvany, and Kortenbruck (2010) observed that, over time, providing extrinsic reading motivation may have a negative effect on performance, even when they controlled for children's frequency of reading and previous reading performance.

2.3.4 Individual differences in the representation of texts

These and other potential factors that influence the processes that occur *during* reading result in differences in the mental representation of a text in a reader's memory and, hence, in differences in higher levels of comprehension that take this representation as input. Thus, problems in comprehension processes at the representational level likely reverberate in a reader's ability to engage in other comprehension activities such as reflecting on and evaluating the text, and integrating it with information from other texts or media.

With respect to the *product* of comprehension, there are considerable individual differences in the quality of representation and the sensitivity to structural centrality, in adults and in children. For example, strong comprehenders consistently recall or judge as important events from a text that have many connections to other elements of the text, but struggling or less-experienced (younger) readers show a much weaker tendency to do so (Bourg, Bauer, & van den Broek, 1997). This difference in sensitivity to structural centrality suggests that the latter group identifies and represents fewer (or different) connections than good comprehenders. Likewise, differences in background knowledge that the reader has recruited during reading result in differences in the richness and /or accuracy of the information that is included in the representation (Kendeou, Rapp, & van den Broek, 2004). Thus, considerable individual differences in both the quality and content of the representation of texts exist.

2.4 Acquiring reading comprehension skills

Children gradually develop the skills and strategies involved in reading comprehension, through experience, instruction, and maturation of the underlying cognitive functions. For some cognitive factors described above the developmental trajectories are fairly well mapped out. This is the case, for example, for working-memory capacity and other executive functions such as suppression of irrelevant information and attention shifting (Demetriou, Christiou, Spanoudis, & Platsidou, 2002; Gathercole, Pickering, Ambridge, & Wearing, 2004).

With respect to the development of reading-specific skills, several patterns have been clearly established. With age and schooling children's inference-making processes improve and their repertoire of strategies (e.g., for repairing inconsistencies, for searching texts for relevant information) expands dramatically. As a result, they become increasingly able to identify semantic relations between text elements that are distal in the text as well as relations that are abstract (e.g., about characters' emotional and motivational states, about themes) rather than concrete and physical (Diergarten & Niedling, 2015; Lynch & van den Broek, 2007; van den Broek, Lynch, Naslund, Ievers-Landis, & Verduin, 2003; Williams, 1993). In addition, relations can become more complex, involving crossing episodic boundaries, or depending on integration of multiple pieces of information (Linderholm, Therriault, & Kwon, 2014).

As these skills and processes develop, individual differences remain fairly stable. The results of several longitudinal investigations indicate that comprehension and inference-making skills as described above already form a stable cluster of skills at an early age –as young as 4 years- and that this cluster predicts comprehension many years later, when the children are well into elementary school (e.g., Kendeou, van den Broek, White, & Lynch, 2009; Oakhill & Cain, 2011; van den Broek et al., 2009). Thus, children that comprehend well at a young age are likely to remain good comprehenders as they grow older, whereas children who struggle with comprehension when young are at risk to struggle and have continued difficulties later in their lives. Importantly, this cluster of skills develops relatively independently from a second cluster of skills, those concerning letter and word identification. The longitudinal results show that these two clusters come together once the child starts to read for comprehension, with each cluster contributing uniquely to reading comprehension performance (e.g. Gough & Tunmer, 1986; Kendeou et al., 2009).

2.5 Concluding remarks

Individuals differ in their ability to comprehend the texts they read. Even among those who arrive at a solid understanding, there are differences in the profiles of processes they recruit to achieve that goal. Similarly, struggling readers who arrive at inadequate understanding may do so because of problems in different processes, leading to distinct subgroups of struggling readers. In this chapter, we have attempted to provide an overview of the automatic and strategic processes that are involved in the comprehension of a text, and of the gradual emergence of a coherent, meaningful representation of the text in the reader's mind. This representation is the basis for other comprehension processes, such as analyzing and evaluating the text, comparing its content to that of other texts or non-texts, and so on. The content, quality, and form of the final representation are determined by the processes during reading of the text.

Chapter 03

Processing of Expository and Narrative Texts by Low- and High-Comprehending Children

This chapter is based on
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Abstract

The present study investigated comprehension processes and strategy use of second-grade low- and high-comprehending readers when reading expository and narrative texts for comprehension. Results from think-aloud protocols indicated that text genre affected the way the readers processed the texts. When reading narrative texts they made more text-based and knowledge-based inferences, and when reading expository texts they made more comments and asked more questions, but also made a higher number of invalid knowledge-based inferences. Furthermore, low- and high-comprehending readers did not differ in the patterns of text-processing strategies used: all readers used a variety of comprehension strategies, ranging from literal repetitions to elaborate knowledge-based inferences. There was one exception: for expository texts, low-comprehending readers generated a higher number of inaccurate elaborative and predictive inferences. Finally, the results confirmed and extended prior research by showing that low-comprehending readers can be classified either as readers who construct a limited mental representation that mainly reflects the literal meaning of the text (struggling *paraphrasers*), or as readers who attempt to enrich their mental representation by generating elaborative and predictive inferences (struggling *elaborators*). A similar dichotomy was observed for high-comprehending readers.

3.1 Introduction

Reading is a vital skill in daily life, in work, and in education. At school, a significant amount of the knowledge is transmitted by texts, so to be successful children need to be able to understand and learn from the texts they read (e.g., Slavin, Lake, Chambers, Cheung, & Davis, 2009). Reading comprehension is not only an important skill; it also is a difficult skill for many school-going children to master (e.g., Kuhlemeier et al., 2014; National Center for Education Statistics, 2011). Children who have trouble comprehending texts may suffer the consequences in several domains. These problems can hinder them in learning the required content at school, which may lead to poor results on important tests. In addition, they can lead to low self-efficacy, and even to behavioral problems (e.g., Hall, 2004). Given these far-reaching consequences, it is important that we understand why these children experience problems in reading comprehension.

Central to frameworks on reading comprehension (for an overview see McNamara & Magliano, 2009) is the idea that readers construct a mental text representation of what the text is about (Kintsch, 1988; Trabasso, Secco, & van den Broek, 1984; van den Broek, 1994). Many cognitive processes are involved in the construction of a mental text representation. It calls for basic language skills such as word decoding, syntactic skills, and word knowledge (vocabulary). In addition, successful comprehension also requires higher-level cognitive skills such as inference generation, comprehension monitoring, and knowledge of text structure (Cain & Oakhill, 1999; Oakhill, Cain, & Bryant, 2003; Perfetti, Landi, & Oakhill, 2005; Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007; van den Broek, Rapp, & Kendeou, 2005).

In the current study, we focus on such higher-order cognitive skills. In a think-aloud study we investigate the differences between low- and high-comprehending readers in elementary school (second grade) in terms of their cognitive abilities and of the reading strategies they deploy to comprehend narrative and expository texts. In doing so, we also consider potential differences *within* the low- and high-comprehending reader groups. The goal is to gain insight into the important processes involved in reading comprehension and strategy use at an early age and to identify aspects of reading that hamper text comprehension for less proficient readers in elementary school.

3.1.1 Reading comprehension processes and strategy use of proficient and struggling readers

It is important to distinguish between comprehension processes and comprehension products. The product is what readers understand and know after reading a text (the mental text representation), whereas the comprehension processes concern the cognitive activities that readers deploy to construct that representation (Rapp et al., 2007). It is commonly assumed that readers (consciously or subconsciously) execute strategies to facilitate comprehension (Pressley & Afflerbach, 1995). Pearson, Roehler, Dole, and Duffy (1992), among others, provided a detailed description of key strategies that are part of the 'toolkit' of successful readers. These readers use their general background knowledge and their knowledge of text structure to make sense of texts (Duke & Pearson, 2002; Oakhill & Cain, 2012; Pearson et al., 1992; Pressley & Wharton-McDonald, 1997; Rapp et al., 2007). Successful readers are metacognitive, goal-oriented, and flexible, and they constantly monitor their mental representation (Pearson et al., 1992). They have a clear goal for reading a text (Duke & Pearson, 2002; Pressley & Wharton-McDonald, 1997), try to determine the meaning of unfamiliar words and concepts (Duke & Pearson, 2002), and adjust their reading strategies to the task and the text to deal with inconsistencies and/or information gaps (Duke & Pearson, 2002, Rapp et al., 2007). Successful readers are also well equipped to determine what is important in a text and to summarize and rehearse the information they want to remember (Duke & Pearson, 2002; Pearson et al., 1992; Pressley & Wharton-McDonald, 1997). Moreover, successful readers synthesize information when they read, and draw inferences during and after reading to construct a coherent mental representation of the meaning of the text (Duke & Pearson, 2002; Pearson et al., 1992; Pressley & Wharton-McDonald, 1997; Rapp et al., 2007). Importantly, they make text-connecting inferences by connecting key ideas within the text, and knowledge-based inferences by relating their prior knowledge to these ideas (Perfetti et al., 2005; Pressley & Wharton-McDonald, 1997; Rapp et al., 2007; van den Broek, White, Kendeou, & Carlson, 2009).

Struggling readers also engage in these comprehension processes and strategies, but they tend to do so to a lesser extent or are less adept. For instance, struggling readers often do not use all their relevant prior knowledge to make sense of a story (Pearson et al., 1992) and are less aware of the characteristics of stories (text genre) that might help them in the construction of a mental representation (Oakhill & Cain, 2012; Perfetti et al., 2005). They also are less proficient at comprehension monitoring (e.g., Perfetti et al., 2005) and less likely to adjust their reading when comprehension fails, presumably because they do not possess adequate repair strategies (Pearson et al., 1992). Furthermore, low-comprehending readers are less proficient at judging what is important in texts, and they have difficulties synthesizing information when they read texts with a complex structure (Pearson et al., 1992). Finally, low-comprehending readers may struggle with identifying certain text relations, integrating information from the text with their background knowledge, and generating relevant inferences at the right moments (Cain, Oakhill, Barnes, & Bryant, 2001; Perfetti et al., 2005; Rapp et al., 2007).

However, not all low-comprehending readers struggle with all of these issues, nor do they form a homogeneous group of readers. For example, McMaster et al. (2012) and Rapp et al. (2007) distinguished two types of struggling readers. The first type are labeled *paraphrasers*: they remain close to the literal meaning of the text by rereading or paraphrasing it and make relatively few text-connecting and knowledge-based inferences. *Elaborators,* in contrast, generate more text-connecting inferences and go beyond the text by making knowledge-based inferences--as proficient readers do--but often do not succeed in doing so correctly.

From an educational point of view, it is important to distinguish between subgroups of struggling readers. For example, although the scores of elaborating and paraphrasing struggling readers on after-reading comprehension tests are similarly low (McMaster et al., 2012; Rapp et al., 2007), they seem to benefit from different intervention programs. Elaborators benefit particularly from causal questioning during reading (*"Why…"*), since this helps them to focus on important information within the text. Paraphrasers, on the other hand, benefit particularly from general questioning during reading (*"How does this sentence connect to an earlier part of the text?"*), since such questions prompt them to make more text-based connections and to think about the text beyond the current sentence (McMaster et al., 2012; McMaster, Espin, & van den Broek, 2014).

3.1.2 Influence of text genre on comprehension processes and strategy use

In the early grades of elementary school the focus of reading instruction lies on technical aspects of learning to read, such as sound-letter correspondences, decoding, and grammar. In later years children read for the purpose of comprehending and learning content from texts on history, geography, science, and other subject areas. In fact, already in fourth grade merely processing the text no longer suffices; children are expected to acquire information from the text for later use (Allington & Johnston, 2002). This shift from *learning to read* to *reading to learn* is accompanied by a change in the type of texts children read at school (Chall, Jacobs, & Baldwin, 1990). Whereas in the early grades children mainly read narrative texts, in later grades expository texts become dominant.

Narrative and expository texts differ in the ways they are structured, the causal coherence of information, the vocabulary, and the presence of a protagonist (Wolfe, 2005). Most children find expository texts more difficult to comprehend than narrative texts (Best, Floyd, & McNamara, 2008), but this is particularly the case for struggling readers (Williams, Hall, & Lauer, 2004). There are several reasons why expository texts pose a challenge. One reason is unfamiliarity: Children are often unfamiliar with expository texts as most reading activities in the early grades in elementary school revolve around narrative texts (Duke, 2000b; Williams et al., 2004). Furthermore, expository texts tend to be more complex than narrative texts, because they often present the children with new (and often abstract) concepts and complex relations, and because their informational density tends to be high (Coté, Goldman, & Saul, 1998; Meyer & Ray, 2011). In addition, expository texts show considerable variability in their local and global structure: They often incorporate a combination of different types of text structures, such as comparison and contrast, cause and effect, problem and solution, and sequence and description (Duke, 2000a; Meyer, 1975, 1985a; Williams et al., 2007).

As a result of these fundamental differences between narrative and expository texts, these texts elicit different processing strategies (McDaniel & Einstein, 1989). Expository texts draw more on background knowledge and evoke processing of details, whereas narrative texts elicit processing of the thematic structure and not so much of details (Kintsch & Young, 1984; Wolfe, 2005). Moreover, narratives may evoke more knowledge-based elaborations because children have more background knowledge relevant to the content of narratives than of expository texts. In contrast, expository texts may be processed in a more literal sense and may elicit fewer knowledge-based elaborations (Coté et al., 1998).

3.1.3 The present study

Prior research on comprehension processes and on-line strategy use of young children has focused on the comprehension of narrative texts (e.g., Cain et al., 2001; Cain & Oakhill, 1999; Cain, Oakhill, & Bryant, 2004; Kendeou et al., 2005). Research on the comprehension of expository texts in the early grades of elementary school (first and second grades) is particularly scarce (but see e.g., Duke, Bennett-Armistead, & Roberts, 2002, 2003, and Williams et al., 2004). Addressing this gap, the present study aims to investigate young children's processing and strategy use, in particular with respect to expository texts. Specific questions are whether the distinction between paraphrasers and elaborators already exists at a very young age, and whether processing patterns apply to expository as well as narrative texts. These issues were investigated in a think-aloud study in which second-grade pupils[1] read narrative and expository texts in a sentence-by-sentence manner and were asked to express their thoughts after each sentence. To assess the quality of their after-reading mental text representation, we asked the children literal and inferential (text-connecting and knowledge-based) comprehension questions (Cain & Oakhill, 1999). To determine possible factors contributing to comprehension differences, we also had them complete a test battery assessing general cognitive and language-related proficiencies.

3.2 Method

3.2.1 Participants

The study included 87 second-grade pupils (51 girls; mean age 7:8, range 7:2-8:7) from 19 classes of nine public elementary schools in the Netherlands, ranging from rural to inner-city schools. They were selected from a larger screening sample (N= 385) on the basis of the following inclusion criteria: (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 (*DMT* [Three Minute Test], Cito, 2009); (3) no diagnosed behavioral and/or attention problems. On the basis of their scores on a Dutch standardized test for reading comprehension (*LOVS Begrijpend Lezen Groep 3* [Reading comprehension test for Grade 1], Cito, 2006), the selected children were assigned to two groups: high-comprehending readers (*N* = 57; > 75th percentile) and low-comprehending readers (*N* = 30; < 50th percentile). Before testing, the parents or guardians

[1] We opted for children in Grade 2 because in the Netherlands formal education in reading comprehension and the use of reading strategies starts in Grade 3.

signed a letter of active consent. After testing, the children received an eraser, and their teachers received a book token (€20).

3.2.2 Measures and materials

Think-aloud session: texts and questions. In the think-aloud session participants read two expository and two narrative texts. The four experimental texts were matched on readability and length[2]. The sentences of the texts were printed in font Arial, font size 12 on cards of 10 x 15 centimeters. The cards were presented in flip-over photo albums. A practice text was presented in a separate photo album. Text comprehension was assessed by posing five questions after each text. Before the test session started, an examiner explained the think-aloud procedure to the child, and modeled it by reading part of the practice text. The child practiced the procedure on the remainder of the practice text. Think-aloud responses were audio-recorded.

Pre-processing of think-aloud data. The recordings of the verbal protocols were transcribed and parsed into idea units (see for details Trabasso & van den Broek, 1985) by trained assistants. First, three raters parsed nine transcripts independently (inter-rater reliability K = .87). Subsequently, two raters parsed the remaining transcripts. Problematic cases were resolved through discussions. 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). The category *Restating the Sentence* includes text repetitions and paraphrases, meaning that the reader restates the text verbatim or rephrases a sentence in his/her own words. *Explaining the Sentence* indicates that the reader provides an explanation for the contents of the current sentence by connecting its meaning to the preceding text. We speak of an *inference* when the reader provides an explanation for the contents of the current sentence on the basis of background knowledge (*Elaborative Inference)* or anticipates or predicts what will occur next in the text *(Predictive Inference)*. These elaborative and predictive inferences can be characterized as either *valid* or *invalid* in the context of the text. The category *Comments* includes associations, affective responses, evaluative comments, and metacognitive comments by the reader. The

[2] We used P-CLIB version 3.0 (Evers, 2008) to determine the difficulty level of the texts. The text difficulty was at *CLIB-4,* which equals Grade 2. Average text length was 146 words.

category *Question* applies when the reader asks or implies a question about the content of the text. *Silent Period* refers to the situation when the reader does not verbalize his or her thoughts for the space of three seconds or longer. *Other* is a miscellaneous category that includes all other responses, as well as passages that are inaudible. Using this procedure of coding the responses, three independent raters coded 15% of the transcripts, resulting in an inter-rater reliability score of 66% and an average correlation of $r = .85$. Two independent raters coded the remaining transcripts. Disagreements were resolved by discussion.

Only the first categorized idea unit of the responses for each sentence was used in the analyses. The reason for this was that the first response is the most spontaneous, and this procedure results in equal numbers of responses for all participants, thereby making comparisons between participants possible (see Ericsson & Simon, 1980; 1993).

3.2.3 Test battery

Non-verbal intelligence. Raven's Standard Progressive Matrices (Raven, Raven, & Court, 1998) was used as a measure for non-verbal intelligence and abstract reasoning. Reported scores are raw scores with a maximum possible score of 60.

Word reading ability. A Dutch standardized test was applied (the 'Drie-Minuten-Toets' -- DMT, *Three-Minute Test* -- Cito, 2009) to assess word decoding skills. Within one minute, children read aloud as many words as possible. The test had been administered by the schools at the end of Grade 1. Reported scores are skills scores.

Reading comprehension. A Dutch standardized test (Cito Leerling- en onderwijsvolgsysteem Begrijpend Lezen Groep 3 -- *Cito Reading Comprehension Test Grade 1* -- Cito, 2006) was used to assess reading comprehension. The test consists of three modules: 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. In six of the nine schools, the children had taken this test at the end of Grade 1. At three schools, we administered the initial module of the test ourselves. Reported scores are skill scores.

Listening comprehension. A standardized Dutch test was used to assess listening comprehension (Cito Begrijpend Luisteren 1 & 2 -- *Cito, Comprehensive Listening 1 & 2* -- Cito, 2011). The test consists of two parts. In both parts, children listen to one- to four-sentence stories and answer a question by choosing the right picture from three pictures. Reported scores are skill scores.

Vocabulary knowledge. The Peabody Picture Vocabulary Test-III-NL (Schlichting, 2005) was used as a standardized measure to assess receptive vocabulary in Dutch. The test consists of words ranging in difficulty. Each word is presented with four pictures, one of which represents the word. Reported scores are raw scores (maximum score of 60).

Reading skills. We developed a Maze test (Espin, Busch, & Shin, 2001) consisting of two experimental texts (and one practice text) in which every sixth word was replaced by a blank. Children filled in the blanks by identifying the correct word out of three options. There was a two-minute time limit for each text. Reported scores are raw scores (maximum score of 37).

Story structure recognition. We translated the Story Anagram Task (Oakhill et al., 2003). The test consists of four six-sentence stories that are cut up to single sentences and displayed to the participants in a random order. Participants are asked to arrange the sentences in the correct order. In the original scoring procedure, participants receive one point for each sentence that is put in the correct order. We adopted a more liberal scoring procedure and assigned points to correct combinations of sentences as well. Reported scores are alternative raw scores (maximum score of 28).

Inference making. We translated the Inference and Integration Task (Cain & Oakhill, 1999). The test consists of three test stories with six comprehension questions each: two questions tapping literal information, two questions requiring a text-connecting inference, and two questions requiring a gap-filling inference. Reported scores are raw scores (maximum score of 18).

Verbal working memory. We translated and adapted the Sentence Span Measure (Swanson, Cochran, & Ewers, 1989). The original test consists of four levels with two sets of unrelated declarative sentences with levels increasing in difficulty: the lowest level consists of two sets of two sentences, the highest level of two sets of five sentences. We added an easier level consisting of two sets of one sentence, because in a pilot test the original lowest level (two sets of two sentences) proved to be too difficult for many children. As in the original test, the sentences were seven to ten words in length. Reported scores are the scores for number of words correctly remembered plus comprehension questions correctly answered.

Socioeconomic status. We translated the Family Affluence Scale (FAS) (Currie, Elton, Todd, & Platt, 1997) to assess the socioeconomic status of the children. Reported scores are raw scores (maximum score of 9).

Reading motivation and reading attitude. We translated the Elementary Reading Attitude Survey (ERAS) (McKenna & Kear, 1990) to assess reading motivation and attitude. The survey consists of statements referring to school-related reading and recreational reading. Reported scores are raw scores (maximum score of 80).

3.2.4 Procedure

Participants were tested in five sessions. The first three (group-administered) sessions took place, at one-week-intervals, at the beginning of Grade 2. In the first session, the children completed the assessment for socioeconomic status, part I of the listening comprehension test, and the assessment for reading motivation. In the second session, the children completed part II of the listening comprehension test, the assessment for receptive vocabulary, and the Maze test for reading skills. In the third session, the children completed the assessments for non-verbal intelligence and the standardized test for reading comprehension if this test had not previously been administered by the school. A session lasted no longer than sixty minutes.

In the two remaining sessions, the children – who had by then spent six months in Grade 2 – were tested individually. In the first individual session (30 minutes), the children completed the test battery -- i.e., story structure recognition, the ability to make inferences, and verbal working-memory capacity were assessed. In the second individual session (45 minutes), the think-aloud protocol was employed.

3.3 Results

3.3.1 Test Battery

Data of one low-comprehending participant were missing on all the tests of the test battery; data of one low-comprehending participant were missing for the tests on reading skills and vocabulary knowledge; data of one high-comprehending participant were missing for the test on verbal working memory. Fifteen participants (3 low- and 12 high-comprehending readers) only completed the initial part of the reading comprehension test.

Independent-samples t-tests revealed that the group of high-comprehending readers outperformed the group of low-comprehending readers on all tasks in the test battery, with the exception of the test on reading motivation (see Table 3.1).

Table 3.1 Results of low- and high-comprehending readers on tasks in the test battery.

Measure	Low-comprehending readers M (SD)	High-comprehending readers M (SD)	Levene's test (*p* value)	*t* value	*df*	*p value*
Reading comprehension	-7.85 (6.44)	19.02 (7.49)	.122	-15.31	69	<.001
Word reading ability	45.31 (9.45)	54.88 (12.62)	.057	-3.60	84	.001
Non-verbal intelligence	27.90 (7.24)	35.30 (6.80)	.489	-4.67	84	<.001
Listening comprehension	49.93 (9.11)	60.86 (8.30)	.371	-5.59	84	<.001
Socioeconomic status	5.79 (2.21)	7.19 (1.27)	.001	-3.16	37.727	.003
Reading skills	19.46 (5.85)	25.32 (7.11)	.128	-3.77	83	<.001
Vocabulary knowledge	33.61 (6.18)	41.65 (6.15)	.895	-5.66	83	<.001
Reading motivation	64.45 (12.30)	60.62 (10.57)	.479	1.50	84	.137
Story structure recognition	18.83 (4.94)	23.12 (4.01)	.254	-4.34	84	<.001
Inference making	12.67 (2.29)	14.68 (1.42)	.011	-4.30	39.196	<.001
Verbal working memory	2.83 (1.14)	5.68 (3.25)	.000	-5.90	75.704	<.001

3.3.2 Think-aloud Experiment

Processing strategies of low-comprehending and high-comprehending readers. The data for the think-aloud experiment were analyzed in a multivariate Repeated Measures (RM) ANOVA, with Text Genre (narrative vs. expository texts) as within-participant factor, and Reading Proficiency (high-comprehending vs. low-comprehending readers) as between-participant factor. The dependent variables were the percentages of each of the strategy categories. The analyses revealed a significant main effect of Text Genre ($F(7,79) = 15.14$, $p < .001$) and a marginally significant main effect of Reading Proficiency ($F(7,79) = 1.88$, $p = .084$).

Univariate ANOVAs revealed that the main effect of Text Genre was present in all response categories (see Figure 3.1). Response categories that were observed more often in narrative texts than in expository texts were Restating the Sentence ($F(1,85) = 9.188$, $p = .003$), Explaining the Sentence ($F(1,85) = 11.763$, $p = .001$), and Valid Inferences ($F(1,85) = 16.278$, $p < .001$). The response categories that were observed more often for expository texts were Comments $F(1,85) = 16.795$, $p < .001$), Question $F(1,85) = 8.813$, $p = .004$), Silent Period $F(1,85) = 35.668$, $p < .001$), and Invalid Inferences $F(1,85) = 14.106$, $p < .001$).

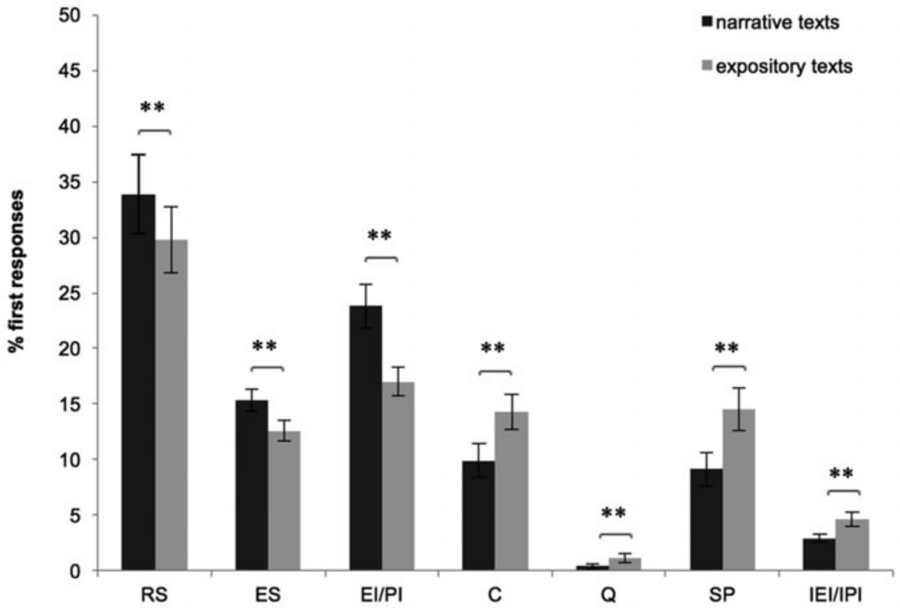

Fig.3.1. Mean percentages of first responses on the strategy categories for narrative and expository texts. RS = restating the sentence; ES = explaining the sentence; EI/PI = elaborative/predictive inference; C = comment; Q = question; SP = silent period; IEI/IPI = invalid elaborative/predictive inference. ** $p < .01$

In addition, the univariate ANOVAs revealed an interaction effect between Text Genre and Reading Proficiency for the category Invalid Inferences ($F(1,85) = 5.10$, $p = .026$). Post-hoc independent-samples t-tests indicated that low-comprehending readers made more invalid inferences than high-comprehending readers when they were reading expository texts ($t(34.27) = 2.13$, $p = .04$). This contrast between the two groups was absent for the narrative texts ($t(42.84) = 1.05$, $p = .30$).

Text representation of low-comprehending and high-comprehending readers. Data of one low-comprehending participant were missing. Performance on the comprehension questions was analyzed with a RM-ANOVA, including the within-participant factors Type of Question (three levels: literal, text-connecting inference, gap-filling inference) and Text Genre, and the between-participant factor Reading Proficiency. The dependent variable was the percentage of questions answered correctly. The results showed a main effect of Reading Proficiency ($F(1,84) = 37.64$, $p < .001$), indicating that the high-comprehending readers (M = 80.19 %, SD = 1.22) outperformed the low-comprehending readers (M = 67.34 %, SD = 1.70). A main effect of Text Genre ($F(1,84) = 32.64$, $p < .001$) showed that the participants answered more questions correctly in relation to narrative texts (M = 78.72 %, SD = 1.44) than in relation to expository texts (M = 68.82 %, SD = 1.27). Also, a main effect of Type of Question was observed ($F(2,168) = 99.05$, $p < .001$). Post-hoc paired-samples t-tests showed that the participants performed better on literal questions (M = 90.16 %, SD = 1.32) than on text-connecting questions (M = 65.83 %, SD = 1.65), (t(85) = 14.06, $p < .001$), and that they performed better on literal questions than on gap-filling questions (M = 65.31 %, SD = 1.71), (t(85) = 11.71, $p < .001$). There was no difference between participants' performance on text-connecting and gap-filling questions (t(85) = -.65, $p = .515$). In addition, the analysis revealed an interaction effect for Type of Question and Text Genre ($F(1,84) = 8.29$, $p < .001$). Post-hoc paired-samples t-tests indicated that Text Genre had no effect on participants' performance on literal questions ($t(85) = .09$, $p = .929$), but that participants performed better on text-connecting and gap-filling questions in relation to narrative texts than in relation to expository texts (text-connecting: $t(85) = 5.81$, $p < .001$; gap-filling: $t(85) = 4.65$, $p < .001$), see Figure 3.2.

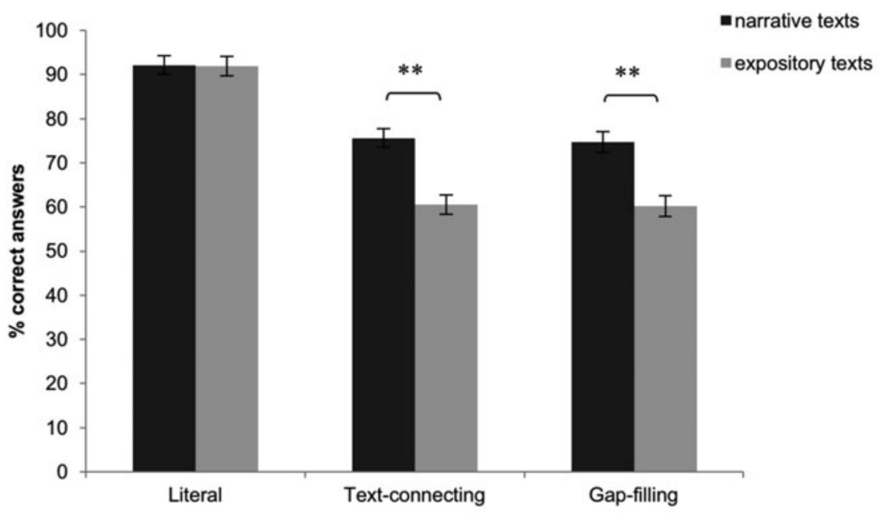

Fig.3.2. Percentages of mean correct responses on comprehension questions for narrative and expository texts. ** *p < .01*

3.3.3 Identifying Subgroups of Readers

Subgroups of low-comprehending readers. A cluster analysis was conducted on the group of low-comprehending readers to explore the existence of subcategories. Following McMaster et al. (2012), we used Ward and Hook's (1963) procedure which aims to minimize the sums of squares of observations within any two clusters that are formed at each step. This procedure revealed two distinct subgroups of low-comprehending readers. To classify these subgroups, a multivariate RM-ANOVA was conducted to examine the distribution of the first responses in the think-aloud experiment, with Text Genre as within-participant factor and Cluster (i.e., the two subgroups of low-comprehending readers) as between-participant factor.

The results showed a main effect of Cluster ($F(7,22) = 14.94$, $p < .001$). See Figure 3.3.

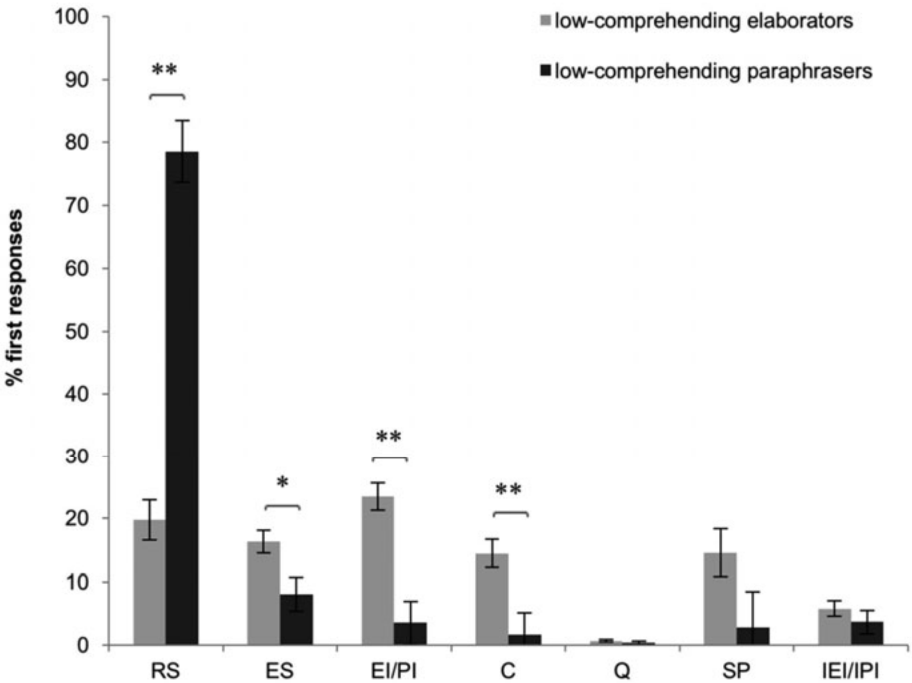

Fig.3.3. Mean percentages of first responses per subgroup of low-comprehending readers on the strategy categories. RS = restating the sentence; ES = explaining the sentence; EI/PI = elaborative/predictive inference; C = comment; Q = question; SP = silent period; IEI/IPI = invalid elaborative/predictive inference. * $p < .05$, ** $p < .01$

The follow-up analyses revealed that subgroup A of low-comprehending readers (*N*=9) more frequently displayed think-aloud responses of the type Restating the Sentence than did subgroup B ($F(1,28) = 98.99$, $p < .001$), whereas subgroup B (N=21) more frequently displayed think-aloud responses of the types Explaining the Sentence ($F(1,28) = 6.45$, $p = .017$), Valid Inferences ($F(1,28) = 24.28$, $p < .001$), and Comments ($F(1,28) = 9.45$, $p < .005$). Readers in subgroup A predominantly responded by restating the sentences they read. Therefore, we denote readers in subgroup A as *paraphrasers*. In contrast, responses by readers in subgroup B frequently belonged to categories that involve inference making. We therefore denote readers in subgroup B as *elaborators.*

Text representation of elaborating and paraphrasing low-comprehending readers. We repeated the analyses of the comprehension questions for the subgroups of elaborating and paraphrasing low-comprehending readers to investigate possible differences with respect to text representation. A main effect of Cluster (F(1,27) = 5.44, $p = .027$), showed that elaborators had a higher percentage correct responses (M = 66,75 %, SD = 10,07) than paraphrasers (M = 56.67 %, SD = 12.50). In addition, a two-way interaction between Type of Question and Cluster was observed (F(2,54 = 3.25, $p = .046$). Post-hoc independent-samples t-tests revealed that elaborators were better at answering gap-filling questions than paraphrasers (t(27) = 2.79, $p = .010$). This effect was absent for the other types of questions (literal questions: t(27) = 0.26, $p = .795$); text-connecting questions: t(27) = 1.01, $p = .323$). The three-way interaction between Text Genre, Type of Question, and Cluster was also significant (F(2,26) = 3.36, $p = .042$). Post-hoc testing revealed that elaborators were better at answering gap-filling questions about expository texts than paraphrasers (t(27) = 3.91, $p = .001$). This contrast between subgroups was absent for narratives texts (t(27) = 1.13, $p = .267$) (See Figure 3.4).

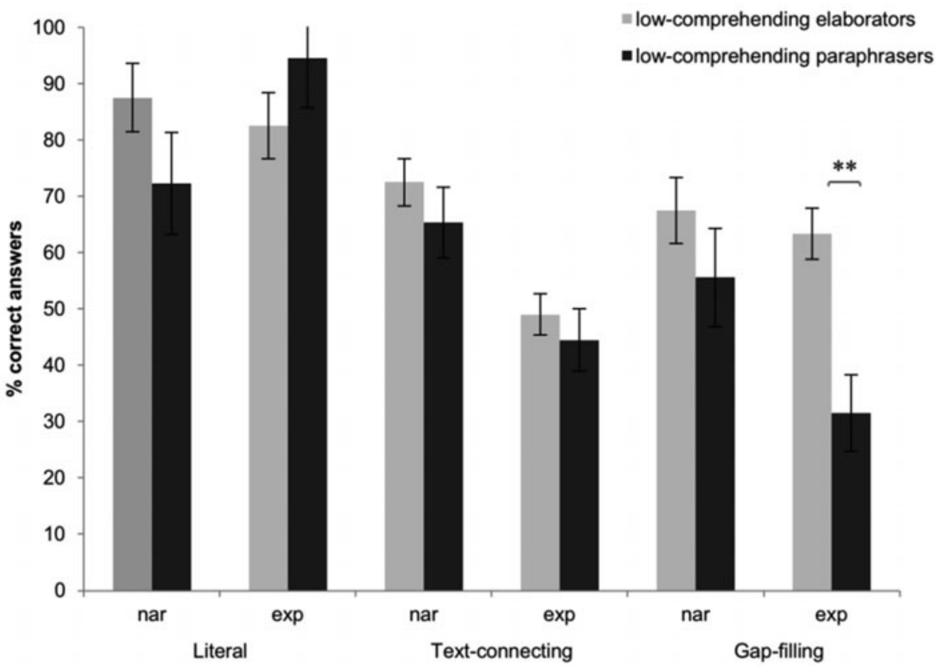

Fig.3.4. Percentages of mean correct responses per subgroup of low-comprehending readers on comprehension questions for narrative and expository texts.
nar = narrative texts, exp = expository texts. ** $p < .01$

Cognitive profiles of low-comprehending elaborators and paraphrasers. Independent-samples t-tests were conducted to uncover potential differences in the (cognitive) profiles of the two types of low-comprehending readers. These exploratory analyses revealed that elaborators had a higher socioeconomic status than paraphrasers (elaborators: M = 6.5, SD = 1.93, paraphrasers: M = 4.22, SD = 2.05), (t(27) = 2.884, *p* = .008) and that they outperformed paraphrasers on receptive vocabulary knowledge (elaborators: M = 35.37, SD = 5.46, paraphrasers: M = 29.89, SD = 6.23), (t(26) = 2.372, *p* = .025), inference and integration skills (elaborators: M = 13.40, SD = 1.92, paraphrasers: M = 11.06, SD = 2.34), (t(27) = 2.849, *p* = .008), and verbal working-memory capacity (elaborators: M = 3.20, SD = 1.06, paraphrasers: M = 2.00, SD = 0.87), (t(27) = 2.979, *p* = .006). Paraphrasers, in contrast, outperformed elaborators on the tests for technical word-reading skills (elaborators: M = 42.45, SD = 7.78, paraphrasers: M = 51.67, SD = 10.17), (t(27) = -2.685, *p* = .012) and on the Maze test for reading skills (elaborators: M = 17.95, SD = 5.75, paraphrasers: M = 22.67, SD = 4.92), (t(26) = -2.117, *p* = .044).

Subgroups of high-comprehending readers. We explored the composition of the group of high-comprehending readers with the same cluster procedure as conducted for the low-comprehending readers. The analysis revealed two subgroups of high-comprehending readers. The multivariate RM-ANOVA to classify these subgroups showed a main effect of Cluster ($F(7,49) = 28.16$, $p < .001$), and a two-way interaction for Cluster and Text Genre ($F(7,49) = 3.18$, $p = .007$). Post-hoc analyses revealed that subgroup A (n=27) more frequently displayed think-aloud responses of the type Restating the Sentence ($F(1,55) = 164.46$, $p < .001$) than did subgroup B, whereas subgroup B (n=30) more frequently displayed think-aloud responses of the type Valid Inferences ($F(1,55) = 20.99$, $p < .001$), Comments ($F(1,55) = 21.65$, $p < .001$), and Silent Period ($F(1,55) = 13.91$, $p < .001$) than did subgroup A (see Figure 3.5).

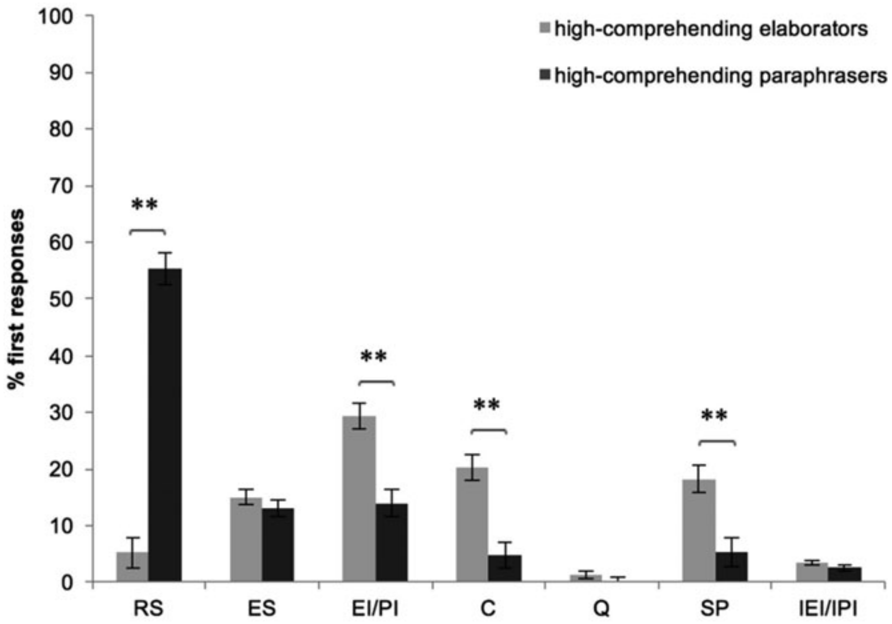

Fig.3.5. Mean percentages of first responses per subgroup of high-comprehending readers on the strategy categories. RS = restating the sentence; ES = explaining the sentence; EI/PI = elaborative/predictive inference; C = comment; Q = question; SP = silent period; IEI/IPI = invalid elaborative/predictive inference. ** *p < .01*

This mirrors the pattern that we observed for the low-comprehending readers. Readers in subgroup A predominantly responded by restating the sentences they had read. Therefore, we denote readers in subgroup A as *(high-comprehending) paraphrasers*. In contrast, responses by readers in subgroup B frequently belonged to categories that involve inference-making. We therefore denote readers in subgroup B as *(high-comprehending) elaborators.*

In addition to the main effect of Cluster, a two-way interaction for Cluster and Text Genre ($F(7,49) = 3.18$, $p = .007$) was observed for two response categories: Restating the Sentence ($F(1,55) = 11.04$, $p = .002$) and Valid Inferences ($F(1,55) = 7.47$, $p = .008$). Paraphrasers repeated or rephrased the sentence more often when reading narrative texts than when reading expository texts ($t(26) = 2.56$, $p = .017$), whereas elaborators repeated or rephrased the sentence more often when reading expository texts than when reading narrative texts ($t(29) = -2.29$, $p = .030$). Text Genre did not influence the responses of paraphrasers on the category Valid Inferences ($t(26) = 1.21$, $p = .237$), but elaborators made more valid elaborative and predictive inferences when reading narrative texts than when reading expository texts ($t(29) = 4.87$, $p < .001$) (see Figure 3.6).

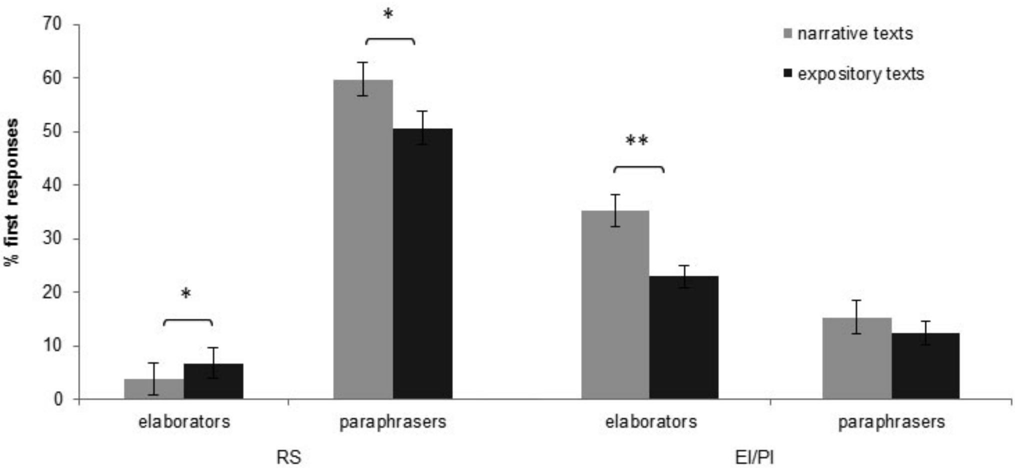

Fig.3.6. Mean percentages of first responses per subgroup of high-comprehending readers on two strategy categories for narrative and expository texts. RS = restating the sentence; EI/PI = elaborative/predictive inference. * $p < .05$, ** $p < .01$

Text representation and cognitive profiles of elaborating and paraphrasing high-comprehending readers. With respect to the comprehension questions, a RM-ANOVA revealed no main or interaction effects of Cluster (*p*s > .3). This suggests that the subgroups of high-comprehending readers did not differ in their ability to answer the comprehension questions in the think-aloud experiment. This equivalence between subgroups was reflected in their cognitive profiles, as independent samples t-tests revealed no differences on any of the tasks administered in the test battery (*p*s > .1).

3.4 Discussion

In this study, we investigated the comprehension processes and strategy use of second-grade low- and high-comprehending readers when reading narrative and expository texts for comprehension. The main findings are as follows. First, the high-comprehending readers performed better than the low-comprehending readers on the comprehension questions posed after each text. Second, while thinking out aloud the children used a variety of comprehension strategies, ranging from textual repetitions and paraphrases to elaborate text-based and knowledge-based inferences. With one exception, there was no evidence that low- and high-comprehending readers differed in their patterns of text-processing strategies, the exception being that for expository texts low-comprehending readers generated more inaccurate inferences than high-comprehending readers. Third, our study showed that young, eight-year-old low-comprehending readers can be classified either as readers who construct a mental representation that emphasizes the literal meaning of the text (paraphrasers) or as readers who embellish their mental representation by generating elaborative and predictive inferences (elaborators). Fourth, we observed a similar division of paraphrasers and elaborators in our group of high-comprehending readers. Finally, our study indicated that text genre affected the way children processed the texts.

3.4.1 Processing Strategies and Text Comprehension of Low- and High-Comprehending Readers

A robust finding in our study was that high-comprehending readers performed better than low-comprehending readers on the after-reading comprehension questions, for both narrative and expository texts. Concerning the expository texts the think-aloud responses present a relatively straightforward explanation. For these texts, low-comprehending readers generated more inaccurate inferences than did high-comprehending readers. Inclusion of inaccurate inferences had a negative impact on the quality of their overall mental representation of the text. As a result, they performed worse than high-comprehending readers on questions across the board. However, this explanation does not hold for the narrative texts. For narratives, the low-comprehending readers were again outperformed by the high-comprehending readers on all question types, but here their poorer performance was not due to making more inaccurate inferences. Indeed, the low- and high-comprehending readers did not differ in their overall patterns of strategy use. These results should be interpreted with some caution as methodological aspects of the current study may have contributed to the patterns observed. For example, the single-sentence presentation format may have impaired comprehension processes and may have discouraged the use of certain strategies during reading (Coté et al., 1998; Rapp & Mensink, 2011), perhaps differentially for the low and high comprehenders. Likewise, the think-aloud procedure may have influenced the results (Rapp et al., 2007). Therefore, it is important to explore whether these results can be replicated by using different methods. Nevertheless, it is worth speculating about possible explanations for the paradoxical findings concerning narrative texts.

One approach is to assume that although low- and high-comprehending readers do not process narrative texts differently, low-comprehending readers nonetheless experience problems in constructing their mental representation. Rapp et al. (2007) argued that high- and low-comprehending readers possess a similar "toolkit of strategies", but low-comprehending readers are less likely to use the toolkit effectively. They are either less efficient at using the right tools at the right time (Cain et al., 2001; Perfetti et al., 2005; Rapp et al., 2007), or they use the right tools at the right time, but apply these tools in the wrong way (Pearson et al., 1992; Rapp et al., 2007). Furthermore, it is also possible that low-comprehending readers activate the right type of information by using the right tool at the right time, but that they are still unable to produce a fully coherent mental representation of a text at the global level (Cain et al., 2001). In other words, their micro- and local-processing skills (e.g., their ability to make connections between sentences) are sufficient to establish basic comprehension, but their macro-processing skills (ability to form a mental representation of the text as a whole) are insufficient (Van Dijk & Kintsch, 1983).

A different approach is to relate the inferior quality of low-comprehenders' text representation to processes of memory retrieval and maintenance. In the current study, the quality of the children's mental text representations was measured by after-reading comprehension questions. Hence, whether the children were able to answer the questions satisfactorily depended not only on the quality of the mental model they developed as they were reading the text, but also on how proficient they were at keeping the representation active over time, and how easily they retrieved the relevant information from this representation. It is thus possible that the problems of low-comprehending readers did not lie in them forming an inferior initial mental representation, but rather that, due to processes of memory decay and interference, this representation deteriorated more quickly and was more difficult for them to access.

The results of the test battery revealed that in comparison to high-comprehending readers, low-comprehending readers displayed deficiencies in several (cognitive) domains – including decoding skills, higher-level comprehension skills, and verbal working-memory capacity -- that are closely associated with successful reading comprehension. As a result, it is not feasible to decide which of the alternatives discussed above (i.e., wrong inferences vs. wrong timing of inferences vs. macro-processing deficiencies vs. memory maintenance and retrieval deficiencies) is the most likely underlying cause of the comprehension difficulties. Instead, the most plausible conclusion is that the challenges faced by low-comprehending readers are of a 'multimorbid' nature, meaning that some text comprehension deficiencies (and their precursors) exist independently of each other, whereas other deficiencies are intrinsically intertwined (e.g., since they share a common source).

3.4.2 Subgroups of Low- and High-Comprehending Readers

In line with previous studies (McMaster et al., 2012; Rapp et al., 2007), our study showed that low-comprehending readers can be classified either as struggling paraphrasers or as struggling elaborators. While thinking aloud, the paraphrasers predominantly repeated or paraphrased the sentences of the texts. By contrast, elaborators frequently generated text-based and knowledge-based inferences. For narrative texts, these different processing strategies did not produce reliable differences in performance on the after-reading comprehension questions. This is consistent with the proposal of McMaster et al. (2012), who argued that paraphrasers and elaborators struggle with narrative texts to the same extent, yet for different reasons.

Whereas paraphrasers fail to generate a sufficient number of inferences and consequently have difficulty establishing coherence (e.g., Cain & Oakhill, 2006), elaborators have difficulty building a coherent representation of text because of inappropriate use of background knowledge or personal viewpoints (e.g., Williams, 1993). The current study extended these previous findings by sketching a different picture for expository texts. For these texts, the low-comprehending elaborators obtained higher scores on the comprehension questions that elicited knowledge-based inferences. In other words, for expository texts the processing strategy of elaborators seems to have a positive influence on the quality of their mental representation.

The observation that elaborators obtained better mental representations for expository texts cannot be attributed to differences in decoding skills because the results from the tests battery suggest that in the current study the low-comprehending paraphrasers are in fact the better technical readers. However, the elaborators did outperform the paraphrasers on tests for inference and integration skills, receptive vocabulary knowledge, and verbal working memory. This could indicate that struggling paraphrasers do not yet possess all the abilities (cognitive or otherwise) required to generate inferences in order to comprehend expository texts at a deeper level. The lower scores of paraphrasers on receptive vocabulary knowledge, for instance, are an indication that they lacked the necessary background knowledge to generate accurate knowledge-based inferences, particularly in more demanding situations. In addition, low-comprehending paraphrasers may have been impeded by a smaller working-memory capacity. As a rule, reading expository texts imposes a heavier load on young readers' working memory than reading narrative texts, because children tend to be less familiar with the structure and content of the text (Williams et al., 2004). In all, a tentative conclusion would be that working memory capacity and vocabulary knowledge are important precursors for generating accurate knowledge-based inferences, and that limitations in these cognitive domains hamper struggling paraphrasers in constructing a high-quality mental representations of expository texts.

Going beyond the analyses conducted in previous studies (McMaster et al., 2012; Rapp et al., 2007), we also explored whether subgroups can be distinguished for high-comprehending readers. We observed that, like low-comprehending readers, high-comprehending readers can also be categorized as paraphrasers and elaborators. These two types of high-comprehending readers performed equally well on the after-reading comprehension questions and all the tasks in the test battery. This shows that, for high-comprehending readers, multiple pathways (i.e. employing different reading strategies) produce the same level of comprehension (cf. McMaster et al., 2012).

3.4.3 Text Genre and Discourse Markers

A common assumption is that narrative and expository texts require (or at least elicit) different processing strategies due to differences in complexity and differences in readers' familiarity with their structure (McDaniel & Einstein, 1989). An important aim of the current study was to explore whether young, unexperienced readers are already sensitive to the notion of genre, or whether they approach narrative and expository texts in a similar way. Our findings show that young children do indeed process narrative and expository texts differently. The think-aloud data revealed that in narrative texts the children more frequently explained the sentence they just read or generated a valid inference to obtain a deeper understanding of the text. In expository texts, the children experienced some problems during processing, as indicated by more (irrelevant) comments, more invalid inferences, and more silences. This was true for low-comprehending readers in particular, because as a group they generated significantly more inaccurate inferences for expository texts. These overall processing differences between narrative and expository texts also influenced the answers on the after-reading comprehension questions. It was more difficult for children to answer knowledge-based inference questions about expository texts than about narrative texts. Hence, it seems that what they were not able to do spontaneously during text processing, they were also not able to do when triggered by a question.

The good news is that sensitivity to text genre seems to apply to young low-comprehending readers as well as to young high-comprehending readers. The bad news is that most children, and in particular low-comprehending readers, do not possess all the tools to do what is required to understand expository texts. An important question, therefore, is how educators should provide children with these tools. One approach is to improve readers' comprehension strategies. For example, McMaster et al. (2012, 2014) manipulated the reading task depending on the processing behavior of readers observed with regard to narrative texts: low-comprehending elaborators were stimulated to focus on important information within the text by answering causal questions during reading, whereas low-comprehending paraphrasers were stimulated to make text-connecting inferences and to think about the text beyond the current sentence by answering general questions during reading. A similar logic can be applied to improve young children's comprehension of expository texts. It remains an open question however, what type of during-reading questioning is most effective in this case. On the one hand, it may be beneficial to develop questions for all young readers that 'force' them to stay close to the literal meaning of the text, because they seem to lack the relevant knowledge to generate accurate elaborate inferences. On the other hand, generating accurate inferences while reading expository texts is exactly the kind of skill that children should acquire at school, and hence educators should stimulate this. So, this raises the puzzle: How can we get the best of both worlds?

One way to address this puzzle is to encourage readers to pay special attention to discourse markers of a text such as connectives, referential pronouns, and markers representing topic organization. Discourse markers can be particularly helpful in expository texts because they guide readers' comprehension of the relational and referential connections in a text, inducing (knowledge-based) inferences (cf. Land, 2009; Lorch, Lemarié, & Grant, 2011; Sanders, Land, & Mulder, 2007; van Silfhout, Evers-Vermeul, & Sanders, 2015). In other words, if young readers are encouraged to focus on discourse markers, they can be instructed to build their mental representation predominantly on the basis of the information provided by the text; at the same time, however, they are stimulated to connect different parts of the text, which promotes inferential processing.[3]

There is, however, another side to this coin. Although discourse markers can possibly prevent young (low-comprehending) readers from making invalid elaborative and predictive inferences, Best, Ozuru, Floyd, and McNamara (2006) have shown that young children benefit from coherence-marking in narrative texts, but not in expository texts. These authors suggest that in many expository texts discourse markers do not provide enough information for readers to make the necessary inferences without being provided with specific background information that is normally left unstated. Moreover, Land (2009) points out that although discourse markers can increase comprehension by adding cohesion, they also increase sentence length and complexity. In addition, discourse markers are abstract words and therefore difficult for less-skilled readers to comprehend.

[3] The experimental texts contained few discourse markers because the central interest concerned 'unprompted' text processing patterns to capture possible differences between low- and high-comprehending readers.

3.4.4 Implications for Education

The current study provides important insights for education. First, the challenges that young, low-comprehending readers are facing are most likely of a 'multimorbid' nature. Second, both low- and high-comprehending readers can be classified as elaborators and paraphrasers. Third, both low- and high-comprehending readers are sensitive to text genre, but they do not possess the skills to adapt their processing strategy adequately. On the basis of these results, and inspired by the studies discussed throughout this contribution, we suggest multi-dimensional interventions. Where possible, these interventions should be custom-made by varying the instructions in light of the processing behavior of the child in combination with the type of text he or she is reading. Discourse markers may play an important facilitative role, especially in expository texts – although care should be taken that enough background knowledge is provided in the text (Best et al., 2006). Furthermore, in light of the results of the test battery and think-aloud data, all low-comprehending readers may benefit from pre-teaching of vocabulary, and from strategy instruction to interpret word meaning (Best et al., 2008; McMaster et al., 2014). Crucially, all interventions should take into account the limited working-memory capacity of low-comprehending readers (low-comprehending paraphrasers in particular). Finally, our study presents new insights to improve education for high-comprehending readers. Given that this group of readers also consists of elaborators and paraphrasers, they too may benefit from custom-made educational programs (cf. McMaster et al., 2012, 2014) to take their reading comprehension skills to the next level.

Appendix I

Original version of the experimental texts used in the think-aloud study

#1 Expository text	#3 Expository text
Veel mensen nemen een souvenir mee van	Astronaut is een spannend beroep.
vakantie.	Je gaat in een raket naar de ruimte.
Souvenirs zijn leuk.	Soms mag je zelfs naar de maan toe.
Ze laten je aan je vakantie denken.	Hoe kun je eigenlijk astronaut worden?
Maar in een vliegtuig mag je niet alles meenemen.	Het is moeilijk, maar het kan wel.
Sommige spullen zijn verboden.	Je moet in ieder geval goed je best doen op school.
Je mag natuurlijk geen wapens of scherpe dingen	Want astronauten zijn heel slim.
meenemen.	Ze zijn heel goed in rekenen en taal.
Schelpen mogen vaak ook niet.	Als je astronaut wilt worden,
Mensen nemen soms toch verboden spullen mee.	is het handig om eerst piloot te worden.
Ze kunnen een boete krijgen van duizend euro!	Dat kun je worden bij het leger.
Soms nemen mensen stiekem dieren mee.	Je moet dan eerst een paar jaar piloot zijn,
Ze smokkelen de dieren.	en daarna moet je nog verder leren.
Ze weten wel dat het niet mag.	Je kunt dan een raket gaan besturen.
Maar ze krijgen er veel geld voor.	Het is ook handig om Russisch te leren.
Tom de Groot werkt bij het vliegveld.	Rusland heeft een raket.
Hij zoekt in koffers naar verboden spullen.	Daarmee kun je naar de ruimte gaan.
Hij ziet meteen of spullen 'goed' of 'fout' zijn.	Je moet dan eerst trainen in Rusland.
Tom de Groot vertelt: Een vrouw smokkelde vogels.	Het is dus handig als je Russisch spreekt.
Ze had vijf vogels in flessen verstopt.	Je moet nooit opgeven als je astronaut wilt worden.
We maakten haar koffer open.	Want astronauten zijn doorzetters.
Er waren toen al twee vogels dood.	Dus, als je echt astronaut wilt worden,
Dan word ik echt heel boos!	geef dan nooit op!

#2 Narrative text

Olifant Okke was niet gelukkig.

Hij was alleen en vond zichzelf veel te dik.

Okke wilde zo slank als een slang zijn.

Okke liep rond en dacht diep na.

Hij dacht: Hoe kan ik minder zwaar worden?

Okke liep langs Peter het paard.

Die stond net een appeltje te eten.

En toen wist Okke het opeens!

Hij ging alleen nog gezonde dingen eten.

En ja hoor, Okke viel een paar kilo af.

Maar hij was nog steeds niet gelukkig.

Toen werd de krant bezorgd.

Okke bladerde hem door.

Hij zag een foto van een mooi, mollig olifantje.

Haar naam was Olga.

Zij was op zoek naar een lieve, mollige man!

Okke schreef een brief naar Olga.

Hij nodigde haar uit voor de film.

Daar werden ze meteen verliefd op elkaar.

Nu zijn ze heel gelukkig samen!

#4 Narrative text

Er was eens een moedermuis met drie baby muisjes.

Een van de muisjes was een stoere jongen.

Een ander muisje was een mooie meid.

Het derde muisje was veel kleiner dan de rest.

Moeder maakte zich zorgen over hem.

Ze hield hem liever binnen.

Iedereen noemde het kleine muisje Watje.

Watje wilde ook buiten spelen.

Hij wilde graag meedoen met de rest.

Maar hij vond het ook een beetje eng.

Misschien had mama wel gelijk.

Op een dag werd het dorp aangevallen.

Door een grote, enge kat.

Niemand durfde iets te doen.

Zelfs de stoere broer van Watje niet.

Watje greep zijn kans.

In de nacht weg sloop hij weg.

Hij sprong op de grote kat die lag te slapen.

Watje pakte hem bij zijn snorharen vast.

Watje riep: Enge kat, ga meteen weg uit mijn dorp!

Anders trek ik al je snorharen uit je kop!

De volgende dag was de kat verdwenen.

Iedereen in het dorp was blij.

Kleine Watje was een held vanaf toen.

Chapter 04

Differences in Text Processing by Low- and High-Comprehending Beginning Readers of Expository and Narrative Texts: Evidence from Eye Movements

This chapter is based on
Kraal, A., van den Broek, P. W., Koornneef, A. W., Ganushchak, L. Y., & Saab, N. (2019). Differences in text processing by low- and high-comprehending beginning readers of expository and narrative texts: Evidence from eye movements. *Learning and Individual Differences: Journal of Psychology and Education, 74*.
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Abstract

The present study investigated on-line text processing of second-grade low- and high-comprehending readers by recording their eye movements as they read expository and narrative texts. For narrative texts, the reading patterns of low- and high-comprehending readers revealed robust differences consistent with prior findings for good versus struggling readers (e.g., longer first- and second-pass reading times for low-comprehending readers). For expository texts, however, the differences in the reading patterns of low- and high-comprehending readers were attenuated. These results suggest that low-comprehending readers adopt a suboptimal processing approach for expository texts: relative to their processing approach for narrative texts, they either do not adjust their reading strategy or they adjust towards a more cursory strategy. Both processing approaches are suboptimal because expository texts tend to demand more, rather than less, cognitive effort of the reader than narrative texts. We discuss implications for (reading) education.

4.1 Introduction

Reading comprehension is one of the most important skills children need to acquire in school, as much academic knowledge is transferred through texts. However, individual differences in comprehension skills are considerable, and many children fail to comprehend the texts they have to read in school (e.g., Kuhlemeier et al., 2014; National Center for Education Statistics, 2011). Whereas in the early grades of elementary school children primarily come into contact with narrative texts, from third grade onward expository texts become more dominant. Expository texts are an important learning tool aimed at transmitting knowledge about a particular theme or subject. However, the processing of expository texts, relative to that of narrative texts, poses a challenge for young readers for several reasons. Young readers often are unfamiliar with the conventions, the global structure, and the reading goals for expository texts (Coté, Goldman, & Saul, 1998; Duke, 2000b; Kaakinen, Hyönä, & Keenan, 2003; Lorch, 2017; Meyer, 1975, 1985a; Meyer & Freedle, 1984; Meyer & Ray, 2011; Oakhill, Cain, & Elbro, 2014; Williams, Hall, & Lauer, 2004; Williams et al., 2007). Furthermore, because expository texts often contain unfamiliar words and concepts (i.e., young readers are likely to have gaps in their prior knowledge), they also require strong inferential skills (Kaakinen et al., 2003; Lorch, 2017; Oakhill et al., 2014). As a result, most children understand narrative texts better than expository texts (Best, Floyd & McNamara, 2008) with expository texts being particularly difficult to comprehend for struggling readers (Williams et al., 2004).

To have an understanding of where exactly these text comprehension problems occur and to be able to alleviate them, it is necessary to gain insight into the processes in which readers engage during reading. Tracking the eye movements of readers during reading can reveal readers' on-line text-processing approaches (Boland, 2004; Juhasz & Pollatsek, 2011; Rayner, 1998). In the current study, we tracked the eye movements of young low- and high-comprehending readers to investigate how they process narrative and expository texts, and how they may differ in terms of on-line text processing.

4.1.1 Individual differences in reading and eye movements

It generally is presumed that readers employ strategies to facilitate comprehension, either consciously or unconsciously (Pressley & Afflerbach, 1995). Sources of individual differences in reading comprehension include general cognitive factors (e.g., background knowledge, working-memory capacity, vocabulary, reasoning skills), comprehension factors (e.g., standards of coherence, inference-making skills), and text-specific factors (e.g., knowledge about text structures. For reviews see Cain & Oakhill, 2007; Helder, van den Broek, Van Leijenhorst, & Beker, 2013; van den Broek & Espin, 2012). A first common finding in research on comprehension processes of successful readers is that they tend to be active, strategic readers (Duke & Pearson, 2002; Pressley & Wharton-McDonald, 1997; Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007; Van der Schoot, Reijntjes, & Van Lieshout, 2012). They read texts with a clear goal (Duke & Pearson, 2002; Pressley & Wharton-McDonald, 1997), read different kinds of texts differently (Duke & Pearson, 2002; Schroeder, 2011; Zabrucky & Ratner, 1992), and regulate their reading strategies depending on the text and the task (Rapp et al., 2007; Schroeder, 2011). A second common finding is that successful readers make inferences while reading. They relate important ideas in the text to one another, and to their prior knowledge (Duke & Pearson, 2002; Pearson, Roehler, Dole, & Duffy, 1992; Pressley & Wharton-McDonald, 1997; Rapp et al., 2007). A third common finding is that successful readers tend to be highly metacognitive. They monitor their reading and, when they encounter a comprehension problem, try to solve it (Pearson et al., 1992; Pressley & Wharton-McDonald, 1997). Sometimes they jump ahead in the text, or they look back when they are confused (Pressley & Wharton-McDonald, 1997). Further, they cope with discrepancies and gaps and attempt to define the meanings of words and concepts they do not know (Duke & Pearson, 2002). Thus, successful readers set themselves high standards of coherence (van den Broek, Bohn-Gettler, Kendeou, Carlson, & White, 2011). They have a drive to understand the texts they read and put cognitive effort into it. By doing all this, successful readers construct a coherent mental representation of the meaning of a text (e.g., van den Broek, White, Kendeou, & Carlson, 2009).

Readers that struggle with comprehension of the texts they read differ from their successful peers in several aspects. One difference concerns the goals they set themselves (Oakhill & Cain 2007). Readers that are unsuccessful in comprehending texts regard reading more as a matter of word decoding than a matter of sense-making (Cain, 1999; Yuill & Oakhill, 1991), and they are less likely than successful readers to adapt their reading style to different reading tasks (Cain, 1999). Furthermore, unsuccessful readers may have difficulty with generating the correct inferences when needed, with identifying particular relations in the text, or with integrating information from the text with background knowledge (Cain, Oakhill, Barnes, & Bryant, 2001; Denton et al., 2015; Oakhill & Cain, 2007; Perfetti, Landi, & Oakhill, 2005; Yuill & Oakhill, 1991). In addition, unsuccessful readers frequently are less proficient than successful readers in comprehension monitoring (Denton et al., 2015; Oakhill & Cain, 2007; Oakhill, Hartt, & Samols, 2005; Perfetti et al., 2005). Finally, whereas successful readers use their knowledge of text structure to relate ideas in the text and to activate relevant text schemas, unsuccessful readers are less sensitive to story structure (Oakhill & Cain, 2007, 2012). Consequently, unsuccessful readers are less conscious of the features of texts that could help them construct a coherent mental representation of the text's meaning (Oakhill & Cain, 2012; Perfetti et al., 2005).

Differences in reading skills may be reflected in differences in eye-movement patterns. In eye-tracking experiments it is common to relate eye-movement measures to cognitive processes (Boston, Hale, Kliegle, Patil, & Vasishth, 2008; Clifton, Staub & Rayner, 2007; Juhasz & Pollatsek, 2011; Kuperman & Van Dyke, 2011; for an overview of commonly used eye-movement measures and the cognitive processes they are assumed to represent, see e.g., Boston et al., 2008). Measures of initial or early processing (first-pass measures) are assumed to represent lower-level processes and skills such as decoding of orthographic information and word identification (Boland, 2004; Boston et al., 2008; Juhasz & Pollatsek, 2011, Kuperman & Van Dyke, 2011). These measures include, for instance, *first fixation duration* (the duration of the first fixation on a word during first pass; Juhasz & Pollatsek, 2011), *first gaze duration* (also *gaze duration or first-pass reading time*: the sum of all fixation durations for a word before the reader moves on or looks back in the text; Boston et al., 2008; Juhasz & Pollatsek, 2011), and *first-pass word skipping probability* (or *skipping rates*: the probability that a word is skipped during first pass; Juhasz & Pollatsek, 2011). Later processing measures are assumed to represent higher-level processes and skills involved in integrative text processing (Boland, 2004; Boston et al., 2008; Juhasz & Pollatsek, 2011; Kuperman & Van Dyke, 2011). Later processing measures include, for instance, *regression rates* (or *regression probability*: the percentage of regressions into a target word or out of a target word; Boston et al., 2008; Juhasz & Pollatsek, 2011), *second-pass fixation duration* (or *re-reading time*: the amount of time that is spent on re-reading a target word after first-pass reading; Boston et al., 2008; Juhasz & Pollatsek, 2011), *total fixation duration* (the sum of all fixation durations on a word; Juhasz & Pollatsek, 2011), and *right-bounded duration* (or *right-bounded reading time*: the sum of all fixation durations for a word during first pass before the reader moves on progressively; Boston et al., 2008; Traxler, Bybee, & Pickering, 1997).

The distinction between initial versus later processing measures has yielded important insights into readers' text processing. For instance, with regard to initial processing measures reflecting lower-level processes and skills, prior research has shown that both beginning readers and poor readers make more fixations, longer fixations, shorter saccades, and more regressions when reading texts than proficient readers do (Rayner, 1998). However, the increased regression rates of struggling readers do not imply that regressive eye movements should be avoided. In fact, they can fulfil an important purpose, namely to repair a failure in text comprehension (Rayner, Schotter, Masson, Potter, & Treiman, 2016). With regard to later processing measures, which reflect higher-level processes and skills that lead to the construction of a mental model of the text, prior research has shown that the effective comprehension-monitoring skills of good comprehenders may result in these readers making more regressive eye movements than do poor comprehenders (Ehrlich, Remond, & Tardieu, 1999; Rayner et al., 2016; Van der Schoot et al., 2012). By investigating initial and later processing measures one can obtain insight into both lower-level processes and higher-level cognitive processes that readers engage in during reading and, possibly, into differences between subgroups of low- and high-comprehending readers. Although one-to-one mapping between specific eye movements and specific cognitive processes is difficult (Boland, 2004; Kuperman & Van Dyke, 2011), the general mapping of early and late measures is widely accepted.

4.1.2 Differences in reading and eye movements as a function of text genre

Differences in reading processes and eye-movement patterns depend not only on the skills of the reader but also on properties of the text (e.g., see Huestegge & Bocianski, 2010; Juhasz & Pollatsek, 2011; Oakland & Lane, 2004). Text genre may play an important role in readers' text-processing styles (McDaniel & Einstein, 1989; Oakhill & Cain, 2012; van den Broek & Kendeou, 2017). As pointed out earlier, expository texts are more challenging than narrative texts to many children (Best et al., 2008). Children may need to make extensive use of comprehension processes such as elaborative inference making (using their prior knowledge to make sense of the information in the text) and comprehension monitoring to meet the challenge of reading these texts. However, their lack of familiarity with the content and structures of expository texts may hamper them in doing this successfully (Coté et al., 1998). In fact, with regard to adolescents Denton et al. (2015) have shown that poor comprehenders have considerable deficits in inference making, particularly in expository text, and in comprehension monitoring in both expository and narrative texts.

To our knowledge, no previous eye-tracking studies have investigated young readers' processing of narrative texts relative to expository texts. However, there is evidence from previous eye-tracking studies that readers process easy texts and difficult texts differently. For difficult texts, readers have longer reading times and longer fixation durations, make more fixations, and skip fewer words (Rayner, 1986). Furthermore, for difficult texts readers look back more often and spend more time looking back to previous parts than for easy texts (Leeuw, Segers, & Verhoeven, 2016). Based on these findings, it is plausible that more cognitive effort is exerted in processing expository texts than in processing narrative texts, and that this leads to a more effortful or intensive reading style. However, it is not sure whether low-comprehending readers are capable of engaging in a more effortful reading style of this kind. Denton et al. (2015) indicate that whereas good comprehenders exert more effort to process difficult texts, poor comprehenders fail to engage in more effortful processing.

Investigation of individual differences in text processing and in the flexibility to adapt to text genre (either automatically or strategically) can provide important insights into comprehension differences. Previous studies on children's eye movements when reading have focused on one text genre (e.g., De Leeuw, Segers, & Verhoeven, 2016; Kaakinen, Lehtola, & Paattilammi, 2015; Olson, Kliegle, Davidson, & Foltz, 1985; Rayner, 1986; Van der Schoot et al., 2012), or on specific word or text manipulations (e.g., Blythe et al., 2006; Blythe, Häikiö, Bertam, Liversedge, & Hyönä, 2011; Blythe, Liversedge, Joseph, White, & Rayner, 2009; Huestegge & Bocianski, 2010; Huestegge, Radach, Corbic, & Huestegge, 2009; Joseph, Bremner, Liversedge, & Nation, 2015; Joseph, Liversedge, Blythe, White, & Rayner, 2009; Schroeder, 2011). With regard to lower-level processes and skills involved in reading, it is likely that poor readers differ from proficient readers in their eye movements (e.g., see Rayner, 1998). However, with regard to higher-level processes and skills in reading, the picture of how young low- and high-comprehending readers differ in their eye movements is less complete. Neither is it clear whether their text processing – as reflected by their eye-movement patterns – differs for different types of texts (expository vs. narrative texts). It is important to obtain a clear understanding of the processes involved in young low- and high-comprehending readers' on-line reading comprehension, especially for different types of texts, as this may shed light on aspects of reading that hinder text comprehension for young unsuccessful readers.

Tracking children's eye movements can contribute to obtaining insights into readers' on-line text processing.

4.1.3 The present study

This study is part of a larger study consisting of several experiments in which various aspects of reading comprehension were investigated. In a prior study we examined the on-line comprehension processes and strategy use of young low- and high-comprehending readers by using a think-aloud protocol (see Chapter 3). The purpose of the present study is to gain insight into the on-line text processing of young low- and high-comprehending readers by tracking their eye movements as they read expository and narrative texts for comprehension. We hypothesized that because young readers have greater difficulty processing expository texts than narrative texts (Best et al., 2008), they need to adapt their reading approach to obtain a proper understanding of expository texts (cf. Leeuw et al., 2016; Rayner, 1986). In addition, we hypothesized that readers with high comprehension skills will adjust their reading approach more easily to the text than readers with poor comprehension skills (Duke & Pearson, 2002; Rapp et al., 2007) because high-comprehending readers generally have better comprehension-monitoring skills (Cain & Oakhill, 2007; Perfetti et al., 2005; Van der Schoot et al., 2012), better strategic skills (Duke & Pearson, 2002; Pressley & Wharton-McDonald, 1997; Rapp et al., 2007; Van der Schoot et al., 2012), greater structural awareness (Ray & Meyer, 2011), and a more flexible reading approach (Duke & Pearson, 2002; Rapp et al., 2007; Schroeder, 2011; Zabrucky & Ratner, 1992). Based on these hypotheses, we predicted an interaction effect between reading proficiency (high vs. low) and text genre (narrative vs. expository) for the eye-movement measures that reflect higher-level integrative text processing and comprehension (e.g., regression rates, re-reading times; Boland, 2004; Boston et al., 2008; Juhasz & Pollatsek, 2011; Kuperman & Van Dyke, 2011).

To explore these issues, we asked second-grade low- and high-comprehending pupils to read expository and narrative texts from a computer screen in an eye-tracking experiment. They were all proficient technical readers with a normally developed intellect. After reading, the pupils answered literal and inferential comprehension questions to determine the quality of their mental text representation (Cain & Oakhill, 1999). In the context of the larger study they completed a test battery measuring general cognitive and language-related skills to identify possible factors contributing to comprehension and processing differences (see Chapter 3).

4.2 Method

4.2.1 Participants

Eighty second-grade pupils (47 girls; mean age 7:8, range 6:4-8:9) from 19 classes of 9 elementary schools in the Netherlands participated in this study. They were selected from a larger screening sample (N=385) (see Chapter 3). Following Cain and Oakhill (2007) and Nation (2005), we defined our low-comprehending readers as readers who have difficulty comprehending connected text despite having age-appropriate technical reading skills. Selection criteria were as follows: Average or above-average score on a standardized test for word-reading ability (*Drie-Minuten-Test* [Three-Minutes-Test], Cito, 2009); average or above-average IQ-score on a non-verbal intelligence test (*Raven's progressive matrices*, Raven, Raven, & Court, 1998); either a score above the 75th percentile or below the 50th percentile score on a standardized test for reading comprehension (*LOVS Begrijpend Lezen Groep 3* [Reading Comprehension Grade 1], Cito, 2006); no diagnosed behavioral and/or attentional problems. On the basis of their score on the standardized test for reading comprehension, the selected children were assigned to a group of high-comprehending readers (*N* = 53) or to a group of low-comprehending readers (*N* = 27). The 50th percentile was applied as a threshold for classifying low-comprehending readers because a score below this percentile indicates a score below the national average. Moreover, we ensured that there was a clear gap in comprehension skills between the low- and high-comprehending readers as we only included high-comprehending pupils that obtained scores above the 75th percentile.

The data of three low-comprehending participants were removed from the dataset due to tracker-loss in the eye-tracking part of the experiment. Therefore, reported analyses relate to 77 participants (high-comprehending, *N* = 53; low-comprehending, *N* = 24). Before testing, participants' parents or guardians provided written informed consent. After testing, the participants received an eraser and their teachers received a book token (€20).

4.2.2 Measures and materials

Stimuli of eye-tracking experiment. In the eye-tracking session, the children read one narrative practice text, two expository texts, and two narrative texts, all of which were especially designed for the current study. The texts were presented in the following order: Narrative practice text about a boy who helps his uncle milking cows on a farm; expository text about the human skeleton; narrative text about two brothers who encounter a problem with their sister's iPad; expository text about lions; narrative text about children playing hide-and-seek in the schoolyard. The texts are provided in appendix II. The texts were matched on length and readability, using an algorithm that calculates text difficulty at the level of conceptual readability (P-CLIB version 3.0, Evers, 2008). See Table 4.1 for details on text features of the experimental texts.

Table 4.1 Text features of narrative and expository experimental texts based on P-CLIB.

	Narrative texts		Expository texts	
	iPad	*Hide-and-seek*	*Human skeleton*	*Lions*
No. of sentences	19	19	19	19
No. of words/text	127	116	123	122
No. of types/text[1]	85	72	64	74
No. of letters/text	504	496	524	525
Average no. of words/sentence	6.7	6.1	6.4	6.4
Average no. letters/word	4.0	4.3	4.3	4.3
Syllables -, 1,2,3,N[2]	0, 87, 33, 7, 0	0, 83, 24, 8, 1	0, 76, 42, 5, 0	0, 80, 35, 5, 2
% of frequent words	86.6	91.4	72.4	78.7
Type-token ratio	0.67	0.62	0.52	0.61
CLIB (Grade level)	CLIB-4[3]	CLIB-4	CLIB-5[3]	CLIB-5

[1]No. of types/text represents the number of distinct words in a text.
[2]Syllables -, 1, 2, 3, N represent the number of words for which no syllables are counted (i.e., abbreviations and numbers not written as text), the number of one-syllable words, the number of two-syllable words, the number of three-syllable words and the number of words with more than three syllables, respectively.
[3]CLIB-4 is the equivalent of the text-difficulty level for Grade 2 and CLIB-5 for Grade 3.

Eye-movement measures. *Full text reading times* and *Full text fixation counts* were computed as coarse measures of processing strategies of different types of readers (low- vs. high-comprehending readers) for different types of texts (narratives vs. expository texts). In addition, to detect more subtle differences for these two factors, we computed several finer-grained reading measures for each individual word of a text (see e.g., Juhasz & Pollatsek, 2011): *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 in the text), *Right-bounded duration* (the sum of all fixation durations for 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), *First-pass regression probability* (based on the ratio of progressive to regressive saccades during first pass), *First-pass word skipping probability* (the probability that a word is skipped during first pass) and *Saccade amplitude* (the amplitude of progressive first-pass saccades in degree of visual angle).

Comprehension questions. Three types of questions were included to assess text comprehension after reading (each reader answered six questions in total after reading each text): 1) two questions eliciting literal information; 2) three text-based questions requiring a text-connecting inference between two sentences in the text, and 3) one knowledge-based question requiring a gap-filling inference between the information in the text and the reader's background knowledge (Cain & Oakhill, 1999). The answers were scored as correct or incorrect. The comprehension questions are provided in the appendix.

4.2.3 Test battery[4]

Non-verbal intelligence (selection criterion). To assess non-verbal intelligence and abstract reasoning, Raven's Standard Progressive Matrices (Raven et al., 1998) were used. Participants completed the test at their own pace in the classroom, marking their answers on an answer sheet. The maximum time on task was 30 minutes. Completion was not required. Raw scores are reported. 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). To assess word-decoding skills, a standardized test was used (*Drie-Minuten-Toets* [Three-Minutes-Test], Cito, 2009). The test consists of three lists of words of increasing difficulty. Children read aloud as many words as they can

[4] The test battery was administered as part of a larger study (see Chapter 3). Here, only tests relevant to the current study are described.

from each list for one minute, with emphasis on both speed and accuracy. The reliability of the DMT is good, α > 0.97 (Krom, Jongen, Verhelst, Kamphuis, & Kleintjes, 2010). In all participating schools, the children took the test at the end of first grade. Skill scores are reported. The scores of the participants ranged from 34 to 85, reflecting above average to very high word-reading ability (range of possible scores: 0-148).

Reading comprehension (selection and classification criterion). To assess reading-comprehension skills, a Dutch standardized reading-comprehension test (*LOVS Begrijpend Lezen Groep 3* [Reading Comprehension Grade 1], Cito, 2006) was used. The reliability of this test is good, MAcc > 0.93 (Feenstra, Kamphuis, Kleintjes, & Krom, 2010). The test consists of three modules: An initial module for all children, an easier follow-up module for struggling comprehenders, and a more difficult follow-up module for average and good comprehenders. The modules contain different types of items: Shuffled stories, fill-in assignments, and questions about the text. The initial module has four example items and 25 multiple-choice items. The follow-up modules consist of 25 multiple-choice items each. The children took the test at the end of first grade in six of the nine schools. At three schools, we administered the initial module of the test instead of the school. The time on task was 30 minutes. Skill scores are reported. The scores of the participants ranged from -30 to 34, reflecting very low to very high reading-comprehension ability (range of possible scores for the easier follow-up module: -87 to 48; range of possible scores for the more difficult follow-up module: -81 to 60).

Listening comprehension. To measure listening-comprehension skills a standardized listening-comprehension test was used (*LOVS Begrijpend Luisteren Groep 3* [Listening Comprehension Grade 1], Cito, 2011). The reliability of this test is adequate, MAcc > 0.72 (Van Berkel et al., 2013). The test includes two parts consisting of 23 multiple-choice questions each. In each part, the children listen to one- to four-sentence stories and answer a question by choosing the correct picture from three available pictures. Administration of the test took 25 minutes per part. There was a one-week interval between the administration of part 1 and 2 to avoid fatigue and loss of concentration. Skill scores are reported. 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. To assess receptive vocabulary in Dutch, the Peabody Picture Vocabulary Test-III-NL (Schlichting, 2005) was used as a standardized measure. The test includes sixty words that differ in difficulty. Each word is presented together with four pictures. The child has to indicate which picture matches the target word. Administration of the task took 25 minutes. Raw scores are reported. The scores of the participants ranged from 22 to 52 (range of possible scores: 0-60).

Verbal working memory. To assess verbal working-memory capacity, a translated and adapted version of the Sentence Span measure (Swanson, Cochran, & Ewers, 1989) was used. The original test comprises four levels with two sets of unrelated sentences, with levels increasing in difficulty: The lowest level contains two sets of two sentences, the highest level contains two sets of five sentences. We translated the test. In a pilot test, the test proved to be too difficult for many children. Therefore, we added an easier level comprising two sets of one sentence of seven to ten words in length (as in the original test). The test was administered individually. Scores for the number of correctly remembered words plus correctly answered comprehension questions are reported. This scoring method has good internal consistency of 0.79 (Conway et al., 2005). The scores of the participants ranged from 1 to 16 (range of possible scores: 0-30).

Inference making. To assess inference-making skills a translated version of the Inference and Integration Task (Cain & Oakhill, 1999) was used. The test contains one practice story and three test stories with six comprehension questions each: Two questions eliciting literal information, two questions requiring a text-based inference, and two questions requiring a knowledge-based inference. Raw scores are reported. The scores of the participants ranged from 7.5 to 17 (range of possible scores: 0-18).

4.2.4 Procedure

All procedures were approved by the Leiden University Institute of Education and Child Studies ethics committee (project number ECPW-2014/073) and conducted in accordance with the Declaration of Helsinki. Participants were tested in two phases, in five sessions in total, see Table 4.2. In the first three sessions of phase 1, the larger screening sample (N=385) was tested on general cognitive and language-related proficiencies. After this first phase, the selection criteria (see 4.2.1 Participants) were applied; resulting in the selection of 80 children. In the second phase, the selected children were further tested in two individual sessions, which took place within a one-week-interval (by this stage the children had spent six months in Grade 2). In the first individual session (30 minutes) inference-making skills and verbal working-memory capacity were assessed. In the second individual test session (45-60 minutes), the eye-tracking experiment was conducted. An Eyelink 1000 setup (SR Research) was used for the experiment, sampling at a rate of 500 Hz. Children were tested at their schools in a quiet and dim room. Children were first familiarized with the eye tracker and then instructed to read the texts for comprehension and to answer comprehension questions after reading each text.

Table 4.2 Testing phases, sessions and tests

	Phase 1 Group-administered sessions	Phase 2 Individual sessions
Session 1	-Listening comprehension part 1	-Inference making -Verbal working memory
Session 2	-Listening comprehension part 2 -Vocabulary knowledge	-Eye-tracking experiment
Session 3	-Non-verbal intelligence -Reading comprehension initial module[1]	

[1]if not administered previously by the school

All texts were displayed 60 cm from the participants' eyes, on a computer screen (*Dell,* P1913sb, 19 inch, 60 HZ). The texts were presented in their entirety (one sentence per line) without title, in black Tahoma font 15 pt. size on a light grey background, with double spacing between the lines. The children rested their head on a chin-rest to prevent them from moving their head during reading. Before the children read each text, their right eye was calibrated using nine black dots on a white background. Each trial began with a fixation point presented about two-character spaces to the left of the first character of the upcoming sentence. The children's eyes were calibrated five times: Before they read the practice text and before they read each experimental text. The task was self-paced. The children read the texts silently for both theoretical and practical reasons. Reading aloud may influence the reader's processing approach. The processes involved in reading aloud (e.g., speech articulation, articulation monitoring, eye-voice coordination) may impose extra demands on the reader's working memory and prevent readers from making regressions (Vorstius, Redach, & Lonigan, 2014). In addition, the fact that the reader must articulate every word possibly leads to more emphasis on sublexical word properties (Huestegge, 2010). A practical reason is that reading aloud is not a good option with a chin-rest, used to prevent participants' head movements and allow accurate eye-movements measurements. After completion of each text, the text was removed from the screen and the child moved his/her head from the chin-rest and answered the six comprehension questions orally. The questions were posed by the experimenter.

4.3 Results

4.3.1 Test battery

On the tests for inference making and verbal working memory data of one low-comprehending participant were missing. On the test for inference making data of one high-comprehending participant were missing. On the test for verbal working memory data of two high-comprehending participants were missing. Fourteen participants (2 low- and 12 high-comprehending readers) only made the initial part of the test for reading comprehension.

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 the group of high-comprehending readers performed better on the tasks than the group of low-comprehending readers ($F(7,52) = 25.58$, $p < .001$). Univariate ANOVAs revealed that this difference between groups was reliable for all tasks (ps $< .01$; see Table 4.3 for descriptive statistics of the dependent measures).

Table 4.3 Mean scores (and standard deviations) of high- and low-comprehending readers on tasks in the test battery.

	Reading Proficiency	
	High	Low
Measure	*M (SD)*	*M (SD)*
Non-verbal intelligence	36.02 (6.24)	27.79 (7.31)
Word-reading ability	54.68 (12.53)	46.88 (9.49)
Reading comprehension	18.78 (7.61)	-8.27 (6.61)
Listening comprehension	61.08 (8.18)	49.50 (9.61)
Vocabulary knowledge	42.08 (6.13)	33.29 (6.54)
Verbal working memory	5.80 (3.35)	2.74 (1.18)
Inference making	14.70 (1.45)	12.37 (2.38)

4.3.2 Comprehension questions

Table 4.4 reports the mean values of the accuracy scores of the comprehension questions as a function of the factors Text Genre (expository vs narrative), Question Type (literal, text-based, and knowledge-based questions), and Reading Proficiency (high vs. low).

Table 4.4 Mean accuracy scores of high- and low-comprehending readers on comprehension questions for expository and narrative texts.[5]

		Reading Proficiency	
		High	Low
Question Type	Text Genre	*M*	*M*
Literal	expository	.61	.32
	narrative	.94	.86
Text-based	expository	.57	.26
	narrative	.77	.52
Knowledge-based	expository	.71	.48
	narrative	.83	.32

A mixed-effects logistic regression model was fitted on the data with the R package LME4 (R-version 3.3.3; LME4 version 1.1-12). 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). Subsequently, Wald chi-square testing (Type II) – as implemented in the R package Car (version 2.1-4) – was applied to select the most parsimonious model by removing non-significant predictors (i.e., $p > .05$, unless mentioned otherwise). For the final models obtained by this procedure, the relevant fixed-effects estimates and z-values will be reported. Statistical significance at approximately the .05 level is indicated by z-values of ≥ 1.96 or ≤ -1.96 (see e.g., Schotter, Tran, & Rayner, 2014). In the case of an interaction effect, fixed-effects estimates

[5] Standard deviations (SD) do not apply to binary data and will only be reported for the continuous dependent variables.

and the associated statistics for all relevant simple effects were obtained by adjusting the reference category of the models and fitting analogous models with the same structure of fixed factors and interactions.

Literal questions. The Wald chi-square tests revealed main effects of Text Genre ($\chi2(1)$ = 12.5, $p < .001$) and Reading Proficiency ($\chi2(1)$ = 14.8, $p < .001$). Accuracy scores of the literal questions were higher for narrative texts than for expository texts (b= 3.24, SE = 0.89, z = 3.63), and high-comprehending readers obtained higher scores than low-comprehending readers (b= 1.62, SE = 0.41, z = 3.95).

Text-based questions. The Wald chi-square tests revealed main effects of Text Genre ($\chi2(1)$ = 7.42, $p <. 01$) and Reading Proficiency ($\chi2(1)$ = 40.9, $p < .001$). Accuracy scores of the text-based questions were higher for narrative texts than for expository texts (b= 1.18, SE = 0.43, z = 2.72), and high-comprehending readers obtained higher scores than did low-comprehending readers (b= 1.43, SE = 0.22, z = 6.40).

Knowledge-based questions. The Wald chi-square tests revealed a main effect of Reading Proficiency ($\chi2(1)$ = 32.9, $p < .001$) and an interaction effect between Text Genre and Reading Proficiency ($\chi2(1)$ = 4.48, $p < .05$). High-comprehending readers obtained higher accuracy scores than low-comprehending readers for both expository (b= 1.19, SE = 0.41, z = 2.87) and narrative texts (b= 2.42, SE = 0.44, z = 5.54). As can be seen in Table 4.4, the magnitude of this difference between low- and high-comprehending readers was smaller for expository texts.

4.3.3 Eye-tracking experiment

Eye-movement measures. Prior to all analyses, trials with full text reading times below 10s were removed from the dataset (< 1%). Furthermore, words that were not fixated by the reader were treated as missing data in the word-based reading time measures. Table 4.5 reports the mean values (and their SDs) of the eye-movement measures computed from the remaining data as a function of Text Genre and Reading Proficiency.

Table 4.5 Mean values (and standard deviations) of the eye-movement measures as a function of Reading Proficiency and Text Genre. First fixation duration and first gaze duration are considered to be 'early' measures of processing. Right-bounded duration, second-pass fixation duration, and regression probability reflect measures of 'later' processing. Word skipping probability and saccade amplitude are more difficult to categorize (they may reflect early measures of processing, but they may also be sensitive to strategic adjustments in reading).

		Reading Proficiency	
		High	Low
Eye-Movement Measures	Text Genre	*M (SD)*	*M (SD)*
Full text reading time[1]	Expository	50.9 (15.3)	54.6 (10.4)
	Narrative	49.4 (14.6)	56.3 (10.9)
Full text fixation count	Expository	181 (41)	180 (32)
	Narrative	175 (39)	185 (32)
First fixation duration[2]	Expository	285 (149)	310 (158)
	Narrative	284 (156)	307 (157)
First gaze duration[2]	Expository	384 (263)	427 (289)
	Narrative	368 (242)	407 (258)
Right-bounded duration[2]	Expository	459 (349)	494 (336)
	Narrative	431 (300)	474 (307)
Total fixation duration[2]	Expository	517 (398)	545 (391)
	Narrative	487 (352)	539 (369)
Second-pass fixation duration[2]	Expository	445 (425)	417 (288)
	Narrative	421 (309)	483 (377)
Saccade amplitude[3]	Expository	2.30 (1.88)	2.22 (2.09)
	Narrative	2.27 (1.86)	2.14 (2.02)
Regression probability	Expository	.25	.20
	Narrative	.25	.22
Word skipping probability	Expository	.33	.32
	Narrative	.34	.28

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

The analyses were conducted in the same way as described in section 4.3.2. Mixed-effects linear regression models for the continuous reading time data – with the response variable log-transformed to correct for right skewness – and mixed-effects logistic regression models for the categorical dependent measures were fitted on the data. First, models were fitted for each dependent variable. Each model included the fixed factors Text Genre and Reading Proficiency, as well as the interaction of these factors. Participants and texts were included as crossed random effects. Subsequently, Wald chi-square testing was applied to select the most parsimonious model. The 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.

Full text reading time. The Wald chi-square tests revealed a main effect of Reading Proficiency ($\chi2(1) = 4.14$, $p < .05$) and an interaction effect between Text Genre and Reading Proficiency ($\chi2(1) = 4.02$, $p < .05$). Further inspection of the interaction indicated that low-comprehending readers (M = 56.32, SD = 10.92) spent more time reading narrative texts than did high-comprehending readers (M = 49.39, SD = 14.56), (b= 0.15, SE = 0.061, t = 2.43). For expository texts, this contrast between low-comprehending readers (M = 54.65, SD = 10.45) and high-comprehending readers (M = 50.89, SD = 15.31) was attenuated (b= 0.094, SE = 0.061, t = 1.54). As illustrated in Figure 4.1A, the effect of reading proficiency was attenuated in expository texts because high-comprehending readers had the tendency to slow down for expository texts in comparison to narrative texts (b= 0.031, SE = 0.025, t = 1.23), whereas low-comprehending readers displayed a tendency in the opposite direction (b= -0.024, SE = 0.030, t = -0.78).

Full text fixation count. The Wald chi-square tests revealed a significant interaction between Text Genre and Reading Proficiency ($\chi2(1) = 5.35$, $p < .05$). The results for the simple effects reported below should be interpreted with caution, because only the interaction effect itself was reliable. That said, the pattern in Fig. 4.1B suggests that low-comprehending readers (M = 185, SD = 32) made more fixations than high-comprehending readers (M = 175, SD = 39) while reading narrative texts (b= 0.066, SE = 0.048, t = 1.39), but not while reading expository texts (b= 0.0057, SE = 0.048, t = 0.12). As can be seen, this interaction occurred because high-comprehending readers made more fixations in expository texts (M = 181, SD = 41) than in narrative texts (M = 175, SD = 39), (b= 0.032, SE = 0.043, t = 0.74), whereas low-comprehending readers showed the opposite pattern by making less fixations in expository texts (M = 180, SD = 32) than in narrative texts (M = 185, SD = 32), (b= -0.028, SE = 0.046, t = -0.61).

First fixation duration. The Wald chi-square test revealed a main effect of Reading Proficiency ($\chi2(1) = 8.42$, $p < .01$). Low-comprehending readers displayed longer first fixation durations than did high-comprehending readers (b= 0.085, SE = 0.029, t = 2.90).

First gaze duration. The Wald chi-square tests revealed a main effect of Reading Proficiency ($\chi2(1) = 9.98$, $p < .01$). Low-comprehending readers displayed longer first gaze durations than did high-comprehending readers (b= 0.11, SE = 0.035, t = 3.16).

Right-bounded duration. The Wald chi-square tests revealed a main effect of Reading Proficiency ($\chi2(1) = 6.46$, $p < .05$). Low-comprehending readers displayed longer right-bounded durations than did high-comprehending readers (b= 0.11, SE = 0.041, t = 2.54).

Total fixation duration. The Wald chi-square tests revealed a main effect of Reading Proficiency ($\chi2(1) = 4.95$, $p < .05$) and an interaction effect between Text Genre and Reading Proficiency ($\chi2(1) = 6.39$, $p < .05$). Low-comprehending readers (M = 539, SD = 369) displayed longer total fixation durations in narrative texts than did high-comprehending readers (M = 487, SD = 352), (b= 0.11, SE = 0.043, t = 2.62). This contrast between low- and high-comprehending readers was attenuated for expository texts (b= 0.076, SE = 0.043, t = 1.75). Figure 4.1C shows that this pattern emerged because low-comprehending readers did not display any notable difference in total fixation durations across expository (M = 545, SD = 391) and narrative texts (M = 539, SD = 369), (b= 0.0094, SE = 0.026, t = 0.36), whereas high-comprehending readers showed a marginal increase in total fixation durations while reading expository texts (M = 517, SD = 398), compared to while reading narrative texts (M = 487, SD = 352), (b= 0.047, SE = 0.024, t = 1.91).

Second-pass fixation duration. The Wald chi-square tests revealed an interaction effect between Text Genre and Reading Proficiency ($\chi2(1) = 12.1$, $p < .001$). Low-comprehending readers (M = 482.83, SD = 376.52) displayed longer second-pass durations than did high-comprehending readers (M = 420.96, SD = 308.94) while reading narrative texts (b= 0.12, SE = 0.043, t = 2.90), whereas for expository texts this contrast between low-comprehending readers (M = 417.26, SD = 288.34) and high-comprehending readers (M = 445.45, SD = 425.49) was not present (b= -0.027, SE = 0.042, t = -0.65). As illustrated in Figure 4.1D, this interaction is primarily driven by decreasing second-pass durations for low-comprehending readers in expository texts (b= -0.13, SE = 0.041, t = -3.09). In contrast, for high-comprehending readers there was no such difference in second-pass durations between expository and narrative texts (b= 0.025, SE = 0.032, t = 0.80).

Saccade amplitude. The Wald chi-square tests revealed a main effect of Reading Proficiency ($\chi2(1) = 8.16$, $p < .01$) and an interaction effect between Text Genre and Reading Proficiency ($\chi2(1) = 4.17$, $p < .05$). Low-comprehending readers (M = 2.14, SD = 2.02) displayed smaller first-pass saccade amplitudes in narrative texts than did high-comprehending readers (M = 2.27, SD = 1.86), (b= -0.13, SE = 0.039, t = -3.26). For expository texts, this contrast between low-comprehending readers (M = 2.22, SD = 2.09) and high-comprehending readers

(M = 2.30, SD = 1.88) was also present but in an attenuated manner (b= -0.089, SE = 0.039, t = -2.27). As illustrated by Figure 4.1E, this attenuation of the effect was due to a relatively stable saccade amplitude for high-comprehending readers across different text genres (b= -0.00051, SE = 0.020, t = -0.025), as opposed to a (non-significant) increment of saccade amplitude for low-comprehending readers in expository texts (b= 0.038, SE = 0.023, t = 1.66).

First-pass regression probability. The Wald chi-square tests revealed no reliable main or interaction effects.

First-pass word skipping probability. The Wald chi-square tests revealed a significant interaction between Text Genre and Reading Proficiency ($\chi2(1) = 16.3$, $p < .001$). When reading narrative texts, low-comprehending readers (M = 0.28, SD = 0.45) showed a trend towards skipping fewer words than did high-comprehending readers (M = 0.34, SD = 0.47), (b= -0.28, SE = 0.15, z = -1.94). This (marginally significant) simple effect of reading proficiency was less pronounced in expository texts (b= -0.080, SE = 0.15, z = -0.55). As illustrated by Figure 4.1F, the attenuation of the effect stemmed from the tendency of low-comprehending readers to skip more words while reading expository texts (M = 0.32, SD = 0.47) than while reading narrative texts (M = 0.28, SD = 0.45), (b= 0.15, SE = 0.085, z = 1.71), as opposed to the tendency of high-comprehending readers in the opposite direction, i.e., less word-skipping in expository texts (M = 0.33, SD = 0.47) than in narrative texts (M = 0.34, SD = 0.47), (b= -0.057, SE = 0.079, z = -0.73). Note, however, that the results for the simple effects should be interpreted with caution because only the interaction effect itself was reliable.

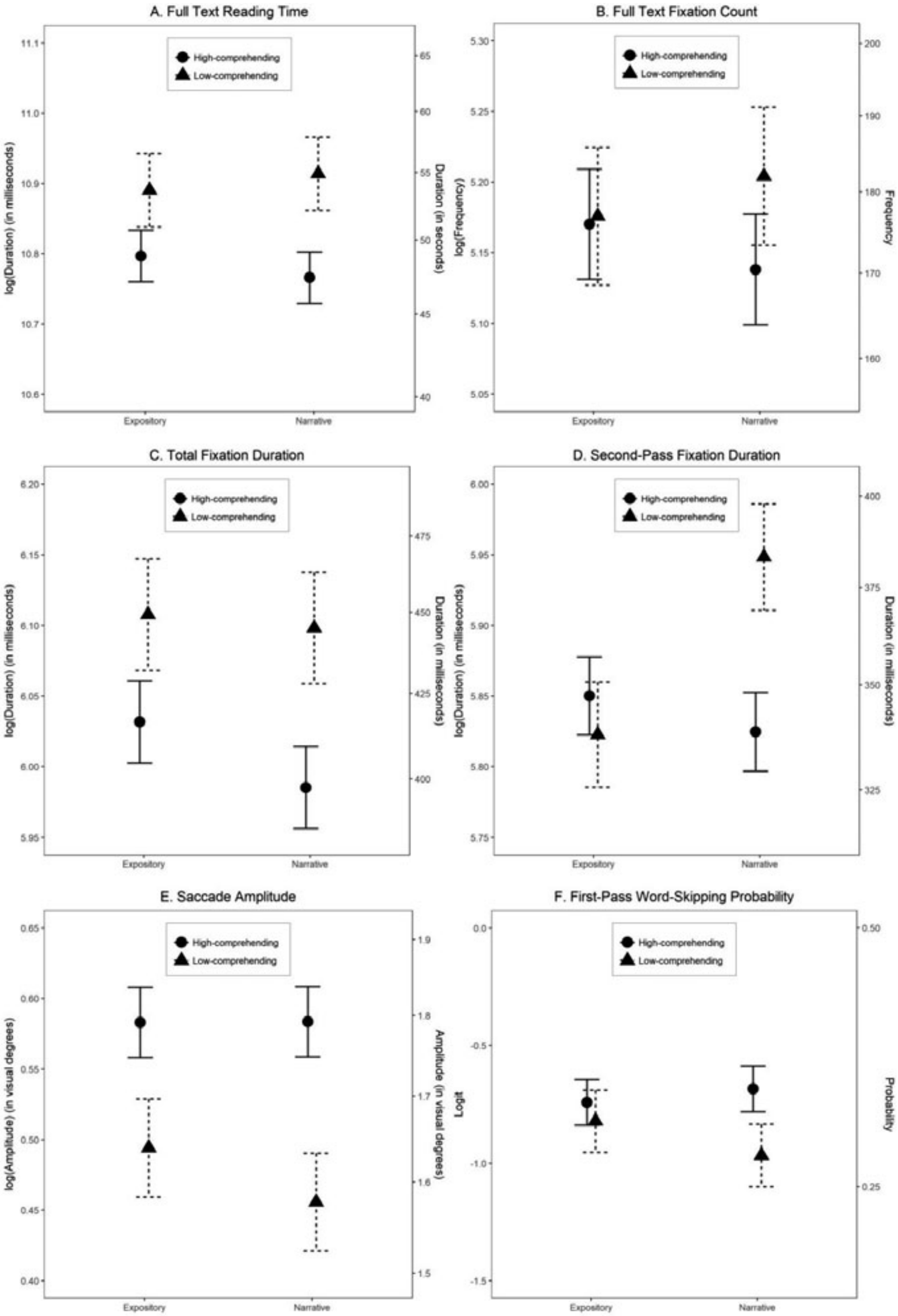

Fig. 4.1. Fixed effects estimates (and their SEs) of the eye-movements measures revealing a significant interaction between Text Genre (expository vs. narrative texts) and Reading Proficiency (high- vs. low-comprehending readers). Reading-time scales (for the log-transformed continuous measures) and logit scales (for the probability measures) are added on the y-axes for convenience.

4.4 Discussion

In the present eye-tracking study, we explored the on-line text-processing approach of low- and high-comprehending second-grade readers as they read expository and narrative texts for comprehension. We hypothesized that, relative to narratives texts, beginning readers need to adjust their reading strategy for expository texts – a genre they are often unfamiliar with – to optimize reading comprehension. Furthermore, we anticipated that high-comprehending readers adjust their reading strategy more easily (and therefore more noticeably) than low-comprehending readers do. Hence, we predicted that reading proficiency and text genre variables should interact and we expected 'later' eye-tracking measures associated with higher-level (e.g., top-down) integrative processing to be more sensitive to this interaction than 'early' (e.g., bottom-up) measures associated with the processing stage of word identification and syntactic parsing.

Indeed, the results revealed evidence for reading proficiency and text genre interactions in several eye-movement metrics (i.e., full text reading time and fixation count, total fixation duration, second-pass fixation duration, saccade amplitude, skipping probability). The general pattern was that narrative texts induced prolonged, more intensive processing for low-comprehending readers than for high-comprehending readers. This difference between low- and high-comprehending readers was attenuated in the case of expository texts. As we will discuss below, the directions of these interactions, however, are not always compatible with the idea that high-comprehending readers adapt their reading style to text genre whereas low-comprehending readers do not. We explore several scenarios that can account for the findings. We first discuss the findings with reference to strategic processing (i.e. along the lines of our hypotheses). We then introduce an alternative account that focuses on the interplay of working-memory capacity, prior knowledge, and the differential processing demands posed by narrative and expository texts.

4.4.1 Eye-movement profiles of low- and high-comprehending readers in narrative and expository texts

In the case of narrative texts, low-comprehending readers displayed longer full text reading times and average fixation durations per word than did high-comprehending readers; this was due, at least partly, to them making more fixations than high-comprehending readers did. For expository texts, the contrast between low- and high-comprehending readers diminished. The observed interaction for these relatively coarse measures of processing may reflect a strategic adjustment by high-comprehending readers (they slowed down in expository texts, relative to narrative texts) or by low-comprehending readers (they sped up in expository texts, relative to narrative texts), as the data are compatible with either account (see Figures 4.1A-1C). The analyses of the finer-grained (i.e., word-based) eye-movement measures provide a more detailed and somewhat mixed picture of why these interactions emerged.

The early eye-movement measures revealed that low-comprehending readers displayed longer first fixation and first gaze durations than high-comprehending readers did. As expected, this seems to indicate that low-comprehending readers experienced more problems with (bottom-up) processes of word identification and early (syntactic) integration (e.g., Boland, 2004). Somewhat surprisingly, although the expository texts were more difficult than the narrative texts (3^{rd} vs. 2^{nd} grade levels, respectively) we observed no significant main effects of genre in the early measures – but note that the first gaze durations showed a numerical difference in the expected direction. Most importantly, we observed no interaction effects between reading proficiency and text genre. This seems to indicate that strategic adjustments of readers' processing style do not affect the early measures extracted from the eye-movement data.

Later eye-movement measures that likely reflect more strategic processing painted a somewhat murky picture. A valid conclusion from the absence of significant genre differences for high-comprehending readers would be that they employed a relatively stable processing approach across narrative and expository texts. However, this conclusion does not fit well with the overall pattern for high-comprehending readers as nearly all (untransformed) measures show a numerical difference in the expected direction: high-comprehending readers seem to slow down (i.e. adjust) their reading pace when confronted with an expository text (see Table 4.5). The interpretation of the results for the low-comprehending readers is not clear-cut either. Again, if we base our conclusion strictly on statistically significant results, low-comprehending readers demonstrated a relatively stable processing approach – i.e., only second-pass durations differed significantly across narrative and expository texts for these readers. That being said, there are also signs that low-comprehending readers adapted their reading behavior to text genre, yet in an unexpected way. First, the analyses for second-pass durations showed that if low-comprehending readers refixated a word, they were inclined to spend less time rereading the words of expository texts than the words of narrative texts. Second, similar patterns emerged for measures of saccade amplitude and word-skipping probability. Again, low-comprehending readers showed an inclination towards a less intensive processing approach for expository texts (i.e., longer saccades, more word skipping). We should emphasize, however, that the interpretation for these latter two measures is complicated by the fact that follow-up analyses of the simple effects returned marginally significant or non-significant results. Therefore, although visual inspection of the significant interactions reveals a consistent picture, we can only be tentative in concluding that low-comprehending readers adjusted their reading strategy whereas high-comprehending readers did not.

So far, we have assumed that the interaction effects have emerged as a result of differential reading strategies by low- and high-comprehending pupils (i.e., we speculated that for expository texts high-comprehending readers have a tendency towards a relatively intensive processing approach, whereas low-comprehending readers have a tendency towards a more cursory processing approach). Hence, our take on the results focuses on the (top-down) influence of readers and not so much on the characteristics of a text. It is also possible that the observed interaction effects are primarily driven by the text, specifically by what a reader knows about the content and structure of the text *prior* to reading this text. In general, expository texts are used for learning and most readers approach the task of reading these texts with low levels of topic-relevant knowledge. The reading process of narrative texts, in contrast, is supported by sufficient knowledge about the content and, as a result, within- and between-sentence inferences may be generated relatively automatically (Best, Rowe, Ozuru, & McNamara, 2005). So, one way to approach the reading advantage of high-comprehending readers compared to low-comprehending readers for narrative texts is to assume that high-comprehending readers have more prior knowledge about the content of narrative texts and that the inferences generated in these texts are carried out more in an adult-like manner, requiring only a limited amount of cognitive resources. These advantages would not hold for expository texts because the content will be new to both low- and high comprehending readers and, hence, inferences will be resource-consuming to both type of readers. As pointed out by an anonymous reviewer, however, another possibility is that the processing of narrative texts relies *less* on prior knowledge than the processing of expository texts because narrative texts can unfold in many different, unpredictable ways. Consequently, narrative texts could make a greater demand on working-memory resources because ‘new’, event-like information needs to be kept active during reading (cf., Williams et al., 2004). As indexed by the eye-tracking data, this would primarily affect the group of low-comprehending, low verbal working-memory capacity (see Table 4.3) readers, while they process narrative texts. Overall, for both narrative and expository texts the conjecture can be made that readers will be unfamiliar with their content, which could explain why high-comprehending readers display a processing advantage (i.e., as indicated by the eye-movement metrics) for narrative texts, but less so for expository texts.

4.4.2 Coping strategies of low-comprehending readers

A general conclusion that we would like to draw from this study is that, relative to narrative texts, low-comprehending readers reacted somewhat differently to expository texts than high-comprehending readers did. The results do not allow for a definitive conclusion about the source(s) of this interaction, however. It may be that low-comprehending readers adopted a more cursory processing approach for expository texts or, alternatively, that high-comprehending readers displayed a more intensive processing approach for expository texts – or these tendencies may both underlie the observed interactions. The results do point out that low-comprehending readers adopt a suboptimal processing approach for expository texts because expository texts tend to demand more cognitive effort of the reader than narrative texts (Williams et al., 2004). In this light, an effortful or intensive reading style seems more appropriate.

If low-comprehending readers have a relatively stable processing approach across different text genres this would suggest that, although they may have acquired an effective reading routine for narrative texts, these eight-year-old readers still have to develop more optimal (intensive) reading strategies for expository texts – and learn how to employ them flexibly in different situations. If, however, low-comprehending readers adopt a more cursory processing approach for expository texts, we should provide an explanation for why they opt for such a processing approach.

One possible explanation is that low-comprehending readers had lower standards of coherence for expository texts than for narrative texts. For more experienced readers, expository texts tend to evoke strict standards of coherence because readers associate them with learning goals, whereas narrative texts tend to evoke more shallow standards of coherence because readers associate them with reading for pleasure (van den Broek et al., 2011). For younger (low-comprehending) children this contrast may not be present, or may even be reversed, because they tend to read many narrative texts in an educational setting. Moreover, low-comprehending pupils may not be capable of applying strict standards of coherence, because they lack the required monitoring skills (Oakhill et al., 2005) or may simply not strive for full comprehension of the text because they view reading mainly as a decoding activity (Cain, 1999; Yuill & Oakhill, 1991). Our observation that low-comprehending readers decreased their refixation duration (and more speculatively, made longer saccades and tended to skip more words) when reading expository texts supports the idea that they lowered their standards of coherence for these texts. However, low-comprehending readers scored relatively high on knowledge-based questions for expository texts. This suggests that they still attempted to relate the text to their background knowledge, which is not what one would expect from a reader who had lowered his or her standards altogether.

A second possibility is that for expository texts low-comprehending readers engaged in a so-called ‘exploring processing approach’ (cf., Olson et al., 1985). This would mean that low-comprehending readers did not necessarily have low standards of coherence for expository texts, but they appealed to their background knowledge to compensate for comprehension difficulties (Coté et al., 1998). However, they did not make the regressive eye-movements associated with an exploring text-processing approach (Olson et al., 1985; cf. Koornneef & Mulders, 2016; Rayner, Castelhano, & Yang, 2009). Regressive eye-movements can be an indication of effective comprehension-monitoring skills (Ehrlich et al., 1999; Rayner et al., 2016; Schotter et al., 2014; Van der Schoot et al., 2012), but as pointed out by Pearson et al. (1992), low-comprehending readers often lack adequate repair strategies (e.g., looking back to earlier sections of a text) to adapt their reading approach in an effective manner when comprehension fails.

A third possibility is that the cursory processing approach was the only viable strategy low-comprehending readers possessed for coping with expository texts, because they simply lacked the ‘tools’ to engage in more effortful processing (Denton et al., 2015). This may be caused by various reader characteristics, or a combination of characteristics, such as lack of sufficient word and/or world knowledge (Coté, et al., 1998; Denton et al., 2015), insufficient inference and integration skills (Cain & Oakhill, 1999), and limited working-memory capacity (Linderholm & van den Broek, 2002). In this context, it should be reiterated that the low-comprehending readers in the present study obtained lower scores than high-comprehending readers on the tests for receptive word knowledge, inference making, and verbal working-memory capacity.

Finally, a fourth possibility is that the results in the current study emerged due to issues that are unrelated to the strategic (cursory versus intensive) processing styles of readers. As outlined in section 4.1, 'optimal' reading behavior is related not only to the strategic enactment of processing but also to what a reader already knows about the topic of a text. This especially holds for expository texts (i.e., 'facts are facts'), which may explain why low- and high-comprehending readers behave similarly while reading expository texts (i.e., because their prior knowledge of the topics does not differ much) but not while reading narrative texts (i.e., prior knowledge is less important in narrative texts because these texts tend to describe new events).

These alternative interpretations of the current findings are worth comparing directly in future research. Such research could also vary methodological aspects of the current study that both allow and limit the conclusions. For example, the topics and questions of the texts were not matched across genre (hence, main effects of text genre are difficult to interpret). Furthermore, we presented the texts in the same fixed order to all participants. This has the advantage that the impact of individual differences between readers on their eye-movement routines can be examined more adequately. However, this also meant that the narrative texts were read later in the experiment (texts 2 and 4) than the expository texts (texts 1 and 3). As a result, the main and interaction effects in the eye-movement metrics and comprehension questions may in part reflect the potential influence of fatigue and/or familiarity with the experimental procedure. Finally, due to strict selection criteria for low-comprehending readers (i.e., average or above-average scores on standardized tests for word-reading ability and non-verbal intelligence) the sample size of this group was relatively small. These limitations of the study should be kept in mind when considering potential implications for education in the following sections.

4.4.3 Educational implications

Based on our interpretation of the data, we suggest that low-comprehending readers in the second grade of primary school employ suboptimal reading strategies for expository texts. On the one hand, if low-comprehending readers adopt a relatively stable processing approach across text genre, they are likely to benefit most from interventions aimed at clarifying the differences between narrative and expository texts and stimulating a more intensive processing style for the latter. On the other hand, if low-comprehending readers adopt a more cursory processing approach for expository texts, the educational implications are less straightforward. We suggested that a cursory processing strategy may stem from lower standards of coherence, an exploring processing approach, or a coping strategy. Depending on which of these explanations best describes the processing strategy of low-comprehending readers, the educational implications will differ.

If low-comprehending readers indeed have low standards of coherence for expository texts, this is not desirable in educational settings because expository texts are widely used to transfer knowledge. In that case it could be useful to make children aware of their coherence standards, e.g., by discussing the task and the reading goals before reading (Cain & Oakhill, 2007). Furthermore, when the attention of readers is guided to certain information in a text that they have processed insufficiently, this can lead to deeper text processing, stricter standards of coherence, and better comprehension (Sanford, Sanford, Molle, & Emmot, 2006).

If the correct interpretation is that low-comprehending readers adopted an exploring processing style for expository texts – comparable to Olson et al.'s explorers (1985), but without the characteristic regressions – this will present different challenges and may require a different approach on the part of educational practitioners. A positive aspect of this reading strategy is that the readers are attempting to connect the information in the text to their background knowledge. There are risks in this, however: It may result in the reader learning less new information from texts than he or she would derive with a more text-based reading manner (Coté et al., 1998), especially if the background knowledge is insufficient or incorrect. In the latter case, misconceptions about a topic will easily persist without a proper intervention (Coté et al., 1998). For this reason, when readers have little or erroneous background knowledge, a more effortful processing style seems more appropriate.

If the third explanation is correct, and low-comprehending readers' reading profile for expository texts reflects an optimal coping strategy, it remains to be seen whether they would benefit from a more effortful reading approach for such texts. Indeed, it is plausible that the mental text representations of low-comprehending readers may become more coherent if they make more and stronger text-connecting inferences, for instance. However, they need to be capable of doing so. In this case, rather than trying to adjust the global reading style of low-comprehending readers from a cursory to a more effortful style, it might be more useful to address the underlying cognitive and language deficiencies.

4.4.4 Conclusion

Investigation of individual differences in text processing across different text genres can provide important insights into comprehension differences; these insights may eventually help low-comprehending readers to overcome their reading difficulties – and high-comprehending readers to further improve their reading skills. Our study showed that narrative texts induce prolonged, more intensive processing for low-comprehending readers than for high-comprehending readers. This difference between low- and high-comprehending readers was attenuated during reading of expository texts. Accordingly, we speculated that either low-comprehending readers adopted a more cursory processing approach for expository texts or that high-comprehending readers displayed a more intensive processing approach for expository texts – or both. In our opinion the results show that, in any case, low-comprehending readers adopt a suboptimal processing approach for expository texts, by either not adjusting their reading strategy or by adopting a more cursory strategy. This raises important questions about how we can best help young (low-comprehending) readers to become effective, flexible and strategic readers.

Appendix II

Original version of the experimental texts and comprehension questions used in the eye-tracking study (and their translations into English).

#1 Expository text 'Skeleton'

In je lijf zitten botten.	Your body contains bones.
Alle botten samen zijn je skelet.	The bones together form your skeleton.
Veel botten kun je voelen.	Many bones you can feel.
Bijvoorbeeld die in je vingers en je tenen.	For example, those in your fingers and your toes.
Botten zijn gemaakt van kalk en lijmstof.	Bones are made of calcium and collagen.
Het ene maakt je botten sterk.	One makes your bones strong.
En het andere maakt ze buigbaar.	And the other makes them bendable.
Kleine kinderen zijn heel lenig.	Small children are very flexible.
Er zit veel lijmstof in hun botten.	There is a lot of collagen in their bones.
Hun botten breken niet snel.	Their bones do not break easily.
Bij oude mensen is het anders.	It is different for old people.
Zij hebben weinig lijmstof in hun botten.	They have little collagen in their bones.
Er zit meer kalk in hun botten.	There is more calcium in their bones.
Hun botten breken sneller.	Their bones break more easily.
Je skelet geeft vorm aan je lijf.	Your skeleton gives shape to your body.
Het bestaat uit meer dan tweehonderd botten.	It consists of more than two hundred bones.
Weet je waar de meeste botten zitten?	Do you know where most bones are?
In je handen en in je voeten.	In your hands and in your feet.
En het grootste bot in je lijf zit in je bovenbeen.	And the biggest bone in your body is in your thigh.
Literal questions:	
(#1) Waar zijn botten van gemaakt?	What are bones made of?
(#6) Waar zit je grootste bot?	Where in your body is your biggest bone?
Text-based questions requiring a text-connecting inference (between sentences):	
(#2) Waarom breken botten van kleine kinderen niet snel?	Why do small children's bones not break easily?
(#3) Waarom breken botten van oude mensen sneller?	Why do old people's bones break easily?
(#5) Waar zitten de meeste botten?	Where are most bones in your body?
Knowledge-based question requiring a gap-filling inference:	
(#4) Hoe denk dat je lijf zou zijn zonder botten, zonder skelet?	What do you think: What would your body be like without skeleton?

#2 Narrative text 'iPad'

Papa is eten aan het koken.	Dad is cooking dinner.
Mama zit te werken achter de computer.	Mama is working at the computer.
Simon en Tom spelen met de iPad van hun grote zus.	Simon and Tom are playing with their big sister's iPad.
Die ligt een boek te lezen op de bank.	She is reading a book on the couch.
Maar dan wordt opeens het scherm zwart.	But then suddenly the screen turns black.
De iPad doet helemaal niets meer.	The iPad does nothing at all anymore.
Trillend lopen ze naar hun zus.	Trembling, they walk over to their sister.
Ze wijzen naar de iPad.	They point to the iPad.
Simon zegt: Hij ging opeens kapot.	Simon says: It broke suddenly.
Sanne kijkt haar broertjes aan en begint te lachen.	Sanne looks at her brothers and starts to laugh.
Het valt wel mee hoor!, zegt ze.	It is not that bad!, she says.
Zullen we hem weer maken?	Shall we fix it?
Sanne pakt een oplader uit de kast.	Sanne takes a charger out of the closet.
En ze zegt: Na het eten doet hij het weer.	And she says: After dinner, it will work again.
De batterij is alleen maar leeg.	The battery is just empty.
Hij moet even in de oplader.	It needs to be charged.
Tom en Simon zijn opgelucht.	Tom and Simon are relieved.
Papa roept dat ze allemaal moeten komen.	Papa calls for them to come.
Zo, nu eerst lekker eten.	Let's eat dinner first.
Literal questions:	
(#4) Wat pakt Sanne uit de kast?	What does Sanne take out of the closet?
(#5) Wie roept dat ze moeten komen?	Who calls them telling them to come?
Text-based questions requiring a text-connecting inference (between sentences):	
(#1) Waarom denken Simon en Tom dat de iPad kapot is?	Why do Simon and Tom think the iPad is broken?
(#2) Hoe heet de zus van Simon en Tom?	What is the name of the sister of Simon and Tom?
(#3) Waarom begint Sanne te lachen?	Why does Sanne start to laugh?
Knowledge-based question requiring a gap-filling inference:	
(#6) Wanneer op de dag speelt dit verhaal zich af, denk je?	What do you think: What time of day does this story take place?

#3 Expository text 'Lions'

Leeuwen leven in een groep.	Lions live in a group.
Zo'n groep leeuwen heet een troep.	A group of lions is called a troop.
Het zijn ongeveer vijftien leeuwen bij elkaar.	It is about fifteen lions together.
Het is handig om in een troep te leven.	It is useful to live in a troop.
De leeuwen jagen samen.	The lions hunt together.
Zo hebben ze meer kans om een prooi te vangen.	That way, they are more likely to catch their prey.
En ze zorgen samen voor de jongen.	And they take care of the young together.
Die hebben zo meer kans om te overleven.	So the young more likely to survive.
Een mannetjesleeuw heeft manen.	A male lion has a mane.
Dat zijn lange haren op zijn kop en nek.	Those are long the hairs on his head and neck.
Daarmee valt hij erg op.	He is therefore very striking.
Een mannetje kan heel hard brullen.	A male can roar very loudly.
Zo jaagt hij andere leeuwen weg.	That is how he chases off other lions.
Bij leeuwen moeten de vrouwtjes jagen.	For lions, the females have to do the hunting.
Zij zorgen voor het eten.	They provide the food.
Het mannetje jaagt niet mee.	The male does not hunt.
Mannetjes vallen veel te veel op.	Males stand out too much.
Van jagen worden leeuwen moe.	Hunting makes lions tired.
Ze slapen veel, soms wel twintig uur per dag.	They sleep a lot, sometimes as much as twenty hours a day.
Literal questions:	
(#1) Wat is een troep?	What is a troop?
(#5) Wie moeten jagen bij leeuwen?	For lions, who does the hunting?
Text-based questions requiring a text-connecting inference (between sentences):	
(#2) Waarom is het handig om in een troep te jagen?	Why is it useful to hunt in a troop?
(#4) Hoe komt het dat mannetjes te veel opvallen?	Why do male lions stand out?
(#6) Waarom slapen leeuwen twintig uur per dag?	Why do lions sleep twenty hours a day?
Knowledge-based question requiring a gap-filling inference:	
(#3) Waarom denk je dat jongen in een groep meer kans hebben om te overleven?	Why, do you think, the chances of survival for the young are better in a troop?

04

#4 Narrative text ‘Hide-and-Seek’

Alle kinderen zijn buiten want het is pauze.	The children are outside because it is recess.
Stef doet verstoppertje met zijn vrienden.	Stef is playing hide-and-seek with his friends.
Luuk heeft zich heel goed verstopt.	Luuk is well hidden.
Hij is in een hoge boom geklommen.	He has climbed into a tall tree.
Stef moet heel lang zoeken.	Stef has to search for a long time.
Als eerste vindt hij Julia.	First, he finds Julia.
Die had zich in het fietsenhok verstopt.	She had hidden in the bicycle shed.
Zij is af en moet aan de kant zitten.	She has been found and has to sit on the side.
Stef zoekt verder en verder.	Stef searches on and on.
Bijna iedereen heeft hij gebuut.	He finds almost everyone.
Alleen Luuk kan hij niet vinden.	He just cannot find Luuk.
Julia ziet Luuk wel.	But Julia sees Luuk.
Ze kijkt omhoog naar Luuk.	She looks up at Luuk.
Stef ziet Julia omhoog kijken.	Stef sees Julia looking up.
En dan ziet Stef hem ook.	And then Stef also sees him.
Heel blij roept hij meteen: Buut Luuk!	Happily he immediately yells: I see you, Luuk!
Luuk vindt het niet eerlijk.	Luuk does not think it is fair.
Hij is een beetje boos op Julia.	He is a little angry with Julia.
Dan gaat de bel en moeten ze naar binnen.	Then the bell rings and they have to go inside.
Literal questions:	
(#1) Welk spel doen Stef en zijn vrienden?	What game are Stef and his friends playing?
(#3) Wie vindt Stef als eerste?	Who does Stef find first?
Text-based questions requiring a text-connecting inference (between sentences):	
(#2) Waar zit Luuk verstopt?	Where is Luuk hiding?
(#4) Waarom ziet Stef Luuk?	Why does Stef see Luuk?
(#5) Wat vindt Luuk niet eerlijk?	Why does Luuk think it’s not fair?
Knowledge-based question requiring a gap-filling inference:	
(#6) Waar denk je dat Luuk en zijn vrienden zijn?	Where do you think Luuk and his friends are?

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 ($ps < .01$; 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 ($F(1,19) = 10.77$, $p < .01$).

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 ($\chi2(1) = 6.47$, $p < .05$). 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 ($\chi2(1) = 6.05$, $p < .05$). 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 ($\chi2(1) = 5.32$, $p < .05$). 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 ($\chi2(1) = 6.75$, $p < .01$). 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 ($\chi 2(1) = 4.98$ $p < .05$). 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 ($\chi 2(1) = 5.12$ $p < .05$). 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 ($\chi 2(1) = 6.21$, $p < .05$). 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 ($\chi 2(1) = 5.81$, $p < .05$). 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 ($\chi 2(1) = 4.91$, $p < .05$). 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.

Chapter 06

Beginning Readers Might Benefit from Digital Texts Presented in a Sentence-by-Sentence Fashion. But Why?

This chapter is based on
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Abstract

The current digital era offers many possibilities to modify the layout of a text to optimize reading and improve comprehension. Here, we examined the idea that the visuo-spatial properties of segmented layouts support beginning readers by reducing the demands of basic eye–movement processes. In a series of self-paced reading experiments, text comprehension and reading speed of second- and third-grade pupils (N=348) were assessed in a baseline condition (i.e., sentences continued on the same line as far as page width allowed) and three conditions with a segmented layout: (1) a discontinuous layout in which each sentence was presented on a new line of the page; (2) a reader-paced Rapid Serial Visual Presentation (RSVP) layout in which the texts were presented sentence by sentence; (3) a reader-paced RSVP layout in which the texts were presented word by word. No advantages were observed for the discontinuous layout. However, at the expense of increased reading times, robust comprehension advantages emerged for the two RSVP layouts. The observed trade-off between speed and accuracy suggests that a RSVP-based layout induces more precise reading, rather than reducing the demands on basic decoding and oculomotor control processes. These findings will be discussed in the context of individual differences in reading skills and several high-potential digital applications that aim at enhancing the abilities of (beginning) readers (e.g., Spritz, BeeLine Reader).

6.1 Introduction

It would almost be an understatement to emphasize that the ability to read constitutes an important skill to master in early childhood. In addition to being an essential skill, reading is a difficult skill to acquire, demanding a precisely-timed coordination between perceptual, linguistic, and more general cognitive mechanisms (e.g., Rayner, 1998). Not surprisingly, there are many attempts in the fields of, for example, education and text design, to augment the reading processes of children. The resulting approaches can be categorized as targeting either the reader or the text. The reader-oriented approaches primarily aim at enhancing pupils' word-decoding skills and comprehension strategies (e.g., McMaster et al., 2012). The text-oriented approaches are more committed to increasing the comprehensibility of a text by optimizing its grammatical and semantic content, its local and global structure, and its layout (e.g., Land, 2009).

A widely held belief in the text-oriented approaches is that beginning readers will benefit from an 'easy' text. In easy texts, words are easily recognized and sentences are easily parsed, which should result in a better understanding of what the text is about. Accordingly, texts for novices are printed in a large font with increased spacing between letters, words, and lines (e.g., Zorzi et al., 2012). In addition, infrequent words and noncanonical sentential structures are kept to a minimum. The sentences of a text are generally short (without subordinating clauses) and presented on a new line each, to avoid line breaks in the middle of a sentence (Land, 2009). In more extreme cases of these *segmented* texts, each page contains only one or two sentences – e.g., in books for the very young. The idea behind these modifications of the layout is that they optimize the eye movements and basic decoding processes during reading, thereby potentially freeing cognitive resources for higher-order comprehension processes such as monitoring, integration, and inference generation (cf., Schneps, Thomson, Sonnert, et al., 2013; Schneps, Thomson, Chen, Sonnert, & Pomplun, 2013).

Although this hypothesis is appealing, and a driving force behind several high-potential digital reading applications (e.g., Span Limiting Tactile Reinforcement, Spritz, BeeLine Reader, WebClipRead), some of its key implications have not been examined. Moreover, the empirical evidence that is available is not always in line with the predictions of the hypothesis (Land, 2009; Van Silfhout, 2014). The present study addresses these issues by examining how the layout of digital texts affects the comprehension performance of beginning readers. More specifically, in four self-paced reading experiments we studied whether 7- to 9-year-old pupils in the Dutch primary school system (Grades 2 and 3) either benefit or experience drawbacks from a segmented presentation mode of texts.

6.1.1 Continuous and discontinuous text layouts

A common instance of a segmented layout is when the text is presented in its entirety, yet with each sentence starting on a new line of the same page. This discontinuous layout is most prevalent in, but not limited to, texts for beginning readers. A corpus study, for example, showed that discontinuous texts are also present regularly in the curriculum of high school students (Land, 2009; Land, Sanders, & van den Bergh, 2008). It is not always clear why publishers opt for this presentation mode, even for more experienced readers, but anecdotal evidence suggests that publishers assume that because the texts look easy, they will also be easier to read, with higher learning outcomes as a result (Land, 2009; Van Silfhout, 2014; Van Silfhout, Evers-Vermeul, Mak, & Sanders, 2014; Van Silfhout, Evers-Vermeul, & Sanders, 2014).

This justification for favoring a discontinuous over a continuous layout is overly simplistic. On the one hand, indeed, there are several good reasons to postulate that readers will benefit from a discontinuous layout. It may function as an aid to segment the texts into separate sentences and, moreover, it avoids that clausal units are interrupted by a line break, thereby limiting parsing problems for beginning readers (LeVasseur, Macaruso, Palumba & Shankweiler, 2006). In addition to simplifying these basic reading procedures, discontinuous texts may also prompt higher-order integration processes. A well-known phenomenon in reading research is that people slow down at the end of a sentence to ensure that before moving on, all within-sentence comprehension problems are settled, and the information of the sentence can be integrated with prior information of the text (Just & Carpenter, 1980). An advantage of discontinuous texts is that the line and sentence endings coincide and together present a prominent cue to the reader that sentence wrap-up and integration processes should be initiated.

On the other hand, there are also several good reasons to postulate that readers will experience drawbacks from a discontinuous layout. First, texts in which each sentence is presented on a new line tend to cover more lines than the same texts presented in a continuous fashion. Consequently, the reader must plan and execute more return sweeps in a discontinuous text. During these long saccades, readers move their eye gaze from the end of one line to the beginning of the next. This poses a challenge for inexperienced readers because corrective eye movements are frequently required to locate the optimal starting position after a return sweep (cf., Just & Carpenter, 1980; Rayner, Schotter, Masson, Potter, & Treiman, 2016). To reduce the cognitive load of oculomotor control processes for beginning readers, return sweeps should thus be kept to a minimum. Second, in a discontinuous layout, readers may perceive the text as a list of isolated events instead of approaching it as a meaningful integrated structure. This undesirable side effect of discontinuous texts is strengthened by the tendency of publishers to keep the sentences short by omitting connectives and other linguistic coherence devices. As a result, readers will not be encouraged to construct a highly connected mental representation of discontinuous texts (Van Silfhout, Evers-Vermeul, & Sanders, 2014).

In a series of experiments with 13- and 14-year-old students, Van Silfhout and her colleagues reported no facilitative influence of a discontinuous layout on reading. In fact, text comprehension was impeded in discontinuous texts for some readers, and discontinuous texts slowed down students' reading processes (Van Silfhout, 2014; Van Silfhout, Evers-Vermeul, Mak, et al., 2014; Van Silfhout, Evers-Vermeul, & Sanders, 2014). For beginning readers there are, to our knowledge, no published studies on the matter, but some preliminary results indicate that a discontinuous layout is not felicitous for 7-year-old pupils either (Evers-Vermeul, n.d.).[6] The results of this study, however, were inconclusive as only comprehension measures and no complementing processing measures (e.g., reading times) were reported. As a result, there are several ways to explain the absence of a comprehension difference between the two text formats. One possibility is that beginning readers benefit from a discontinuous layout, yet the advantages for comprehension are masked by increased processing efforts of readers in the continuous layout (i.e., reflecting a speed-accuracy trade-off). Another possibility is that the advantages and disadvantages of the two text formats cancel each other out, such that the overall impact on processing and comprehension is negligible. A third possibility is that the impact of each of the advantages and disadvantages is trivial in itself. After all, transforming a continuous text into a discontinuous text, or vice versa, does not alter the reading process in any fundamental way. In both layouts, the reader moves his or her eye gaze from left to right

[6] Although references to unpublished work should be avoided, we decided to cite the work of Evers-Vermeul because her study inspired us to conduct the series of experiments presented here.

and from top to bottom to encode the visual information on a page. Moreover, in both formats readers are free to diverge from these customary reading directions by making regressive eye movements or looking ahead into the text. Hence, this raises the question of whether more extreme versions of a segmented presentation mode will have a greater impact on reading comprehension and its underlying processes than does presenting each sentence on a new line.

6.1.2 Rapid Serial Visual Presentation

In the current study, the label 'segmented' captures a broad spectrum of alternate approaches to present written texts, ranging from the discontinuous texts as discussed in section 1.1 to more severely segmented Rapid Serial Visual Presentation (RSVP) approaches. In RSVP, the words, sentential units or full sentences of a text are displayed sequentially on a screen, often for a predetermined, limited amount of time. There has been a long tradition of research examining the influence of RSVP on readability and text comprehension, primarily to design and evaluate new ways to present texts on the small displays of mobile phones, pagers, and more recently, smartphones and smartwatches (e.g., Benedetto, Carbone, Pedrotti, & Fevre, 2015).

In addition to the practical advantages of RSVP, more fundamental reading advantages are attributed to the methodology (e.g., Castelhano & Muter, 2001; Lemarié, Eyrolle, & Cellier, 2008). First, RSVP may reduce the cognitive load of oculomotor control processes by decreasing the number of saccades and eliminating the need for complex return sweeps. This influence of RSVP is most noticeable when the texts are presented word by word, but similar effects arise when larger segments are presented. For example, when the segments of RSVP are full sentences, return sweeps are less demanding than in traditional texts because readers only shift their eye gaze in a horizontal plane, not in a vertical plane (cf. Van Renswoude, Johnson, Raijmakers, & Visser, 2016). Second, RSVP may reduce the negative influence of visual crowding, which is the deleterious effect of clutter on object recognition (Whitney & Levi, 2011) and known to affect reading speed (Pelli & Tillman, 2008). Third, since many popular books on speed reading strongly advocate against making regressive eye movements, a more controversial advantage would be that RSVP reduces or fully eliminates the opportunity to reread prior sections of a text (for a critical assessment of this advantage see Rayner et al., 2016). Fourth, the fact that readers cannot reread prior passages, or can only do so in a very limited way, may impact higher order integration processes. For example, Koornneef and Van Berkum (2006) proposed that readers adapt to a chunk-by-chunk presentation mode by resorting to a more incremental strategy where readers immediately integrate the information afforded by each chunk with the information of prior text (cf. Chung-Fat-Yim, Peterson, & Mar, 2017). Because incrementally updating the mental representation of a text constitutes an important aspect of proficient reading (Rayner & Clifton, 2009), readers may benefit from RSVP as it encourages them to update their mental model more frequently than they would do otherwise.

However, many of the potential advantages of RSVP are counterbalanced by its drawbacks, especially when the texts are presented word by word. First, contrary to popular belief, eye movements may not be resource consuming at all (Rayner et al., 2016) and the suppression of eye movements may even increase cognitive load and visual fatigue in single-word RSVP methods (Benedetto et al., 2015). Second, a large body of research has shown that in traditional reading situations, parafoveal preview allows a reader to use information from more than just the currently fixated word, giving the reader a 'head start' (Rayner et al., 2016). Single-word RSVP methods deny the reader to take advantage of this preview effect. Third, regressive eye movements are initiated to repair a failure in comprehension and protect readers against moving on without correcting their misinterpretations (Schotter, Tran, & Rayner, 2014). So, rather than causing problems, regressive eye movements are the solution to a problem (Rayner et al., 2016). Fourth, due to a lack of peripheral cues in RSVP, readers often report the feeling of 'being lost' (Castelhano & Muter, 2001). In fact, readers may get lost to such an extent that a RSVP text is perceived as an amorphous stream of words, rather than a meaningful integrated textual structure.

Most studies that examined the influence of RSVP-based methods on readability and text comprehension revealed a superiority of traditional reading over RSVP (for recent overviews see Benedetto et al., 2015; Lemarié et al., 2008; Rayner et al., 2016). As pointed out by Ricciardi and Di Nocera (2017), presentation speed appears to be the most important aspect to take into consideration when comparing traditional reading with RSVP, because significant reductions of reading comprehension and retention occur when reading rates exceed a critical threshold. In addition, presenting a pause at the end of each sentence of a RSVP text is crucial to approximate the comprehension scores of traditional texts, in particular for readers with a lower working memory capacity (Busler & Lazarte, 2017).

However, a few early studies revealed beneficial effects of RSVP-based methods (for an overview see Young, 1984). In addition, a recent study on adult readers showed a small increase in comprehension performance for texts that were presented sentence by sentence in a reader-controlled manner (Chung-Fat-Yim et al., 2017). Furthermore, Chen (1986) showed that readers with a low working memory span benefit from RSVP reading. Low working memory span readers performed significantly worse than readers with a high working memory span in a traditional reading condition, yet they were no obvious performance differences in the RSVP condition. According to Chen (1986), this suggests that RSVP-based techniques could be useful for improving the reading abilities or strategies of less efficient readers (cf., Busler & Lazarte, 2017). Other scholars also pointed out that RSVP-based techniques could be valuable for specific populations of readers, such as novices, the visually impaired, older adults, and dyslexics (see Castelhano & Muter, 2001; Lemarié et al., 2008, and the references therein). These proposals, however, have never been studied in a systematic way.

6.1.3 The present study

The discussion above revealed that a segmented text (in its various formats) may have both positive and negative effects on basic and higher-order reading processes. It also became clear that more experienced readers do not benefit from a segmented presentation mode. In fact, for these readers the drawbacks seem to outweigh the benefits. It is not self-evident that same will hold for beginning readers because they are still acquiring and optimizing their reading skills. Since there are hardly any published studies that explored the potential value of segmented texts for novices, the first main aim of our study was straightforward. We examined whether young, beginning readers either benefit or experience drawbacks from segmented texts. We did so for mildly to more severely segmented texts, to obtain a comprehensive picture of the efficacy of adjusting the layout for beginning readers. A second aim was to explore why beginning readers may benefit from a specific layout as the visuo-spatial features of a text can affect reading in several ways, ranging from reducing the cognitive load of basic decoding and eye–movement processes to probing higher order integration processes. A third aim was to gain more insight into whether and how individual differences in reading skills constrain the efficacy of the layout of a text.

These three aims were addressed in four self-paced reading experiments with 7- to 9-year-old Dutch pupils. In each experiment, participants read several narrative and expository texts. The reading times for the texts were recorded and each text was followed by a series of comprehension questions. In addition, standardized test scores on decoding and comprehension skills were retrieved from the schools to explore the influence of readers' individual differences. In Experiments 1-3 we compared a traditional continuous layout to three versions of a segmented layout: a discontinuous layout in which each sentence was presented on a new line of the page (Experiment 1); a RSVP-based sentence-by-sentence presentation mode in which the reader controlled when the next sentence of a text appeared on the screen by pressing a button (Experiment 2); a RSVP-based word-by-word presentation mode in which the reader controlled when the next word of a text appeared on the screen by pressing a button (Experiment 3). Experiment 4 was conducted to compare the two RSVP-based presentation modes of Experiments 2 and 3 in a single design.

6.2 Experiment 1: Continuous texts vs. discontinuous texts

6.2.1 Materials and methods

Participants

Participants were 81 pupils (43 girls; mean age 8.2 years; range 6.9-9.5) in Grade 2 (41 children) and Grade 3 from 21 primary schools in the Netherlands. In all experiments reported in the present study, the children had no diagnosed behavioral and/or attentional problems, and normal or corrected-to-normal vision. The parents or guardians signed a letter of active consent before testing. The children received an eraser after testing.

Texts and comprehension questions

Six age-appropriate texts were designed for the study, including two practice texts. The four critical texts consisted of two expository texts (one about the social structure of a community of lions and one about the human skeleton) and two narrative texts (one about children who play hide-and-seek at school and one about siblings who encounter a problem with their sister's tablet). The texts were pre-tested in a pilot study. The texts consisted of 19 sentences each and the average length was 124 words (range: 117-132 words).

To assess text comprehension, six questions of different types were posed after each text (i.e., questions tapping literal information, text-based questions requiring a text-connecting inference, and knowledge-based questions requiring a ‘gap-filling’ inference; see Cain & Oakhill, 1999). The answers of the children were binary scored as correct or incorrect.

Decoding and comprehension proficiencies

Two standardized, widely-used Dutch tests were administered to assess the reading skills of the pupils. The test for decoding proficiency (Three Minutes Test, developed by CITO) consisted of three lists of words of increasing difficulty. For each list, the children read aloud as many words as possible in one minute with an emphasis on both speed and accuracy. The test for reading comprehension (Reading Comprehension Test*,* developed by CITO) contained a range of different types of items tapping comprehension (e.g., shuffled stories, fill-in assignments, closed- and open-ended questions). In both tests, children received overall standardized scores ranging from 1 (very good) to 5 (poor). The tests were administered by the schools. The parents or guardians signed a separate letter of active consent for using the test scores in the current study.

Design and procedure

The freely accessible server (password protected) Ibex Farm (Drummond, 2013) and its supplementary software were used to run the reading experiment on a laptop at the schools of the participants. The experiment ran in the full-screen modus of an internet browser (i.e., Google Chrome, Mozilla Firefox or Apple Safari) and consisted of two main blocks. Both blocks started with oral instructions and a practice text to familiarize the participants with the procedure of each block. The practice phase of a block was followed by a testing phase in which the children read two texts for comprehension (one narrative text, one expository text). In one of the blocks, the texts were presented in their entirety, and sentences continued on the same line as far as page width allowed (*continuous* presentation mode, see Figure 6.1A). In the other block, the texts were presented in their entirety as well, yet line breaks in the middle of a sentence were removed as each sentence started on a new line (*discontinuous* presentation mode, see Figure 6.1B). The texts were presented in a white (initially empty) text box on a blue background, using a sans-serif font. The children were instructed to press the space bar to make a text appear on the computer screen. At the moment the children finished reading the text, they pressed the space bar again to progress to the comprehension questions. The elapsed time between space bar presses was recorded to obtain the total reading time for a text. After each text, six comprehension questions appeared on screen one by one. This section of the experiment was not self-paced. The test leader read out aloud the question and recorded the answer of the child by typing its content in a response text box on the screen (see Figure 6.2 for a schematic overview of a single trial). The ordering of the two experimental blocks and the four critical texts was rotated across four counterbalanced lists. Participants were randomly assigned to one of those lists.

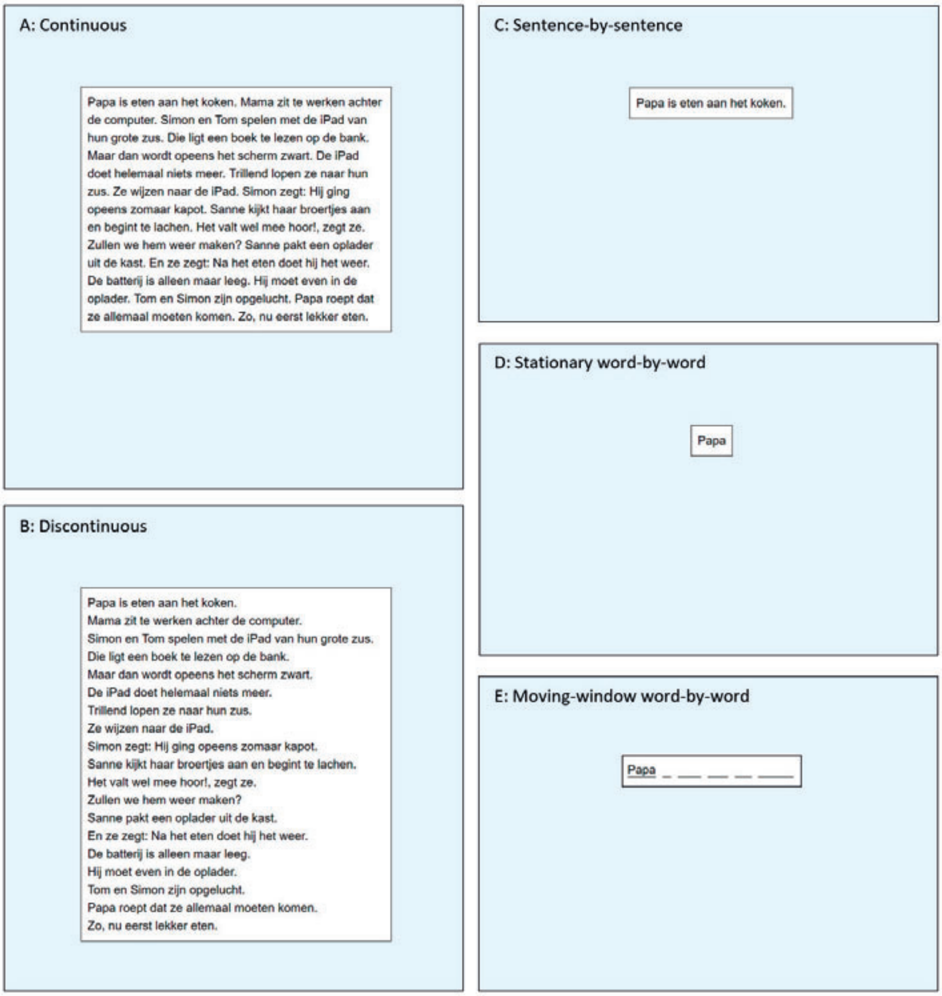

Figure 6.1. Examples of the different presentation modes in Experiments 1-4. *(Fig. A)* Screenshot of the *continuous* (control) condition in Experiments 1-3. *(Fig. B)* Screenshot of the *discontinuous* condition in Experiment 1. *(Fig. C)* Screenshot of the *sentence-by-sentence* condition in Experiments 2 and 4. *(Fig. D)* Screenshot of the (*stationary) word-by-word* condition in Experiments 3 and 4. *(Fig. E)* Screenshot of the *moving-window word-by-word* condition in Experiment 4.

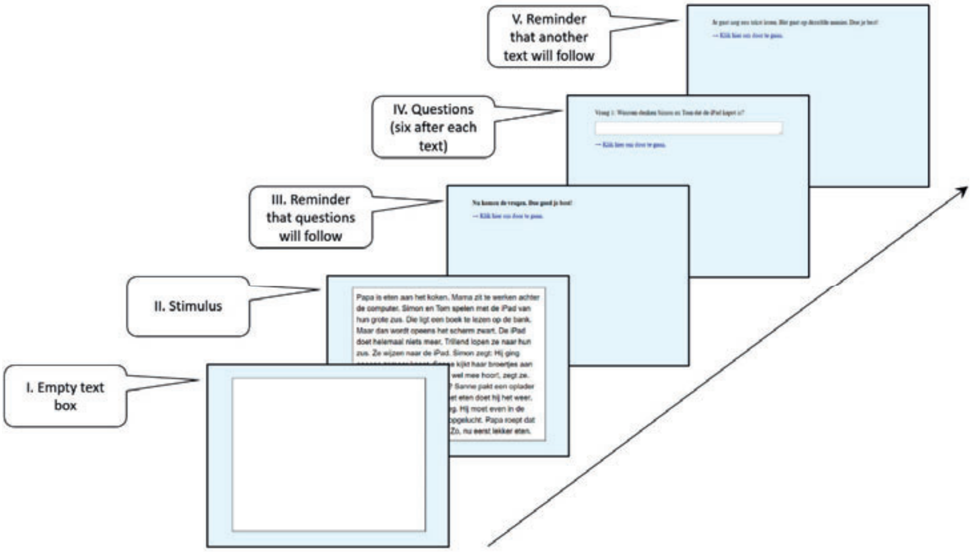

Figure 6.2. Time course of a single trial. A trial started with an empty text box (I). When ready, the participant pressed the space bar and the text appeared (II). When the participant was finished reading the text, he or she pressed the space bar again (note that in the sentence-by-sentence and word-by-word conditions of Experiments 2-4 the participant pressed the space bar repeatedly to progress through a text). After a reminder (III), six comprehension questions appeared one by one on the screen (IV). A trial ended with a reminder that another text (i.e., a trial of the same type) was about to follow (V) – or new instructions were provided when the participant entered the next block of the experiment.

6.2.2 Results

Tables 6.1 and 6.2 report the results for the comprehension questions and reading times respectively. The reading times reflect the average reading time (in milliseconds) of a word in a text. For the analyses, the reading times were log-transformed to correct for right skewness. Mixed-effects logistic regression models were fitted for the comprehension questions and mixed-effects linear regression models were fitted for the reading times. The models were fitted with the statistical software R (version 3.3.3; R Core Team, 2017) using the package LME4 (version 1.1-12; Bates, Mächler, Bolker, & Walker, 2015).

For some participants we were unable to obtain the standardized test scores for decoding and reading comprehension skills (either the parents or guardians did not give permission to use the results of these tests, or the school did not administer the tests as part of their curriculum). Consequently, the analyses consisted of two parts. In the first part we included all children that participated in the experiment and examined the effects of PRESENTATION MODE, Grade and Text Genre. In the second part we included Decoding Proficiency and Comprehension Proficiency as continuous predictors to explore the potential modulating effect of more basic and higher-level reading skills (note that these latter series of analyses were conducted on subsets of the total sample of participants).

Table 6.1 Mean accuracy scores (probability correct) for the comprehension questions in Experiments 1-3 as a function of Presentation Mode, Grade and Text Genre.[7]

		Grade 2		Grade 3	
Experiment	Presentation Mode	Expository	Narrative	Expository	Narrative
1	Continuous	.42	.61	.57	.70
	Discontinuous	.47	.64	.53	.74
2	Continuous	.46	.63	.55	.69
	Sentence-by-sentence	.53	.66	.64	.72
3	Continuous	.45	.64	.62	.72
	Word-by-word	.50	.70	.64	.79

Table 6.2 Mean reading times (in milliseconds per word) and standard deviations (SD) for the texts presented in Experiments 1-3 as a function of Presentation Mode, Grade and Text Genre

		Grade 2				Grade 3			
		Expository		Narrative		Expository		Narrative	
Experiment	Presentation Mode	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Continuous	683	239	628	199	538	202	510	186
	Discontinuous	682	235	653	224	524	207	490	164
2	Continuous	684	283	610	229	503	170	466	149
	Sentence-by-sentence	695	235	660	211	571	173	547	163
3	Continuous	675	300	631	235	464	152	424	146
	Word-by-word	1041	324	966	271	847	281	808	218

6.2.2.1 Effects of Presentation Mode, Grade and Text Genre

Mixed-effects model selection was carried out in the following way. First, a model was fitted that included the fixed factors Presentation Mode (two levels: continuous vs. discontinuous),

[7] Standard deviations (SD) do not apply to binary data and will only be reported for the continuous dependent variables in Tables 6.2 and 6.4.

TEXT GENRE (two levels: narrative vs. expository) and GRADE (two levels: Grade 2 vs. Grade 3) and the full interactional terms for these factors. Participants and items were included as crossed random effects (Baayen, Davidson, & Bates, 2008). Wald chi-square testing (TYPE II) as implemented in the R-package CAR (version 2.1-4; Fox & Weisberg, 2011) was applied to select the most parsimonious structure of fixed effects by removing non-significant (p>.05) predictors. Subsequently, we included the maximal random-slope structures for participants and items that resulted in a converging model (for discussion cf. Barr, Levy, Scheepers, & Tily, 2013; Bates, Kliegl, Vasishth, & Baayen, 2015).[8] For these final models, the 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. To obtain fixed-effects estimates and the associated statistics for the relevant simple effects of an interaction, the reference category of the models was adjusted and analogous models with the same structure of fixed effects and random slopes were fitted.

Comprehension questions. The Wald chi-square tests revealed main effects of GRADE ($\chi2(1)$=5.45, p<.05) and TEXT GENRE ($\chi2(1)$=4.59, p<.05).[9] The children in Grade 3 performed better on the comprehension questions than the children in Grade 2 (b=0.67, SE=0.27, z=2.47). Furthermore, the performance on questions for narrative texts was better than the performance on questions for expository texts (b=1.08, SE=0.52, z=2.07).

Reading times. We observed main effects of GRADE ($\chi2(1)$=11.9, p<.001) and TEXT GENRE ($\chi2(1)$=3.95, p<.05).[10] The children in Grade 3 were reading at a higher pace than the children in Grade 2 (b=-0.26, SE=0.075, t=-3.45) and narrative texts were read more quickly than expository texts (b=-0.056, SE=0.028, t=-1.96).

6.2.2.2 Exploring interactions of DECODING and COMPREHENSION PROFICIENCIES

The test scores on reading proficiency provided by the schools are standardized scores adjusted for grade level. As a result, the scores are not comparable across grades, and separate

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[8] We opted for this two-step approach to simplify the procedure for fitting the random slopes, yet we still avoid inflated TYPE I error rates, as is presumably the case when only random intercepts are included (Barr et al., 2013).

[9] Final model: Score ~ 1 + GRADE + TEXT GENRE + (1+ GRADE + TEXT GENRE | Participants) + (1 + GRADE + TEXT GENRE | Questions).

[10] Final model: Log Reading Time ~ 1 + GRADE + TEXT GENRE + (1+ GRADE + TEXT GENRE | Participants) + (1 | Texts).

analyses for Grades 2 and 3 were carried out. Furthermore, because missing values for the test scores on decoding and comprehension skills were not equally distributed, we also carried out separate analyses for these two aspects of reading proficiency. In all, four separate series of analyses were conducted for the two dependent measures (i.e., accuracy comprehension questions and reading times).

Model selection was approached in a similar way as described in section 6.2.2.1. First, a model was fitted that included a continuous predictor of reading proficiency (either DECODING PROFICIENCY or COMPREHENSION PROFICIENCY), the factors PRESENTATION MODE and TEXT GENRE, and their full interactional terms. Participants and items were included as crossed random effects. Wald chi-square testing was applied to select the most parsimonious structure of fixed effects, followed by an inclusion of the maximal converging random-slope structures for participants and items. The continuous predictor was centered on the mean. In case of a significant modulating effect of reading proficiency, equivalent models with the relevant predictor centered to the highest (i.e. 1) and lowest (i.e. 5) proficiency scores were used to further interpret the interaction effect. We will only discuss (two- and three-way) interactions including the effects of DECODING/COMPREHENSION PROFICIENCY and PRESENTATION MODE.

Comprehension questions. *Grade 2.* There was no modulating effect of the predictor DECODING PROFICIENCY, but COMPREHENSION PROFICIENCY interacted with PRESENTATION MODE ($\chi 2(1)=5.73$, $p<.05$).[11] Further inspection of this interaction showed that high-comprehending children performed better in the discontinuous than in the continuous condition ($b=0.63$, $SE=0.30$, $z=2.13$). This advantage diminished as a function of COMPREHENSION PROFICIENCY, to such an extent that low-comprehending children showed no comprehension advantage (numerically even a disadvantage) for the discontinuous condition ($b=-0.72$, $SE=0.44$, $z=-1.62$). *Grade 3.* The analyses for Grade 3 revealed no modulating effects of DECODING PROFICIENCY and COMPREHENSION PROFICIENCY.

Reading times. *Grade 2.* There was no modulating effect of the predictor DECODING PROFICIENCY, but COMPREHENSION PROFICIENCY interacted with PRESENTATION MODE ($\chi 2(1)=7.56$,

[11] Final model: Score ~ 1 + PRESENTATION MODE x *COMPREHENSION PROFICIENCY* + TEXT GENRE + (1 + PRESENTATION MODE | Participants) + (1 | Questions).

$p<.01$).[12] Further inspection of this interaction revealed that low-comprehending readers displayed longer reading times in the discontinuous condition than in the continuous condition (b=0.11, SE=0.051, t=2.07). High-comprehending children, on the other hand, showed no reading time difference between the continuous and discontinuous conditions (numerically they had the tendency to read the stories in the discontinuous condition more quickly: b=-0.060, SE=0.034, t=-1.76).

Grade 3. The analyses for Grade 3 revealed no modulating effects of DECODING PROFICIENCY and COMPREHENSION PROFICIENCY.

6.2.3 Discussion

In line with a number of empirical studies, Experiment 1 revealed no comprehension advantage for texts in which each sentence was presented on a new line of the page (Van Silfhout, 2014; Van Silfhout, Evers-Vermeul, Mak, et al., 2014; Van Silfhout, Evers-Vermeul, & Sanders, 2014). In addition, the results extended prior findings in two ways. First, the only study on the topic that tested beginning readers (Evers-Vermeul, n.d.) did not rule out that a comprehension advantage for discontinuous texts was obscured due to children's increased processing efforts (as indicated by increased reading times) when reading continuous texts. Experiment 1 showed that this explanation – which presupposes the presence of a speed-accuracy trade-off – is unwarranted as we observed no overall reading time differences between continuous and discontinuous texts. Second, our exploratory analyses on the influence of individual differences revealed an interesting pattern. High-comprehending second-grade readers performed better on the comprehension questions posed after a discontinuous text in comparison to the questions posed after a continuous text. Moreover, this comprehension advantage could not be attributed to more intensive reading in discontinuous texts – in fact, high-comprehending second-grade readers displayed a nonsignificant tendency towards faster processing times for discontinuous texts than for continuous texts. In contrast, low-comprehending second-grade readers slowed down their reading pace when confronted with discontinuous texts, perhaps because more return sweeps were required in these texts. In addition, these increased processing costs were not

[12] Final model: Log Reading Time ~ 1 + PRESENTATION MODE x *COMPREHENSION PROFICIENCY* + TEXT GENRE + (1 + PRESENTATION MODE + TEXT GENRE | Participants) + (1 + PRESENTATION MODE x *COMPREHENSION PROFICIENCY* + TEXT GENRE | Texts).

accompanied by higher comprehension scores. Hence, whereas proficient beginning readers benefit from discontinuous texts, struggling beginning readers do not.

6.3 Experiment 2: Continuous texts vs. sentence-by-sentence texts

6.3.1 Materials and methods

Participants

Participants were 88 pupils (47 girls; mean age 8.2 years; range 7.0-9.4) in Grades 2 (46 children) and 3 from 21 primary schools in the Netherlands. None of them participated in Experiment 1.

Materials

The stimuli and standardized tests for decoding and comprehension proficiencies were identical to those of Experiment 1.

Design and procedure

Experiment 2 also consisted of two experimental blocks. One block was identical to the *continuous* condition of Experiment 1 (see Figure 6.1A). The main (and only) difference with Experiment 1 was that the experimental block in which each sentence was presented on a new line, was replaced by a condition in which each sentence of the texts was presented separately (*sentence-by-sentence* condition, see Figure 6.1C). In this condition a trial also started with a white (yet smaller) empty text box in the middle of the screen. After the child pressed the space bar, the first sentence of a text appeared in the box. After pressing the space bar again, the first sentence of a text was replaced by the second sentence of that text. By repeatedly pressing the space bar the child read all the sentences of a text in a sentence-by-sentence manner. After pressing the space bar, it was not possible to go back to sentences presented earlier in the trial. The elapsed time between space bar presses was recorded to obtain reading times for the sentences of a text.

6.3.2 Results

Tables 6.1 and 6.2 report the results for the comprehension questions and reading times respectively. The procedure for the analyses was identical to Experiment 1.

6.3.2.1 Effects of Presentation Mode, Grade and Text Genre

Comprehension questions. We observed a main effect of Presentation Mode ($\chi 2(1)=8.22$, $p<.01$).[13] Relative to the continuous condition, children performed better in the sentence-by-sentence condition ($b=0.32$, $SE=0.15$, $z=2.18$).

Reading times. We observed main effects of Presentation Mode ($\chi 2(1)= 57.7$, $p<.001$), Grade ($\chi 2(1)=9.14$, $p<.01$) and Text Genre ($\chi 2(1)=7.43$, $p<.01$).[14] Children were reading at a slower pace in the sentence-by-sentence condition than in the continuous condition ($b=0.11$, $SE=0.026$, $t=4.24$), children in Grade 3 were reading at a higher pace than children in Grade 2 ($b=-0.20$, $SE=0.075$, $t=-2.64$), and narrative texts were read more quickly than expository texts ($b=-0.045$, $SE=0.019$, $t=-2.36$).

6.3.2.2 Exploring interactions of Decoding and Comprehension Proficiencies

Comprehension questions. The analyses revealed no modulating effects of Decoding Proficiency and Comprehension Proficiency in Grades 2 and 3.

Reading times. *Grade 2.* We observed a three-way interaction of Decoding Proficiency x Presentation Mode x Genre ($\chi 2(1)=5.68$, $p<.05$).[15] Narrative texts (see Figure 6.3, top left) presented in a sentence-by-sentence manner were read more slowly than narrative texts presented in a continuous manner ($b=0.11$, $SE=0.034$, $t=3.14$). There was no Decoding Proficiency x Presentation Mode interaction for narrative texts ($b=-0.023$, $SE=0.021$, $t=-1.07$).

In contrast, for expository texts (see Figure 6.3, top right) Decoding Proficiency interacted with Presentation Mode ($b=-0.82$, $SE=0.021$, $t=-3.89$). More specifically, proficient decoders displayed longer reading times for the sentence-by-sentence condition than for the continuous condition ($b=0.15$, $SE=0.044$, $t=3.54$), yet struggling decoders displayed the opposite pattern (i.e., shorter reading times for the sentence-by-sentence condition, $b=-0.17$, $SE=0.065$, $t=-2.65$).

[13] Final model: Score ~ 1 + Presentation Mode + (1 + Presentation Mode | Participants) + (1 + Presentation Mode | Questions).

[14] In addition, the Wald chi-square tests revealed a Presentation Mode x Grade interaction ($\chi 2(1)=7.79$, $p<.01$), but this interaction fell short of significance after including the random slopes ($\chi 2(1)=3.63$, $p=.057$). Final model: Log Reading Time ~ 1 + Presentation Mode + Grade + Text Genre + (1 + Presentation Mode + Text Genre | Participants) + (1 + Presentation Mode + Grade + Text Genre | Texts).

[15] Final model: Log Reading Time ~ 1 + Presentation Mode x Text Genre x *Decoding Proficiency* + (1 + Presentation Mode + Text Genre | Participants) + (1 + Presentation Mode x Text Genre + *Decoding Proficiency* | Texts).

In addition, we observed a three-way interaction of COMPREHENSION PROFICIENCY x PRESENTATION MODE x GENRE ($\chi2(1)=4.80$, $p<.05$).[16] As depicted in Figure 6.3 (bottom graphs), narrative texts in the sentence-by-sentence condition were read more slowly than narrative texts in the continuous condition ($b=0.098$, $SE=0.037$, $t=2.68$). This effect of PRESENTATION MODE did not interact with COMPREHENSION PROFICIENCY ($b=0.0065$, $SE=0.025$, $t=0.26$). For the expository texts, however, COMPREHENSION PROFICIENCY interacted with PRESENTATION MODE ($b=-0.055$, $SE=0.025$, $t=-2.24$). Whereas high-comprehending readers displayed longer reading times for the sentence-by-sentence condition than for the continuous condition ($b=0.13$, $SE=0.059$, $t=2.16$), low-comprehending readers did not display a reading time difference between these conditions ($b=-0.094$, $SE=0.069$, $t=-1.36$).

Grade 3. The analyses revealed no modulating effects of DECODING PROFICIENCY and COMPREHENSION PROFICIENCY.

6.3.3 Discussion

Experiment 2 showed that beginning readers have a better understanding of a text when presented in a self-paced sentence-by-sentence manner than when presented in a traditional continuous manner. In addition, the analyses of the reading times showed that sentence-by-sentence texts were processed more slowly than continuous texts. Together, these results suggest a speed-accuracy trade-off in which the higher comprehension scores for sentence-by-sentence texts should at least partly be attributed to a more laborious processing style of the readers.

The exploratory analyses on the influence of individual differences, however, sketched a more complicated picture. In the case of expository texts, struggling second-grade readers did not adhere to the above-mentioned speed-accuracy trade-off as they processed sentence-by-sentence expository texts more quickly than continuous expository texts, apparently without severely compromising their understanding of the content of the text. So, a more comprehensive conclusion would be that, in general, beginning readers benefit from a text presented in segments because this will induce a more accurate, resource-consuming processing strategy. An exception to this general rule applies to struggling second-grade pupils

[16] Final model: Log Reading Time ~ Log Reading Time ~ 1 + PRESENTATION MODE x TEXT GENRE x *COMPREHENSION PROFICIENCY* + (1 + PRESENTATION MODE + TEXT GENRE | Participants) + (1 + PRESENTATION MODE x TEXT GENRE + *COMPREHENSION PROFICIENCY* | Texts).

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when they read expository texts. In that specific situation a more plausible advantage of the sentence-by-sentence presentation method is that the processing load of basic reading processes (e.g., parsing, eye-movement control) is reduced – which in turn may have a beneficial influence on comprehension.

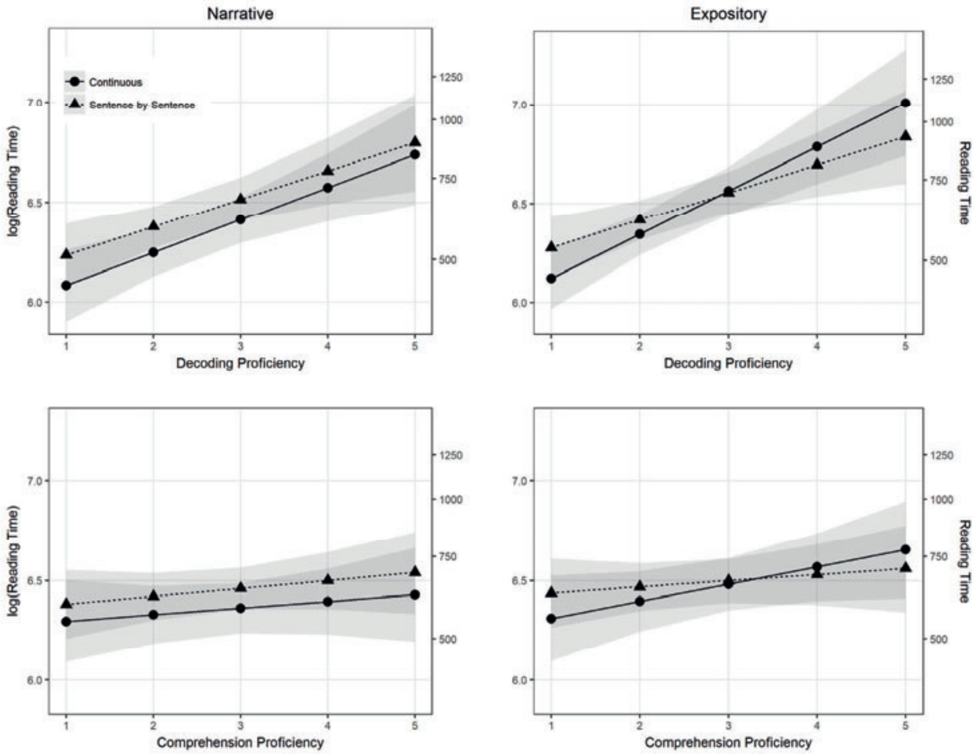

Figure 6.3. Fixed effects estimates (and their 95% confidence intervals) of the log-transformed reading times (in milliseconds per word) of second-grade pupils in Experiment 2, as a function of PRESENTATION MODE, DECODING PROFICIENCY (top), COMPREHENSION PROFICIENCY (bottom) and TEXT GENRE (narrative texts on the left, expository texts on the right). Scales of exponentiated log-values (i.e., approximating untransformed values) are provided as secondary y-axes on the right side of the graphs.[17]

[17] The fixed effects and confidence intervals were extracted and plotted with the R-packages EFFECTS (Fox, n.d.; Fox & Hong, 2009) and GGPLOT2 (Wickham, 2009).

6.4 Experiment 3: Continuous texts vs. word-by-word texts

6.4.1 Materials and methods

Participants

Participants were 83 pupils (45 girls; mean age 8.2 years; range 7.1-9.6) in Grades 2 (46 children) and 3 from 21 primary schools in the Netherlands. None of them participated in the previous experiments.

Materials

The stimuli and standardized tests for decoding and comprehension proficiency were identical to those of the previous experiments.

Design and procedure

Experiment 3 also consisted of two experimental blocks. Again, one of the blocks was identical to the *continuous* condition. In the other block the participants read the texts in a word-by-word manner (see Figure 6.1D). A trial started with a small empty text box. After the child pressed the space bar, the first word of a text appeared in this box. By pressing the space bar another time, the first word of the text was replaced by its second word. The child read all the words of a text by repeatedly pressing the space bar. It was not possible to go back to words presented earlier in a trial. The elapsed time between space bar presses was recorded to obtain reading times for the words of a text.

6.4.2 Results

Tables 6.1 and 6.2 report the results for the comprehension questions and reading times respectively. The procedure for the analyses was identical to the previous experiments.

6.4.2.1 Effects of Presentation Mode, Grade and Text Genre

Comprehension questions. We observed main effects of Presentation Mode ($\chi2(1)=8.96$, $p<.01$), Grade ($\chi2(1)=10.31$, $p<.01$), and Text Genre ($\chi2(1)=5.69$, $p<.05$). Children answered more questions correctly in the word-by-word condition than in the continuous condition ($b=0.33$, $SE=0.11$, $z=3.00$), children in Grade 3 performed better on the comprehension questions than children in Grade 2 ($b=0.71$, $SE=0.23$, $z=3.13$), and the performance on questions for narrative texts was better than the performance on questions for expository texts (*b*=1.02, *SE*=0.44, *z*=2.33).[18]

Reading times. We observed main effects of PRESENTATION MODE ($\chi 2(1)$= 542, *p*<.001) and GRADE ($\chi 2(1)$=14.2, *p*<.001), and a PRESENTATION MODE x GRADE interaction ($\chi 2(1)$=12.7, *p*<.001).[19] Children in Grade 3 were reading at a higher pace than children in Grade 2 in both conditions (continuous: *b*=-0.35, *SE*=0.091, *t*=-3.81; word-by-word: *b*=-0.17, *SE*=0.067, *t*=-2.55). Furthermore, children in both grades displayed longer reading times in the word-by-word condition than in the continuous condition (Grade 2: *b*=0.48, *SE*=0.055, *t*=8.68; Grade 3: *b*=0.65, *SE*=0.062, *t*=10.57). The PRESENTATION MODE x GRADE interaction indicated that, relative to the continuous condition, children in Grade 3 showed a more marked reading time increase in the word-by-word condition than the children in Grade 2 did.

6.4.2.2 Exploring interactions of DECODING and COMPREHENSION PROFICIENCIES

The analyses for the comprehension questions and reading times revealed no modulating effects of DECODING PROFICIENCY and COMPREHENSION PROFICIENCY in Grades 2 and 3.

6.4.3 Discussion

Experiment 3 mirrored the findings of Experiment 2 in showing that beginning readers obtained a better understanding of a text that was presented chunk by chunk, relative to the situation in which the text was presented in its entirety. Experiment 3 extended the findings of Experiment 2 by demonstrating that a comprehension advantage persisted when smaller chunks were presented, consisting of only a single word. In addition, the results of Experiment 3 displayed a speed-accuracy trade-off as the reading times for the word-by-word texts were considerably longer than the reading times for the continuous texts – for third-grade readers the reading times for the word-by-word texts were almost twice as long.

[18] Final model: Score ~ 1 + PRESENTATION MODE + *GRADE* + TEXT GENRE + (1 + *GRADE* + TEXT GENRE | Participants) + (1 + TEXT GENRE | Questions).

[19] Final model: Log Reading Time ~ 1 + PRESENTATION MODE X *GRADE* + (1 + PRESENTATION MODE + *GRADE* | Participants) + (1 + PRESENTATION MODE X *GRADE* | Texts).

6.5 Experiment 4: Sentence-by-sentence texts vs. word-by-word texts

Experiments 2 and 3 revealed that sentence-by-sentence and word-by-word texts increase reading comprehension in comparison to a continuous text. It is, however, difficult to decipher how the two segmented texts induce this increment. Moreover, it is unclear which of the two segmented presentation modes reflects the most suitable way of presenting texts to beginning readers because they were examined in two distinct experiments. To address these issues, we directly compared the influence on reading comprehension of sentence-by-sentence and word-by-word presentation modes in Experiment 4. In addition, we included a third condition in which the texts were presented in a self-paced word-by-word moving-window fashion (henceforth, we will refer to the word-by-word condition of Experiment 3 as the *stationary* word-by-word condition and we will refer to the new condition as the *moving-window* word-by-word condition) (cf. Busler & Lazarte, 2017). In this condition, each word of a sentence appeared at the same position it would occupy if the sentence was presented in its entirety. Accordingly, the children read each sentence of the text in a word-by-word manner, yet they were still required to plan and execute saccades, comparable to the situation in which the consecutive segments of the text were full sentences. In all, Experiment 4 allowed us to more carefully consider the influence of the following factors on reading speed and text comprehension: (1) visual crowding (i.e., present in the sentence-by-sentence condition, reduced in the word-by-word conditions); (2) the word-preview effect (present in the sentence-by-sentence condition, absent in the word-by-word conditions); and (3) left-to-right (i.e., horizontal) saccadic eye movements (required in the sentence-by-sentence and moving-window conditions, not required in the stationary condition).

6.5.1 Materials and methods

Participants

Participants were 96 pupils (55 girls; mean age 7.9 years; range 6.8-9.0) in Grades 2 (43 children) and 3 from 9 primary schools in the Netherlands. None of them participated in the previous experiments.

Materials

Experiment 4 included three self-paced reading conditions. To ensure that in every condition two texts were read by the participants, we constructed two additional critical texts (one expository text and one narrative text) with six comprehension questions each. The expository text explained what it takes to become an astronaut (155 words). The narrative text told the story of a chubby elephant, eventually meeting the love of his life (134 words). The standardized tests for decoding and comprehension proficiencies were identical to those of the previous experiments.

Design and procedure

In addition to the sentence-by-sentence (see Figure 6.1C) and stationary word-by-word (see Figure 6.1D) conditions, the experiment included a moving-window word-by-word condition (see Figure 6.1E). In this latter condition, a trial started with a text box that already contained horizontal lines that indicated the length and position of the words of the first sentence of a text. When the child pressed the space bar, the first word of the sentence appeared above its corresponding line in the text box. When the child pressed the space bar for a second time, the first word of the sentence disappeared, and at the same time the second word of the sentence was presented above its own corresponding line in the text box, i.e., to the right of the first word. By repeatedly pressing the space bar, the child read the first sentence of a text by shifting his or her eye gaze from word to word in the sentence. When the child finished reading the first sentence, an empty text box with horizontal lines indicating the structure of the second sentence replaced the text box of the first sentence. The second and remaining sentences of a text were read in the same word-by-word moving window fashion as described for the first sentence. It was not possible for the child to go back to words or sentences that were presented earlier in a trial. The elapsed time between space bar presses was recorded to obtain reading times for the words of a text. The ordering of the three experimental blocks and the six critical texts was rotated across six counterbalanced lists. Participants were randomly assigned to one of those lists.

6.5.2 Results

Tables 6.3 and 6.4 report the results for the comprehension questions and reading times respectively. Four trials (1.2% of the data) were removed due to unrealistically short average reading times per word (< 40 milliseconds). The procedure for the analyses was identical to the previous experiments.

Table 6.3 Mean accuracy scores (probability correct) for the comprehension questions in Experiments 4 as a function of PRESENTATION MODE, GRADE and TEXT GENRE

	Grade 2		Grade 3	
Presentation Mode	Expository	Narrative	Expository	Narrative
Sentence-by-sentence	.50	.60	.62	.79
Stationary word-by-word	.56	.62	.66	.78
Moving word-by-word	.53	.64	.70	.76

Table 6.4 Mean reading times (in milliseconds per word) and standard deviations (SD) for the texts presented in Experiments 4 as a function of PRESENTATION MODE, GRADE and TEXT GENRE

	Grade 2				Grade 3			
	Expository		Narrative		Expository		Narrative	
Presentation Mode	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sentence-by-sentence	986	525	847	373	542	232	527	166
Stationary word-by-word	1127	565	1121	580	853	252	837	237
Moving word-by-word	1008	379	964	319	757	203	732	186

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6.5.2.1 Effects of PRESENTATION MODE, GRADE and TEXT GENRE

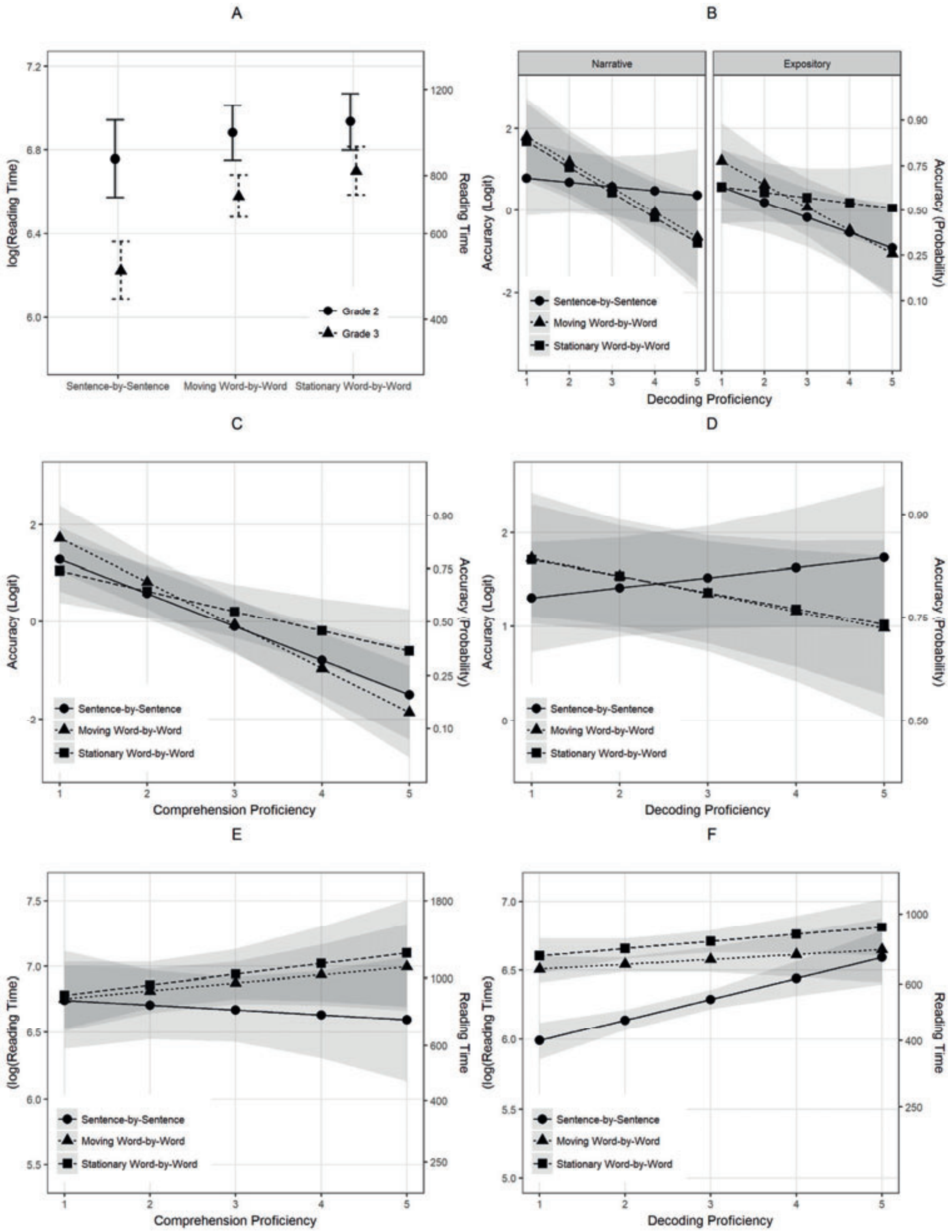
Comprehension questions. We observed a main effect of GRADE ($\chi 2(1)=20.6$, $p<.001$).[20] Children in Grade 3 performed better on the comprehension questions than children in Grade 2 did ($b=0.90$, $SE=0.20$, $z=4.46$).

Reading times. We observed main effects of PRESENTATION MODE ($\chi 2(2)= 253$, $p<.001$) and GRADE ($\chi 2(1)=17.6$, $p<.001$), and a PRESENTATION MODE X GRADE interaction ($\chi 2(2)=43.2$, $p<.001$).[21] As illustrated in Figure 6.4A, pupils in Grade 3 read more quickly than pupils in Grade 2 did, in all three conditions (sentence-by-sentence: $b=-0.53$, $SE=0.11$, $t=-4.78$; stationary: $b=-0.23$, $SE=0.089$, $t=-2.63$; moving-window: $b=-30$, $SE=0.081$, $t=-3.72$). The impact of the three reading conditions, however, diverged for second- and third-grade readers. Whereas pupils in both grades read more slowly in the stationary condition than in the sentence-by-sentence

[20] Final model: Score ~ 1 + GRADE + (1 + GRADE | Participants) + (1 + GRADE | Questions).
[21] Final model: Log Reading Time ~ 1 + PRESENTATION MODE X *GRADE* + (1 + PRESENTATION MODE | Participants) + (1 + PRESENTATION MODE X *GRADE* | Texts).

condition (Grade 2: *b*=0.18, *SE*=0.070, *t*=2.51; Grade 3: *b*=0.47, *SE*=0.052, *t*=9.09), the two remaining contrasts (moving-window vs. sentence-by-sentence, moving-window vs. stationary) showed a different pattern. More specifically, pupils in Grade 3 read more slowly in the moving-window condition than in the sentence-by-sentence condition (*b*=0.35, *SE*=0.046, *t*=7.70), but pupils in Grade 2 did not display a significant increase in reading times for the moving-window condition (*b*=0.12, *SE*=0.066, *t*=1.86). Similarly, whereas readers in Grade 3 read more slowly in the stationary condition than in the moving-window condition (*b*=0.12, *SE*=0.030, *t*=4.03), pupils in Grade 2 did not display reliable reading time differences between these two conditions (*b*=0.052, *SE*=0.038, *t*=1.36).

Figure 6.4. Fixed effects estimates (and their 95% confidence intervals) of the accuracy scores (probability correct) and log-transformed reading times (in milliseconds per word) of pupils in Experiment 4. The figures for the accuracy scores contain logit scales (primary y-axes in the left) and probability scales (secondary y-axes on the right), and the figures for the reading times contain log scales (primary y-axes in the left) and exponentiated log scales (secondary y-axes on the right). *(Fig. A)* Estimates of the log-transformed reading times as a function of Presentation Mode and Grade. *(Fig. B)* Estimates of the accuracy scores of second-grade pupils as a function of Presentation Mode, Decoding Proficiency and Text Genre. *(Fig. C)* Estimates of the accuracy scores of second-grade pupils as a function of Presentation Mode and Comprehension Proficiency. *(Fig. D)* Estimates of the accuracy scores of third-grade pupils as a function of Presentation Mode and Decoding Proficiency. *(Fig. E)* Estimates of the log-transformed reading times of second-grade pupils as a function of Presentation Mode and Comprehension Proficiency. *(Fig. F)* Estimates of the log-transformed reading times of third-grade pupils as a function of Presentation Mode and Decoding Proficiency.


A
log(Reading Time)
Reading Time
Grade 2
Grade 3
Sentence-by-Sentence
Moving Word-by-Word
Stationary Word-by-Word
B
Narrative
Expository
Accuracy (Logit)
Accuracy (Probability)
Decoding Proficiency
C
Comprehension Proficiency
D
Decoding Proficiency
E
(log(Reading Time)
Comprehension Proficiency
F
(log(Reading Time)
Decoding Proficiency

6.5.2.2 Exploring interactions of Decoding and Comprehension Proficiencies

Comprehension questions. *Grade 2.* We observed a reliable three-way interaction of Decoding Proficiency x Presentation Mode x Genre ($\chi2(2)=7.98$, $p<.05$).[22] We discuss this interaction in the context of narrative texts first. As illustrated in Figure 6.4B (left graph), struggling decoders obtained a higher accuracy score for the narrative texts in the sentence-by-sentence condition in comparison to both word-by-word conditions (sentence-by-sentence vs. stationary: b=-1.18, SE=0.53, z=-2.24; sentence-by-sentence vs. moving-window: b=-1.04, SE=0.52, z=-1.99). No differences were observed between the two word-by-word conditions (b=-0.14, SE=0.52, z=-0.28). A different pattern emerged for proficient decoders. That is, although no difference was present between the two word-by-word conditions (b=-0.12, SE=0.42, z=-0.27), both conditions induced higher accuracy scores than the sentence-by-sentence condition did (sentence-by-sentence vs. stationary: b=0.88, SE=0.41, z=2.12; sentence-by-sentence vs. moving-window: b=1.00, SE=0.41, z=2.41). The results for the expository texts sketched a different picture (see Figure 6.4B, right graph). For struggling decoders, the highest accuracy score was observed in the stationary condition (moving-window vs. stationary: b=1.13, SE=0.51, z=2.22; sentence-by-sentence vs. stationary: b=0.96, SE=0.51, z=1.90; sentence-by-sentence vs. moving-window: b=-0.15, SE=0.51, z=-0.29). For proficient decoders, however, Presentation Mode did not reliably affect the accuracy scores for expository texts (sentence-by-sentence vs. stationary: b=0.0057, SE=0.38, z=0.015; sentence-by-sentence vs. moving-window: b=0.63, SE=0.39, z=1.63; moving-window vs. stationary: b=-0.63, SE=0.38, z=-1.64).

In addition, Comprehension Proficiency interacted with Presentation Mode ($\chi2(2)=7.79$, $p<.05$).[23] As depicted in Figure 6.4C, struggling comprehenders obtained the highest accuracy score while reading in a stationary manner and the lowest accuracy score while reading in a moving-window manner (moving-window vs. stationary: b=1.24, SE=0.49, z=2.54; sentence-by-sentence vs. stationary: b=0.88, SE=0.49, z=1.81; sentence-by-sentence vs. moving-window: b=-0.36, SE=0.52, z=0.69). Proficient comprehenders showed the opposite pattern. They obtained the lowest accuracy score in the stationary condition and the highest accuracy

[22] Due to convergence issues we could not include random slopes. Final model: Score ~ 1 + Presentation Mode x Text Genre x *Decoding Proficiency* + (1 | Participants) + (1 | Questions).

[23] Due to convergence issues we could not include random slopes. Final model: Score ~ 1 + Comprehension Proficiency x Presentation Mode + (1 | Participants) + (1 | Questions).

score in the moving-window condition (moving-window vs. stationary: b=-0.67, SE=0.31, z=-2.13; sentence-by-sentence vs. stationary: b=-0.23, SE=0.30 z=-0.77; sentence-by-sentence vs. moving-window: b=0.43, SE=0.32, z=1.35).

Grade 3. As illustrated in Figure 6.4D, Decoding Proficiency interacted with Presentation Mode ($\chi 2(2)$=6.10, p<.05).[24] The analyses for struggling decoders revealed no significant differences between the three reading conditions, yet the general pattern was that their accuracy scores were lower in the two word-by-word conditions in comparison to the sentence-by-sentence condition (sentence-by-sentence vs. stationary: b=-0.72, SE=0.39, z=-1.83; sentence-by-sentence vs. moving-window: b=-0.76, SE=0.42, z=-1.79; moving-window vs. stationary: b=0.033, SE=0.44, z=0.08). Proficient decoders showed no significant differences between the three conditions either, yet for proficient decoders the two word-by-word conditions had a positive, instead of a negative impact on the accuracy scores (sentence-by-sentence vs. stationary: b=0.40, SE=0.24, z=1.64; sentence-by-sentence vs. moving-window: b=0.42, SE=0.27, z=1.57; moving-window vs. stationary: b=-0.015, SE=0.29, z=-0.05). We observed no reliable interactions of Comprehension Proficiency.

Reading times. *Grade 2.* We observed no reliable interactions of Decoding Proficiency, but Comprehension Proficiency interacted with Presentation Mode ($\chi 2(2)$=20.2, p<.001).[25] As illustrated in Figure 6.4E, struggling comprehenders read more quickly in the sentence-by-sentence condition, relative to both word-by-word conditions (sentence-by-sentence vs. stationary: b=0.50, SE=0.16, t=3.18; sentence-by-sentence vs. moving-window: b=0.40, SE=0.15, t=2.65; moving-window vs. stationary: b=0.10, SE=0.076, t=1.39). This reading time advantage for the sentence-by-sentence condition was absent for proficient comprehenders (sentence-by-sentence vs. stationary b=0.037, SE=0.095, t=0.39; sentence-by-sentence vs. moving-window: b=0.010, SE=0.092, t=0.11; moving-window vs. stationary: b=0.023, SE=0.052, t=0.45).

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[24] Final model: Score ~ 1 + Decoding Proficiency x Presentation Mode + Text Genre + (1 + Presentation Mode | Participants) + (1 | Questions).

[25] Final model: Log Reading Time ~ 1 + Comprehension Proficiency x Presentation Mode + (1 + Comprehension Proficiency + Presentation Mode | Participants) + (1 + Comprehension Proficiency x Presentation Mode | Texts).

Grade 3. DECODING PROFICIENCY interacted with PRESENTATION MODE ($\chi2(2)=36.4$, $p<.001$).[26] As depicted in Figure 6.4F, struggling decoders read most slowly in the stationary condition (sentence-by-sentence vs. stationary: $b=0.22$, $SE=0.092$, $t=2.36$; moving-window vs. stationary: $b=0.16$, $SE=0.064$, $t=2.57$) and obtained a similar reading pace in the sentence-by-sentence and moving-window conditions ($b=0.052$, $SE=0.080$, $t=0.65$). Proficient decoders obtained their highest reading pace in the sentence-by-sentence condition (sentence-by-sentence vs. stationary $b=0.61$, $SE=0.066$, $t=9.34$; sentence-by-sentence vs. moving-window: $b=0.52$, $SE=0.052$, $t=9.94$; moving-window vs. stationary: $b=0.096$ $SE=0.050$, $t=1.94$). We observed no reliable interactions of COMPREHENSION PROFICIENCY.

6.5.3 Discussion

None of the three presentation modes revealed a clear comprehension advantage, yet texts that were presented sentence by sentence induced a significant reading time advantage over texts that were presented word by word. Hence, the sentence-by-sentence format seems to be a more efficient way of presenting texts to beginning readers. These results indicate that, in general, horizontal saccadic eye movements and visual crowding effects of adjacent words do not pose substantial problems for beginning readers. Moreover, word-preview benefits – and the opportunity to skip words – may permit readers to attain a higher reading pace without compromising their comprehension of texts.

However, the exploratory analyses on the influence of readers' decoding and comprehension proficiencies revealed a more complicated picture, especially for second-grade readers. Perhaps the most remarkable finding was that second-grade readers with lower decoding skills obtained relatively high accuracy scores for narrative texts that were presented in a sentence-by-sentence format, yet their accuracy scores for expository texts were relatively high in the stationary word-by-word format. This suggests that reducing the number of saccades may be beneficial for struggling decoders if the text poses high demands on their comprehension skills, as is presumably the case when they are confronted with an expository text – a genre younger readers are often unfamiliar with (Best, Floyd, & Mcnamara, 2008). This view on the data is strengthened by the observation that the accuracy scores of second-grade

[26] Final model: Log Reading Time ~ 1 + DECODING PROFICIENCY x PRESENTATION MODE + (1 + DECODING PROFICIENCY + PRESENTATION MODE | Participants) + (1 + DECODING PROFICIENCY x PRESENTATION MODE | Texts).

readers with lower comprehension skills were also relatively high during stationary reading, in particular when compared to their accuracy scores in the moving-window word-by-word condition.

In addition, the exploratory analyses showed that not only struggling readers benefit from word-by-word texts. Proficient second-grade decoders obtained their highest accuracy scores for narrative texts when reading in a stationary and moving-window fashion. Similarly, proficient second-grade comprehenders obtained their highest accuracy scores in the moving-window condition. However, for these readers the beneficial effects of word-by-word reading cannot be attributed to a reduction of the number of saccades. In fact, the opposite seems to be the case. Preventing proficient second-grade comprehenders from moving their eyes during reading has a detrimental effect on comprehension as they obtained their lowest comprehension scores during stationary reading. Hence, perhaps a more plausible explanation for the advantages of word-by-word reading for proficient second-grade readers is that it induces an (incremental) processing approach in which the information of each word is immediately and meticulously integrated with the information of prior text (Koornneef & Van Berkum, 2006).

Lastly, the advantages of reading without saccades (i.e., stationary reading) are most relevant in Grade 2. By the time pupils are attending Grade 3, the vast majority of pupils – including those who struggle – benefit from a text format in which a more customary reading style (i.e., including horizontal saccadic eye movements) can be attained.

6.6 General Discussion

Three research objectives were identified in the current study. First, we examined whether second- and third-grade readers in the Dutch educational system either benefit or experience drawbacks from texts with a segmented layout. Second, we considered the sources of the advantages and disadvantages of segmented texts by evaluating how their features impact basic reading and higher-order integration processes. Third, we studied how individual differences in reading abilities constrain the efficacy of the layout of a text.

Relative to texts with a traditional layout, no overall comprehension advantage was observed for texts in which each sentence was presented on a new line of the page (Experiment 1). Yet, a robust comprehension advantage manifested itself in two self-paced

RSVP layouts in which the texts were presented one sentence or one word at a time (Experiments 2 and 3). Improved comprehension was accompanied by increased reading times in both presentation modes. This trade-off between speed and accuracy was exceptionally prominent when the texts were presented word by word. The reading time delays in texts that were presented sentence by sentence were far less extreme (Experiments 2-4). We therefore postulate that a single-sentence self-paced RSVP format constitutes a suitable way – arguably one of the most suitable ways – of presenting texts to beginning readers.

6.6.1 Why do beginning readers benefit from segmented texts?

As discussed in sections 6.1.1 and 6.1.2, a comprehension advantage for segmented texts may stem from two main sources. One the one hand, segmented texts may require fewer cognitive resources for basic reading (decoding, parsing) and eye–movement processes, thereby releasing cognitive resources for higher-order comprehension processes. On the other hand, segmented texts may probe higher-order comprehension by inducing a more accurate yet intensive processing approach. While both accounts have their merits, we will argue that the overall pattern of results is more compatible with the latter account.

Relating to the first account, we obtained no strong evidence for the claim that reading comprehension is compromised when clausal units are interrupted by a line break (Experiment 1) (cf., Levasseur et al., 2006; Tiffin-Richards & Schroeder, 2018). Furthermore, horizontal saccadic eye movements do not seem to pose a severe problem for beginning readers and reducing the degree of visual crowding does not positively influence reading comprehension and reading speed. At least not to the extent that it outweighs word-preview benefits and the possibility to skip words (Experiment 4). Our results, however, do point out that beginning readers may profit from limiting or fully eliminating the possibility to look back to earlier sections of a text – as is the case in sentence-by-sentence and word-by-word presentation modes respectively. Moreover, removing the need for complex return sweeps may be beneficial for reading comprehension (Experiments 2 and 3). Hence, these finding are compatible with the claim that segmented texts positively impact comprehension by streamlining more basic aspects of reading.

However, the presence of a robust speed-accuracy trade-off in Experiments 2 and 3 lends more support for an account in which the comprehension advantage of segmented texts is attributed to more intensive processing on part of the reader. Intensive processing may be an artefact or a strategic consequence of self-paced RSVP reading tasks. Because quite a few repetitive manual responses (i.e., button presses) are required to progress through the texts, readers are essentially forced to spend more time on the task at hand. As an advantageous epiphenomenon their understanding of the texts may improve. In addition to this inherent property of the task, readers may regulate their processing strategy for self-paced RSVP texts more actively. Because they cannot reread prior sentences or prior words, they are stimulated to consider the available visible input more carefully and update their mental representation of the text more frequently. Moreover, a sentence-by-sentence presentation mode may encourage readers to spend more time on sentence wrap up, to settle comprehension problems and integrate the sentence into the prior context before moving on to the next sentence.

This latter view on our results is particularly interesting considering a recent study by Tiffin-Richards and Schroeder (2018). They observed that German-speaking children in Grades 2 and 3 need to rely more on sentence-final wrap up than do older readers, presumably because less efficient readers postpone integrational processing to sentence boundaries. In Grade 4 the wrap-up processes of the German children exhibited a more adult-like pattern. These results present a rationale for why a sentence-by-sentence presentation mode reflects an optimal layout for our population of second- and third-grade pupils. Because these readers still heavily rely on sentence-final wrap up to obtain an integrated representation of a text, stimulating them to do so may increase the quality of their mental representation of a text considerably.

6.6.2 Who will benefit the most from segmented texts?

A common hypothesis is that less efficient readers will benefit the most from texts presented in segments (Castelhano & Muter, 2001; Chen, 1986; Lemarié et al., 2008). On the assumption that many pupils in Grades 2 and 3 are less efficient readers compared to older children and adults, our results are in line with this hypothesis. After all, the vast majority of our participants displayed a comprehension advantage for segmented texts, whereas prior studies did not reveal this pattern for older, more experienced readers (Benedetto et al., 2015; Lemarié et al., 2008; Rayner et al., 2016; Van Silfhout, 2014; Van Silfhout, Evers-Vermeul, Mak, et al., 2014; Van Silfhout, Evers-Vermeul, & Sanders, 2014; but see Chung-Fat-Yim et al., 2017). Perhaps more interestingly, the hypothesis also predicts that less efficient readers within a population of beginning readers should benefit the most. Our exploratory analyses on the interplay of text layout and readers' decoding and comprehension skills showed that this holds to some extent. We did not observe a consistent pattern across experiments, however.

On the one hand, several findings confirmed the hypothesis. In Experiment 4, struggling second-grade readers displayed increased comprehension for texts in which saccadic eye movements were kept to a minimum. Proficient second-grade readers showed the opposite. Their understanding of a text decreased when saccadic eye movements were marginalized during reading. Furthermore, in Experiment 2 struggling second-grade readers processed expository texts that were presented sentence by sentence more quickly than expository texts that were presented in a traditional, continuous manner. This reading time advantage was not observed for more proficient readers, which again is consistent with the idea that struggling readers will benefit the most from a segmented layout.

On the other hand, it also became clear that in some specific situations segmented texts yield more advantages for proficient beginning readers. For example, in Experiment 4 proficient second-grade pupils obtained relatively high comprehension scores for texts when presented in a word-by-word manner – possibly because they were stimulated to adopt a more incremental processing strategy. Furthermore, the most striking evidence against the hypothesis that segmented texts solely assist more vulnerable beginning readers was obtained in Experiment 1. Proficient second-grade readers displayed a comprehension advantage (and a nonsignificant reading time advantage) for a discontinuous layout in which each sentence started on a new line of the page. The results for struggling second-grade readers showed no signs of these benefits. In fact, struggling readers slowed down while reading discontinuous texts. Hence, although the main purpose of a discontinuous layout is to assist more vulnerable beginning readers, the results of Experiment 1 enforce an unanticipated conclusion: not struggling beginning readers will benefit from a discontinuous layout, but proficient beginning readers will – reflecting a 'Matthew effect' (e.g., Shaywitz et al., 1995) for this reading intervention.

At this point we should reemphasize that our analyses on the interplay of text layout and pupils' reading skills were exploratory. Due to the nature of the data several separate analyses were conducted, thereby inflating the probability of reporting on false-positive findings. Furthermore, no consistent picture emerged when comparing the modulating effects of decoding skills to the modulating effects of comprehension skills. We therefor refrain from committing to an overly detailed interpretation of these exploratory analyses. The results allow for several interesting general conclusions, nevertheless. First, many pupils in Grades 2 and 3 will benefit from a segmented presentation mode of texts. Second, both reader characteristics and text genre determine the efficacy of the presentation mode of a text. Third, severely segmented (i.e., word-by-word) texts have a beneficial influence on comprehension in some situations, even for more proficient beginning readers. Fourth, the potential advantages of severely segmented texts are most relevant in the early stages of reading acquisition. By the time pupils are attending Grade 3 the advantages seem less prominent, and a mildly segmented (i.e., sentence-by-sentence) mode becomes a more suitable way of presenting texts to most readers.

6.6.3 Digital approaches to enhance reading: The educational toolbox of future reading

The present study has several interesting implications for reading in educational environments. Perhaps the most remarkable practical implication is that segmented texts present a feasible alternative to texts with a traditional layout. Educational practitioners and developers should be made more aware of this as it will provide a tool for designing optimal learning environments, especially in the current digital era. To further illustrate the wide scope of possibilities offered by segmented texts and other powerful features of the 'educational toolbox of future reading', we will discuss the main findings of our study in light of several high-potential digital reading applications (i.e., SLTR, Spritz, BeeLine Reader, WebClipRead).

The computer-based reading intervention Span Limiting Tactile Reinforcement (SLTR) is arguably the most comprehensive method that will be addressed. STLR was originally developed by Schneps and his colleagues to optimize the learning outcomes of dyslexic readers (Schneps, 2015; Schneps, Thomson, Sonnert, et al., 2013; Schneps et al., 2010; Schneps, Thomson, Chen, et al., 2013). In SLTR a digital text is reformatted into a single column with only a few words per line. Readers are encouraged to keep their gaze at the top of the page and control their reading pace with a jockey wheel to manually progress through a text one line at a time. Schneps et al. observed that while SLTR improves the reading of dyslexics, the benefits vary with individuals. They speculated, therefore, that the advantages of SLTR should carry over to more typically developing readers.

Several of the design principles of SLTR are rooted in the layout features that were assessed in the current study. First, short lines of text are presented. By adopting this presentation mode, the reader will profit from the word-preview effect, yet the overall distractibility of surrounding text is decreased. According to Schneps et al. this will diminish the incidence of redundant regressive eye movements. Second, by instructing readers to maintain their focus on the top line and scroll through the text line by line, SLTR closely resembles our self-paced sentence-by-sentence presentation mode. Consequently, SLTR may relax the demands on oculomotor control while promoting incremental integration, just like we postulated for a single-sentence presentation mode. Another beneficial feature of SLTR is that the finger action required to proceed to the next line of the text provides ‘tactile-kinesthetic’ reinforcement. This reinforcement may increase comprehension as it punctuates each phrase while reading (Schneps et al., 2010). Interestingly, these potential benefits of manual reinforcement would provide an explanation for why we observed no overall comprehension advantage for the discontinuous layout in Experiment 1 (where each sentence was presented on a new line) yet observed a comprehension advantage for the single-sentence RSVP layout in Experiment 2. These two presentation formats share many design principles, yet only the latter provides tactile-kinesthetic support as readers press a button to proceed to the next sentence.

Whereas Schneps and his colleagues put their reading application to the empirical test, many developers fail to do that, or claim too much based on the available evidence. Spritz (www.spritzinc.com) is one of the applications that has been criticized for doing the latter and, perhaps as a result thereof, received a lot of attention in the media and academic world (Benedetto et al., 2015; Rayner et al., 2016; Ricciardi & Di Nocera, 2017; Schotter et al., 2014). In Spritz, single-word stationary RSVP reading is combined with an algorithm to highlight the letter that reflects the optimal viewing position of each word. Furthermore, longer words are displayed for a longer time and longer sentences have longer pauses at the end of the sentence. Although the criticism of several scholars concerning the bold claims of the developers is accurate (e.g., “only 20% of the reader’s time is spent processing content while 80% of the time is spent moving the eyes” and “every saccade has a penalty in both time and comprehension”, see Rayner et al., 2016), we should nuance the criticism somewhat. That is, based on the findings in the current study it is clear that Spritz incorporates several powerful design principles to assist beginning and other less efficient readers (e.g., segmented layout, additional time for sentence-final wrap-up). Hence, it would be premature to disregard this high-potential reading application.

The layout features of texts presented with methods like SLTR and Spritz are radically different from those of traditional texts. Instead, BeeLine Reader (www.beelinereader.com) is an interesting digital reading aid that modifies the appearance of texts in a subtle way. With BeeLine Reader the lines of a text are colored in a gradient by adopting a procedure that ensures that the end of one line and the beginning of the next are colored similarly. This is thought to facilitate visual tracking and it allows for smooth return sweeps. In fact, according to its developers "Beeline Reader is a research-backed tool that improves reading ability for students of all ages and skill levels". Although we were unable to locate the research that would substantiate these claims, we agree with the developers and Schneps (2015) that BeeLine Reader is a clever application that has the potential to make reading more efficient, in particular for beginning readers who struggle to guide their eye gaze and attention from one line to the next.

Without a doubt, the current digital era produced several high-potential digital applications to streamline a wide range of reading processes – the reading applications discussed above only represent a small sample of the total number of potentially useful applications. In the long run, we envision even more comprehensive digital systems that take full advantage of the ongoing developments by combining the strengths of multiple reading applications. These systems of the future should be adaptive, meaning that they will be able to monitor readers' eye-movement behavior, cognitive load, and text comprehension on the fly, and modify the layout of a text accordingly (cf., Öquist & Goldstein, 2003; Rosch & Vogel-Walcutt, 2013).

Before these adaptive systems can become operational, however, a more complete picture should be obtained of how specific adjustments to the layout of a text will affect reading. That is, although we believe that our study presents a significant step forwards in this endeavor, many open issues remain. For example, our data show that only proficient beginning readers (not struggling beginning readers) will benefit from a discontinuous layout with each sentence starting on a new line of the same page. At this point, we do not fully understand why that is the case. Furthermore, whereas we highlighted the beneficial effects of single-word and single-sentence presentation modes, Schneps et al. (2010) proposed that each line in a segmented text should contain two or three words instead. Moreover, Walker et al. (2005) developed a technique to make a segmented multiple-word layout even more powerful by using Visual Syntactic Text Formatting (VSTF). This procedure transforms blockshaped text into cascading patterns to help readers identify the grammatical structure of a sentence (VSTF is available as WebClipRead at www.liveink.com). Together, these design principles raise the question of what would constitute the optimal parsing procedure for a segmented text in terms of the length and content of its chunks (cf. Sharmin, Špakov, & Räihä, 2012; Young, 1984). Another issue concerns our interpretation of the increased reading times for segmented texts. We postulated that they reflect a more intensive, effortful processing strategy. However, other factors may play a role here. For example, most children will be unfamiliar with sentence-by-sentence or word-by-word texts and increased processing times for these presentation modes can thus be attributed to a novelty effect. In fact, one could argue that the pupils in our study were quite attracted to the layout of segmented texts – thereby increasing their attention – which in turn could affect their level of engagement and reading motivation. This would raise the question of whether segmented texts have a durable influence on children's reading approach, as novelty effects tend to wear off quickly (Reinders, 2017).

In all, the issues that were addressed in the present study illustrate that, in a way, we are still beginning to uncover the wealth of opportunities offered by information technology. Consequently, we should commit to investigate the potential benefits of alternate digital reading methods in a more systematic way. An important next step is to examine the collective influence of a set of prominent layout features (smaller vs. larger chunks of text, single- vs. multiple-line layout, self-paced vs. non-self-paced reading, manual reinforcement, gradient coloring, etc.) in series of well-controlled (longitudinal) studies in which the configuration of features is varied systematically among different age groups and types of readers. Only then we will be able to decipher how layout features and the characteristics of readers interact and make grounded decisions on effective text design.

6.6.4 Conclusion

Whether, when, and how segmented texts will be applied in classrooms or other educational settings will be closely related to the goals set by reading education. On the one hand, presenting texts with simplified layouts to beginning readers may prevent them from optimizing their reading skills for texts with a traditional layout. On the other hand, in the current day and age the landscape of reading is expanding at a remarkable rate. Many texts are read in a digital form, not seldom from small, handheld devices. Although this development induces substantial challenges to readers, it also presents many opportunities to improve the reading experience of people. Moreover, it suggests that presenting texts on paper in a continuous format is something of the past.

Regardless of whether traditionally formatted texts will disappear (gradually), we can conclude that segmented texts present a powerful tool to increase the reading abilities of beginning readers. Pending relevant data to suggest otherwise, a presentation mode in which texts appear one sentence at a time seems to combine the better of two worlds. First, while preserving word-preview benefits, disruptive return sweeps and long-distance regressions are removed from the eye-movement behavior. Second, a sentence-by-sentence presentation mode may promote sentence wrap-up and other integration processes, thereby improving the quality of reader's mental representation of a text. Together with the design principles of high-potential reading applications (SLTR, Spritz, BeeLine Reader, WebClipRead) these findings present a fruitful starting point to develop adaptive applications, aimed at augmenting the comprehension abilities of young, beginning readers.

Chapter 07

Summary and General Discussion

The central aim of this dissertation was to gain insight into the on-line text processing and strategy use by young (second-grade) low- and high-comprehending readers as they read expository and narrative texts for comprehension, with an additional aim to provide insight into distinct reading profiles. A second important aim of this dissertation was to gain insight into the effect of text layout on the text comprehension and reading speed of young (second- and third-grade) readers.

This dissertation consists of six chapters. The first chapter introduces the subject 'reading comprehension' and provides an outline of the chapters of this dissertation. Chapter 2 is a theoretical chapter which reviews research on sources of individual differences in reading-comprehension skills from the view of the Landscape Model of Reading Comprehension (van den Broek, Risden, Fletcher, & Thurlow, 1996; Helder, van den Broek, Van Leijenhorst, & Beker, 2013). Chapters 3 and 4 describe two experimental studies that focused on the on-line text processing and strategy use by young low- and high-comprehending readers. Specifically, a think-aloud study is described in Chapter 3 and an eye-tracking study in Chapter 4. By using different, complementary on-line research methods we intended to define a comprehensive picture of the on-line text processing and strategy use of these young readers. In Chapter 5 the data of the think-aloud and eye-tracking studies described in Chapters 3 and 4 are analyzed in conjunction, to explore whether subgroups of readers with specific reading styles that were distinguished in the think-aloud study were also characterized by different eye-movement patterns. Chapter 6 describes a study that focused on the effect of different text layouts on young readers' text comprehension and reading speed.

Following Cain and Oakhill (2007) and Nation (2005), in the studies described in Chapters 3, 4, and 5, we defined our low-comprehending readers as readers who have difficulty comprehending connected text despite having age-appropriate technical reading skills, with the addition that their intelligence is normally developed and that they don't have diagnosed behavioral problems. In Chapter 6, two Dutch standardized tests for reading comprehension and decoding proficiency were used as continuous variables for reading-comprehension skills and word-decoding skills, respectively.

The remainder of the current chapter is structured as follows: first, I summarize the main findings of the conducted empirical studies. Second, I discuss the findings in a broader context. Third, I reflect on limitations and future research, and, finally, I discuss implications for educational practice.

7.1 Summary of empirical studies

In a think-aloud study described in **Chapter 3**, we investigated the on-line comprehension processes and strategy use of second-grade low- and high-comprehending readers when reading narrative and expository texts for comprehension. In addition, we investigated whether the distinction of two types of struggling readers -- i.e., *paraphrasers* and *elaborators* (McMaster et al., 2012; Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007) -- already exists at a young age, and whether the distinction of paraphrasers and elaborators also pertains to high-comprehending readers, expanding prior research on this matter.

Participants read two narrative and two expository texts aloud in a sentence-by-sentence manner and were asked to express their thoughts out loud after each sentence. Recordings of the verbal protocols were transcribed and parsed into idea units (Trabasso & van den Broek, 1985), which were then coded into eight categories (*Restating the Sentence, Explaining the Sentence, Elaborative* and *Predictive Inferences* that are either *Valid* or *Invalid*, *Comments, Question, Silent Period,* and '*Other*'; Linderholm & van den Broek, 2002; McMaster et al., 2012; Rapp et al., 2007). To assess the quality of the after-reading mental text representations, participants answered literal and inferential comprehension questions (cf., Cain & Oakhill, 1999), and to determine possible factors contributing to comprehension differences, they completed a test battery assessing general cognitive and language-related proficiencies. In addition, to explore the existence of subcategories of readers a cluster analysis (Ward & Hook, 1963) was conducted on the subgroups of low-comprehending readers (cf., McMaster et al., 2012) and high-comprehending readers.

A general conclusion from the results of the think-aloud study is that low- and high-comprehending readers do not differ in their overall patterns of strategy use and use a variety of comprehension strategies, ranging from literal repetitions to elaborate text-based and knowledge-based inferences. In addition, the results indicate that text genre affects the way the readers process texts; when reading narrative texts they made more text-based and knowledge-based inferences, and when reading expository texts they made more comments and asked more questions, but they also made a higher number of invalid knowledge-based inferences. This latter finding could be ascribed to the low-comprehending readers. A secondary conclusion from this study is that both young low-comprehending readers as well as high-comprehending readers can be classified as paraphrasers or elaborators, each subgroup having its distinct, characteristic reading profile; paraphrasers construct a limited mental representation that mainly reflects the literal meaning of the text, whereas elaborators attempt to enrich their mental representation by generating text-connecting and knowledge-based inferences (cf., McMaster et al., 2012; Rapp et al., 2007).

Whereas in the study described in Chapter 3 we examined the on-line comprehension processes and strategy use of young low- and high-comprehending readers by using a think-aloud protocol, the purpose of the study described in **Chapter 4** was to gain insight into the on-line text processing of these young low- and high-comprehending readers by tracking their eye movements as they read expository and narrative texts for comprehension. We hypothesized that, compared with narrative texts, beginning readers need to adjust their reading strategy for expository texts to optimize reading comprehension. Furthermore, we anticipated that high-comprehending readers would adjust their reading strategy more easily (and therefore more noticeably) than low-comprehending readers. Based on this anticipation, we predicted that reading proficiency and text genre variables would interact and expected ‘later’ eye-tracking measures associated with higher-level integrative processing (e.g., *second-pass fixation duration*) to be more sensitive to this interaction than ‘early’ measures associated with the processing stage of word identification (e.g., *first fixation duration*; Boland, 2004; Boston et al., 2008; Juhasz & Pollatsek, 2011, Kuperman & Van Dyke, 2011).

Participants silently read two expository texts and two narrative texts from a computer screen while their eye movements were recorded. The texts were presented in their entirety with each sentence beginning on a new line. The task was self-paced. After completion of each text, the text was removed from the screen and the participant answered six comprehension questions orally. *Full text reading times* and *full text fixation counts* were computed as coarse measures of processing strategies. In addition, several finer-grained reading measures for each individual word of a text were computed (see e.g., Juhasz & Pollatsek, 2011): *first fixation duration*, *first gaze duration*, *right-bounded duration*, *total fixation duration*, *second-pass fixation duration*, *first-pass regression probability, first-pass word skipping probability* and *saccade amplitude*.

A general conclusion from this study is that, relative to narrative texts, low-comprehending readers react differently to expository texts than high-comprehending readers. The results revealed evidence for reading proficiency and text genre interactions in several eye-movement measures (i.e., *full text reading time* and *fixation count, total fixation* *duration, second-pass fixation duration, saccade amplitude, word-skipping probability*). The general pattern was that narrative texts induced prolonged, more intensive processing for low-comprehending readers than for high-comprehending readers. This difference between low- and high-comprehending readers was attenuated in the case of expository texts. However, the patterns of these interactions were difficult to reconcile with the hypothesis that high-comprehending readers adapt their reading style to text genre, whereas low-comprehending readers do not. Namely, for narrative texts, the reading patterns of low- and high-comprehending readers revealed robust differences consistent with prior findings for good versus struggling readers (e.g., longer first- and second-pass reading times for low-comprehending readers). For expository texts, however, the differences in the reading patterns of low- and high-comprehending readers were attenuated. The results suggest that low-comprehending readers adopt a suboptimal processing approach for expository texts: relative to their processing approach for narrative texts, they either do not adjust their reading strategy or they adjust towards a more cursory strategy. Both processing approaches are suboptimal because expository texts tend to demand more, rather than less, cognitive effort of the reader than narrative texts (Williams, Hall, & Lauer 2004).

In the study described in **Chapter 5**, we explored whether readers that were characterized as low- and high-comprehending paraphrasers and elaborators on the basis of the think-aloud experiment described in *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 the eye-tracking experiment described in *Chapter 4* in conjunction with their think-aloud data. 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 showed similarities with the eye-movement patterns of subgroups of readers that have been distinguished in prior eye-tracking studies by Koornneef and Mulders (2016), Olson, Kliegle, Davidson and Foltz (1985), Rayner, Castelhano and Yang (2009), and Rayner, Reichle, Stroud, Williams and Pollatsek (2006). Based on these prior eye-tracking studies on subtypes of readers, the primary measures consisted of *first-pass regression probability* and *first-pass word skipping probability*. We hypothesized that paraphrasers would look back less often in the texts and would skip fewer words than elaborators.

Regarding high-comprehending readers, the results indicate that high-comprehending paraphrasers skip fewer words than high-comprehending elaborators, but there is no indication that they look back less often. Also, there is no indication that the subgroups follow different eye-movement patterns for narrative and expository texts, respectively, on the primary eye-movement measures, nor that their eye-movement patterns correspond to the patterns of subgroups of readers that have been distinguished in prior eye-tracking studies. General conclusions for high-comprehending readers are that the reading profiles of high-comprehending elaborators and paraphrasers are partly characterized by different eye-movement patterns and that there is no evidence that paraphrasers and elaborators adapt their eye movements to texts genre.

Regarding low-comprehending readers, the results indicate that the subgroups demonstrate similar eye-movement patters regarding word-skipping probability and regression probability. However, low-comprehending paraphrasers adjust their reading style to text genre, whereas low-comprehending elaborators do not. Specifically, low-comprehending paraphrasers make more regressions and skip fewer words when reading narratives than when reading expository texts**.** Thus, they appear to read narratives more carefully than expository texts. This adaptation would seem counterproductive in that a more *precise* reading style for expository texts would be desirable instead of a more cursory one 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). In addition, there is no indication that the eye-movement patterns of low-comprehending paraphrasers and elaborators match the patterns that have been distinguished in prior eye-tracking studies. Besides, their eye-movement patterns differ from those of the subgroups of high-comprehending paraphrasers and elaborators. General conclusions for low-comprehending readers are that the reading profiles of low-comprehending paraphrasers and elaborators are not characterized by different eye-movement patterns and that low-comprehending paraphrasers adapt their reading style to text genre, in a direction that is undesirable for comprehending expository texts.

Whereas the studies described in Chapters 3, 4, and 5 focused on the reader, the study described in **Chapter 6** focused on text properties, in particular text layout. The central aim was to examine the effect of layout of digital texts on text comprehension and reading speed of beginning, young readers. A second aim was to explore why beginning readers may benefit from a specific layout. A third aim was to gain more insight into whether and how individual differences in reading skills (i.e., decoding and comprehension skills) constrain the efficacy of the layout of a text. A series of four self-paced reading experiments in which second- and third-grade pupils read two narrative and two expository texts with different text layouts was conducted to assess the effect on text comprehension and reading speed. In the baseline condition, sentences continued on the same line as far as page width allowed. In three conditions with a segmented layout, (1) each sentence was presented on a new line of the page in a discontinuous layout, (2) texts were presented sentence by sentence in a reader-paced Rapid Serial Visual Presentation (RSVP; Young, 1984), and (3) texts were presented word by word in a reader-paced RSVP. In a fourth experiment, we compared the influence on reading comprehension of sentence-by-sentence and word-by-word presentation modes and included a third condition in which the texts were presented in a self-paced word-by-word moving window manner, requiring readers to plan and execute saccades. To assess pupils' comprehension of the texts, six comprehension questions were posed after each text. To get insight into the pupils' word-decoding and text comprehension proficiencies, their scores on two widely used standardized tests were obtained from their schools.

The results of this study imply that a single-sentence self-paced RSVP format is a particularly suitable way of presenting texts to readers in the early stages of reading acquisition. Specifically, the results revealed that no overall comprehension advantage was observed for texts in which each sentence was presented on a new line of the page (Experiment 1), relative to texts with a continuous layout. However, a robust comprehension advantage manifested itself in the two self-paced RSVP layouts in which the texts were presented sentence by sentence (Experiment 2), or word by word (Experiment 3), at the cost of increased reading times. This trade-off between speed and accuracy was particularly prominent when the texts were presented word by word. Reading time delays were far less extreme in texts that were presented sentence by sentence (Experiments 2 and 4).

We also explored *why* beginning readers benefit from segmented texts. The overall pattern of results indicated that segmented texts probe higher-order comprehension by inducing a more accurate yet intensive processing approach.

Lastly, with this study we wanted to gain more insight into whether and how individual differences in reading skills constrain the efficacy of the layout of a text. The analyses on the interaction of text layout and pupils' reading skills were of an exploratory nature, but allow for four general conclusions. First, many pupils in Grades 2 and 3 will benefit from a segmented presentation mode of texts. Second, the efficacy of the presentation mode of a text is determined by both reader characteristics and text genre. Third, severely segmented (word-by-word) texts have a beneficial influence on comprehension in some situations, even for more proficient readers. Fourth, the potential advantages of severely fragmented texts (word-by-word presentation) are most relevant in the early stages of reading acquisition; for readers in Grade 3 the advantages seem less prominent, and a sentence-by-sentence presentation mode of texts then is a more suitable for most readers.

7.2 General discussion

The studies of this dissertation advance our understanding of how young, second-grade low-comprehending readers differ from high-comprehending readers in their on-line cognitive processes and strategy use when reading narrative and expository texts for comprehension and provide insight into distinct reading profiles. In addition, they provide insight into the effects of different text layouts on text comprehension and reading speed of young, second- and third-grade readers. In the following section, I will discuss these issues along with some questions that the studies of this dissertation raise.

7.2.1 Individual differences in reading comprehension: low- versus high-comprehending readers

Comprehension of a text implicates the construction of a mental representation of the meaning of the text. In order to understand individual differences in reading comprehension, it is useful to consider both the *product* of reading (i.e., the mental representation) and the *process* leading to the construction of a mental representation. The Landscape Model of Reading Comprehension (van den Broek et al., 1996; Helder et al., 2013) takes into account both the product and the process in an integrative explanation of reading comprehension. According to the model, the reader must connect parts of the text with each other and combine parts of the text with information from background knowledge that he or she has recruited during reading in order to construct a coherent mental representation of the meaning of the text. Comprehension of a sentence and the ongoing development of a mental representation constantly interact with each other as the reader progresses in the text, making reading a dynamic process. Studying the process of reading by looking at on-line text processing can give an insight into readers' heads and shed light on individual differences and possible underlying sources.

Process of reading. Both the think-aloud method and the eye-tracking method give insight into the cognitive processes readers engage in during reading. We applied both methods to provide a comprehensive picture of these processes. And, in fact, the two methods complemented each other in delineating the text-processing approaches and strategy use of low- and high-comprehending readers. On the one hand, results from the think-aloud study revealed that the text-processing approaches of low- and high-comprehending readers were quite similar. That is, both groups of readers made use of a range of strategies and, moreover, they did not differ in their patterns of text-processing strategies. Results from the eye-tracking study, on the other hand, revealed differences between the eye-movement patterns of low- and high-comprehending readers. In general, in eye-tracking studies measures of initial or early processing (first-pass measures) are assumed to represent lower-level processes and skills, such as decoding of orthographic information and word identification, whereas later processing measures are assumed to represent higher-level processes and skills involved in integrative text processing (Boland, 2004; Boston et al., 2008; Juhasz & Pollatsek, 2011, Kuperman & Van Dyke, 2011). Results on early eye-movement measures in our eye-tracking study indicated that low-comprehending readers experience more problems with processes of word identification and early (syntactic) integration than high-comprehending readers.

The findings of the think-aloud and eye-tracking studies in this dissertation provide different insights into the different text-processing approaches of low- and high-comprehending readers. This may lead to the reflection that the think-aloud and eye-tracking methods are both viable methods to give insight into readers' on-line text-processing approaches, but that they reveal different aspects of what young readers do when processing texts, or different stages in their text processing. Both methodologies have their strengths and limitations. Eye tracking, on the one hand, does not have an impact on the normal reading process and provides a precise time sequence of processing, but it does not provide direct insight into what processing occurs exactly. So, one-to-one mapping between specific eye movements and specific cognitive processes is difficult (Boland, 2004; Kuperman & Van Dyke, 2011), but the general mapping of early and late measures is widely accepted. Thinking aloud, on the other hand, does provide insight into the exact processing that occurs during reading, but the method itself may alter the normal reading process and can only give insight into processes readers are aware of (Rapp et al., 2007). In our think-aloud study, children were instructed to think out loud after each sentence they read, without further guidance. According to Ericsson and Simon (1980) this manner of concurrent verbalization “will not change the structure and course of the task processes, although it may slightly decrease the speed of task performance” (p. 226). Likewise, Rhenius and Deffner (1990) concluded that verbalizations reflect concurrent thought and that concurrent thinking aloud only differs from normal thinking with regard to solution times (i.e., longer solution times for thinking aloud) when they compared data of concurrent thinking aloud with eye-movement data in problem-solving and logical-reasoning tasks. However, in the context of discourse comprehension it has been postulated that the think-aloud protocol may alter or disrupt the reading process (Pressley & Afflerbach, 1995; Rapp et al., 2007), that thinking aloud tends to stimulate active use of strategies during reading (Chi, de Leeuw, Chiu, & LaVancher, 1994; Coté, Goldman, & Saul, 1998), and that the methodology can be used as an intervention to stimulate children to apply strategies during reading (Trabasso & Magliano, 1996).

Although combining concurrent thinking aloud with eye tracking is rather common in usability research (e.g., research on the functionality of websites), in research on text-comprehension processes a concurrent combination of both research methods is much less common (but see e.g., Kaakinen & Hyönä, 2005: in this study on the effect of perspective taking on text comprehension, eye-fixation patterns were associated with processing strategies that were verbally reported. Verbal responses indicating deeper processing were associated with longer first-pass fixation times than verbal responses indicating shallower processing). Leaving aside practical challenges, in future research it would be interesting to follow up on combining both methods concurrently to investigate readers’ on-line text-processing approaches.

As to the differences in the findings of the think-aloud and eye-tracking studies in this dissertation regarding the text-processing approaches of low- and high-comprehending readers, it should also be noted that although the experimental texts were matched on readability and length, they were not presented in the same mode in the think-aloud and eye-tracking studies. That is, in the think-aloud study, experimental texts were presented in a booklet, in a sentence-by-sentence manner, and the children read the texts out loud and thought aloud after reading each sentence. In the eye-tracking study, experimental texts were presented digitally on a computer screen, in their entirety with each sentence beginning on a new line, and the children read the texts silently.

It has been proposed that the single-sentence format in the think-aloud method may impair comprehension processes and discourage or prevent proficient readers from using certain strategies they would normally use during reading, for instance looking back and forward in the text (Coté et al., 1998; Rapp & Mensink, 2011). However, results from our text-layout study pointed out that low- as well as high-comprehending readers benefited in terms of comprehension from a sentence-by-sentence presentation as opposed to a presentation of the text as a whole. Therefore, it is not likely that our high-comprehending readers were disadvantaged by the think-aloud method with a single-sentence presentation.

It has also been proposed that reading aloud may influence the reader's processing approach, because the processes involved in reading aloud –e.g., eye-voice coordination and speech articulation--, may enforce extra demands on the reader's working memory and prevent readers from making regressions (Vorstius, Redach, & Lonigan, 2014). Similarly, the fact that the reader must articulate every word possibly leads to more emphasis on sublexical word properties (Huestegge, 2010). However, the children in our think-aloud and eye-tracking studies were beginning readers (second grade) and reading aloud is typical of beginning reading (Chall, 1983). Therefore, it is not very likely that the reading aloud hindered the children in their reading approach. Actually, the fact that the children had to read silently in the eye-tracking study may have contributed to the finding that low-comprehending readers experienced more difficulties with processes of word identification and early (syntactic) integration than high-comprehending readers in that study.

Product of reading. Regarding the *product* of reading, a general finding of the studies in this dissertation is that low-comprehending readers construct mental text representations of poorer quality than high-comprehending readers, as measured by off-line comprehension questions. This is not very surprising, since we clearly distinguished between low- and high-comprehending readers in our selection procedure. A second finding concerning the product of reading relates to the three types of questions we distinguished in our studies (i.e., literal questions that do not require inference making, questions requiring a text-connecting inference, and questions requiring a gap-filling or knowledge-based inference; cf., Cain & Oakhill, 1999). In the think-aloud study, all children performed better on literal questions than on text-connecting and gap-filling questions, and there was no difference between their performance on text-connecting and gap-filling questions. In the eye-tracking study, high-comprehending readers outperformed low-comprehending readers on all three question types.

There are various conceivable explanations for the poorer mental text representations of low-comprehending readers, as reading comprehension depends on a complex set of interacting processes. Several general cognitive factors (including background knowledge and working-memory capacity) and comprehension skills (including inferential skills) influence an individual's comprehension abilities and cause individual differences. As a rule, the more knowledge readers possess on topics in the text, the richer and more interconnected their text representation will be (Anderson & Pitchert, 1978; McNamara, Kintsch, Songer, & Kintsch, 1996; Voss, Vesonder, & Spilich, 1980). The inferential processes that allow readers to identify semantic relations draw heavily on their prior knowledge. Therefore, differences in background knowledge strongly influence readers' comprehension and representation of a text. We did not assess children's background knowledge on the topics of the experimental texts in our studies, but, possibly, differences in background knowledge led to differences in the quality of the mental text representations of low- and high-comprehending readers. It is important that children expand their background knowledge since this facilitates inference making. This can be achieved by offering children texts on a wide range of (current and informational) topics from an early age.

Another significant source of individual differences in readers' comprehension abilities concerns working memory. Differences in the capacity and efficacy of working memory affect comprehension in adults (Just & Carpenter, 1992; Linderholm & van den Broek, 2002; Virtue, van den Broek, & Linderholm, 2006; Whitney, Ritchie, & Matthew, 1991) as well as in children (Cain & Oakhill, 2007). A greater working memory facilitates the maintenance and processing of more information from the text and background knowledge, thus supporting the generation of inferences and the construction of a coherent representation. Results on a test that we administered to assess the children's verbal working-memory capacity pointed out that low-comprehending readers had a smaller working-memory capacity than high-comprehending readers.

A third source of individual differences in comprehension I want to address here relates to inferential skills. The information that is available to the reader at a particular point in reading needs to be connected by the reader by constructing, actively or passively, a particular semantic relation. Poorly comprehending readers often engage in suboptimal inferential processing during reading (Oakhill & Cain, 2011; Rapp et al., 2007). In fact, results from a test that we administered to assess the children's inferential skills indicated that low-comprehending readers had poorer inferential skills than high-comprehending readers. All in all, the challenges that young, low-comprehending readers are facing are most plausible of a multimorbid nature and deficits in skills closely related to reading comprehension need attention in order to improve readers' comprehension skills. In the section about implications for education (section 7.4), I will discuss this in further detail.

7.2.2 Individual differences in reading patterns and subgroups of readers: paraphrasers versus elaborators

As discussed in the previous section, individuals differ in their ability to comprehend the texts they read. And, even among high-comprehending readers who attain a solid understanding, there are differences in the profiles of processes they recruit to achieve their level of understanding. Similarly, low-comprehending readers who arrive at inadequate understanding may do so because of problems in different processes, leading to distinct subgroups of low-comprehending readers. Indeed, in our think-aloud study two subgroups of readers with their own, characteristic text-processing approach were clearly distinguished both within the subgroups of high- and low-comprehending readers, on the basis of their on-line think-aloud responses: paraphrasers and elaborators (cf. Karlsson et al., 2018; McMaster et al., 2012; Rapp et al., 2007). Paraphrasers, on the one hand, restrict their text-processing approach mostly to the current text by rewording and repeating sentences and generate relatively few inferences that connect text elements. Elaborators, on the other hand, link their own background knowledge to the information in the text, thereby making relatively many text-based and knowledge-based inferences and comments on the texts (McMaster et al., 2012). We distinguished these subgroups both within the groups of low- and high-comprehending readers, hereby expanding research on this topic. Yet, low-comprehending paraphrasers and elaborators did not differ in their eye-movement patterns and high-comprehending paraphrasers and elaborators only differed in some measures. Moreover, the eye-movement patterns of low- and high-comprehending paraphrasers and elaborators do not seem to be linked to subgroups of readers that have been distinguished in previous eye-tracking studies by Olson et al. (1985), Rayner et al. (2006, 2009), and Koornneef & Mulders

(2016); *plodders* or *conservative readers* who skip few words and make few regressions to previous words versus *explorers* or *risky readers* or *proactive readers* who skip words more often and make more regressions. In the current study, eye-movement patterns of low-comprehending paraphrasers and elaborators did not differ on the measures for word-skipping probability or regression probability and were not associated with the reading styles that Olson et al. (1985), Rayner et al. (2006, 2009), and Koornneef and Mulders (2016) distinguished. High-comprehending elaborators skipped more words than high-comprehending paraphrasers, displaying a somewhat more exploring or proactive reading style than high-comprehending paraphrasers, but the subgroups did not differ on the measure for regression probability.

A possible explanation, also mentioned in the previous section, is that the think-aloud and eye-tracking methods measured different aspects of the reading process. That is, the think-aloud method provides insight into the exact processing that occurs during reading but alters the normal reading process, whereas the eye-tracking method provides a precise time sequence of processing without interfering with the normal reading process but does not provide direct insight into what specific processing occurs. A related possible explanation is that the think-aloud method induced an active text-processing approach (Chi et al., 1994; Coté et al., 1998), and therefore revealed more differences between subgroups of readers, whereas the eye-tracking method did less so. 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. This calls for more (eye-tracking) research with a bigger sample size of low-comprehending paraphrasers and elaborators.

7.2.3 Influence of text properties on text processing

A reader's ability to adjust his or her reading to the genre of a text influences the depth of knowledge gained from reading (Oakhill & Cain, 2011). Expository texts are a genre young readers are often unfamiliar with (Duke, 2000) and tend to demand more cognitive effort of the reader than narrative texts (Williams et al., 2004). Therefore, to come to a good understanding of expository texts one would expect readers to need to adopt a more precise and intensive processing approach, relative to narrative texts. The studies of this dissertation examined differences between readers' processing of narrative texts and expository texts. Regarding the product of reading, overall, outcomes on after-reading comprehension questions revealed that readers constructed better mental representations of narrative texts than of expository texts, indicating that both low- and high-comprehending readers comprehended expository texts less well than narrative texts. This is in line with previous research (e.g., Best, Floyd, McNamara, 2008; Eason et al., 2012) and, considering that the participating children were young, unfamiliarity with expository texts is likely to have played a role here as well (Duke, 2000).

The findings of the studies of this dissertation do not provide a clear answer to the question of whether young, second-grade low- and high-comprehending readers can distinguish between different types of text and adjust their text-processing approach to text genre. On the one hand, the results of the think-aloud study provide an affirmative answer to this question. Moreover, the results of the think-aloud study indicated that low-comprehending readers made a similar distinction between narrative and expository texts as high-comprehending readers, using the same range of strategies for narrative texts and expository texts respectively, although low-comprehending readers made more invalid inferences when processing expository texts. Furthermore, the distinction the readers made in the use of strategies for narrative and expository texts was quite sensible, considering that young children are relatively unfamiliar with expository texts due to a lack of exposure to this type of texts (Duke, 2000) and that processing of expository texts requires more cognitive effort (Williams et al., 2004). Specifically, when processing expository texts both low- and high-comprehending readers asked more questions, were silent more often, made more comments, and made more invalid elaborative and predictive inferences (low-comprehending readers in particular) than when reading narrative texts. Whereas the text-processing approach of low-comprehending readers resembled the approach of high-comprehending readers in the think-aloud experiment, the eye-tracking experiment on the other hand revealed that low- and high-comprehending readers differed in their text-processing approaches for narrative and expository texts, the differences being more prominent in narratives. Their eye-movement patterns for narrative texts differed in line with prior findings for good versus struggling readers (e.g., longer first- and second-pass reading times for low-comprehending readers). Their reading styles for expository texts were more similar. Regarding high-comprehending readers, results suggested that they adopted a relatively stable processing approach across genre. Regarding low-comprehending readers, results suggested that they either did not adjust their reading strategy to text genre or that they adjusted towards a more cursory strategy for expository texts relative to their processing approach for narrative texts, instead of a more apt intensive processing approach. The relatively stable processing approach of high-comprehending readers suggests that these readers still have to develop more optimal (intensive) reading strategies for expository texts and learn how to employ them flexibly in different situations. The think-aloud study, however, revealed that high-comprehending readers were capable of doing this. And, the stable or more cursory approach of low-comprehending readers for expository texts relative to narrative texts in the eye-tracking study is undesirable. Yet, low-comprehending readers were capable of adjusting their reading style to text genre in a sensible manner in the think-aloud study. This raises the question of how this discrepancy can be explained; by the presentation modes of the texts in the think-aloud and eye-tracking experiments, by the nature of the think-aloud protocol, or both?

The presentation modes of the texts may elucidate this matter; the overall pattern of results of the text-layout study indicated that segmented texts (presented word by word or sentence by sentence, as in the think-aloud study) – at the cost of reading speed -- probe higher-order comprehension by inducing a more accurate and intensive processing approach than texts that are presented in their entirety (as in the eye-tracking study). This is in contrast with the principle that readers, good readers in particular, are hindered in their construction of a mental text representation when text layout prevents them from engaging in strategic processes, such as rereading, looking forward and backwards in a text (Coté et al., 1998; Rapp & Mensink, 2011). A possible explanation is that when readers cannot look back in a text they are stimulated to think through the available visual input more cautiously and update their mental representation of the text more frequently. Also, a sentence-by-sentence presentation mode may encourage readers to spend more time on sentence wrap up, to settle comprehension problems and integrate the sentence into the prior text before moving on to the next sentence. In addition, this presentation mode may reduce the processing load of basic reading processes such as eye-movement control and this may be particularly beneficial for beginning, low-comprehending readers. Also relevant in this matter is the potential impact of thinking aloud on readers' text-processing approaches, as discussed in a previous section (7.2.1). Moreover, 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). All things considered, we cannot tell with certainty what exactly has led low- and high-comprehending readers to adapt their reading approach to text genre in a rather similar way in the think-aloud experiment, but not in the eye-tracking experiment. Further research on this matter is needed. Also, further research on text layout that takes into account the trade-off between reading speed and reading comprehension is needed to give more insight into the ideal text presentation modes of different types of texts for different types of readers. Yet, the foregoing can lead to the tentative conclusion that both low- and high-comprehending second-grade readers are sensitive to text genre, but, when texts are presented to them in their entirety and when they read them silently, they employ suboptimal reading strategies for expository texts and do not possess the skills to adapt their processing strategy adequately. Young, low-comprehending readers in particular seem to not optimally process expository texts. Implications for education will be discussed in section 7.4.

7.3 Limitations and future research

Although we designed our studies carefully, in this section I want to address some limitations that have not been addressed in detail in previous sections. These limitations relate to the number of low- and high-comprehending participants, the number and difficulty level of our experimental texts, the number of off-line comprehension questions, and (the lack of) a test to assess background knowledge.

A first limitation is that fewer low-comprehending readers than high-comprehending readers participated in the think-aloud and eye-tracking experiments. On the one hand, this was attributable to our strict selection criteria for these studies. Namely, all selected children had to be competent in technical reading and have a normally developed intelligence. There were numerous children who were low-comprehending readers but did not meet these specific standards. However, we did not want to adjust our selection criteria because we considered it important to rule out that comprehension problems occurred as a result of poor technical reading skills or below-average intelligence. On the other hand, amongst the children who did meet all the selection criteria, fewer low- than high-comprehending readers were willing to participate in the think-aloud and eye-tracking experiments. Future research should try to resolve this reluctance and include more low-comprehending readers. This is especially relevant in the context of research on subgroups of low-comprehending readers.

A second limitation is the limited number of experimental texts the children read in each experiment (one practice text, two narrative and two expository experimental texts) and off-line comprehension questions they answered (5-6 per text). Future research should include more texts to give more insight into the generalizability of the findings over texts. The texts in our experiments were however of substantial length – the average number of sentences was 21 and the average number of words was 136 --, because we wanted to gain insight into children's processing approach of 'real' texts (as opposed to a couple of related sentences). We felt that offering more than four texts of substantial length in one test session would not be feasible for beginning readers, particularly not for low-comprehending readers. Regarding the experimental texts, I also want to mention that they were age appropriate, but possibly not challenging enough for high-comprehending readers. This may have led to a suboptimal text-processing approach. That is, readers perform optimally with texts that are appropriate but somewhat challenging to their skill level; motivation declines when the text is considered too simple (van den Broek, 2010).

A final limitation worth mentioning is that we did not administer a test to assess the children's background knowledge, although background knowledge is known to have an effect on comprehension (e.g., Best et al., 2008; Kendeou & van den Broek, 2007; McKeown, Beck, Sinatra, & Loxterman, 1992; McNamara, 2001). Yet, the measure we used to assess receptive vocabulary knowledge (PPVT-III; Schlichting, 2005) is frequently used as an alternative for general knowledge (Eason et al., 2012) and the experimental texts were about topics for which children in Grades 2 and 3 likely have prior knowledge. Nonetheless, we cannot rule out that a lack of prior knowledge caused our low-comprehending readers to have comprehension problems. Nor can we rule out the possibility that they did possess relevant background knowledge, but not the ability to infer when background knowledge should be integrated. In future research, it would be worth collecting information about prior knowledge or topic interest (e.g., Clinton & van den Broek, 2012), directly exploring the role of prior knowledge.

7.4 Educational implications

Although there are limitations to the studies of this dissertation and more research is needed, the studies do provide some interesting insights with implications for the educational practice. First, when instructed to think out loud and confronted with a fragmented, sentence-by-sentence text layout, low-comprehending readers process texts in a similar way as high-comprehending readers do. They are, however, less successful in constructing a coherent mental representation of the meaning of the text. Second, both low- and high-comprehending readers can be classified as elaborators and paraphrasers on the basis of their think-aloud responses. Third, the text-processing approach of young readers can be manipulated by varying the layout of the texts they read. And fourth, when texts are presented to them in a sentence-by-sentence manner and when they are stimulated to think aloud during reading, both low- and high-comprehending readers are sensitive to text genre and adapt their processing approach according to genre. Below, I will discuss these four insights and their implications.

A first insight is that low-comprehending readers process texts similar to high-comprehending readers when confronted with a segmented, sentence-by-sentence text layout and instructed to think out loud. However, they are not as adequate in their text-processing approach as high-comprehending readers. This implies that thinking aloud in combination with a sentence-by-sentence text presentation is a promising intervention to stimulate young readers to use strategies (cf. Trabasso & Magliano, 1996), but for low-comprehending readers the active use of strategies alone is no guarantee for a qualitatively good mental text representation. The problems that low-comprehending readers are facing are probably of a multimorbid nature, but education can work on deficits in skills closely related to reading comprehension. Inferring relations is a particularly important comprehension process which determines success and failure of comprehension and readers need to make both text-based and knowledge-based inferences to construct a coherent mental text representation (Kintsch, 1988, 1998; Graesser, Singer, & Trabasso, 1994; van den Broek et al., 1996; Helder et al., 2013). So, it is vital that children become competent in inference making and that they practice with different types of questions that require or prompt inference making (Eason et al., 2012). Interactive reading that includes practicing explanations and making connections is likely to foster the development of inferential skills --

especially relevant for comprehension of expository texts. Because such methods change the processing, they are particularly effective in improving comprehension when implemented *during* reading. However, children need to be proficient decoders for this type of interventions because if the processing load of basic reading is high, the added burden of processing and answering questions may hinder rather than support comprehension (e.g., van den Broek, Tzeng, Risden, Trabasso, & Basche, 2001).

A second insight is that both low- and high-comprehending readers can be classified as elaborators and paraphrasers on the basis of their think-aloud responses. Paraphrasers engage in little inference generation beyond the sentence and elaborators engage in relation-building activities, but often to irrelevant pieces of information in the case of low-comprehending readers. Results from studies by McMaster and colleagues suggest that paraphrasers benefit from answering questions during reading that stimulate them to go beyond the sentence in their comprehension, whereas elaborators benefit from being stimulated to focus selectively on inferences that explain the current sentence (McMaster et al., 2012; McMaster, Espin, & van den Broek, 2014). It would be useful to have diagnostic tools for identifying these subgroups -- such as MOCCA (Multiple-choice, Open-ended, and Cloze Comprehension Assessments; Carlson, Seipel, & McMaster, 2014) -- in order to be able to customize interventions. MOCCA measures on-line reading comprehension by having participants complete a cloze task at a discourse level: one line of the short text is deleted, with four choices specially designed to identify subgroups of struggling comprehenders. To build a mental representation, the reader has to infer and correctly choose an answer during reading. The correct answer completes the text coherently, whereas three distracters can also complete the text, but not coherently. Pending the availability of such tools in Dutch, having children read out loud can give insight into their on-line reading style. And, since elaborators and paraphrasers are also distinguished within the group of high-comprehending readers, they too may benefit from personalized educational programs (cf. McMaster et al., 2012, 2014) to take their reading comprehension skills to the next level.

A third insight is that segmented texts present a powerful tool to increase the reading skills of beginning readers: readers in Grades 2 and 3 have a better understanding of a text when presented in a self-paced sentence-by-sentence manner than when presented in a continuous layout. Specifically, in a sentence-by-sentence presentation mode disruptive return sweeps and long-distance regressions are removed from the eye-movement behavior while word-preview benefits are preserved. Also, a sentence-by-sentence presentation mode may promote sentence wrap-up and other integration processes, thereby improving the quality of readers' mental representation of a text. A practical implication is that self-paced segmented texts present a potential alternative to texts with a traditional layout. Whether and how segmented texts can be applied in educational settings is closely related to the goals set by reading education. On the one hand, presenting texts with segmented layouts to beginning readers may prevent them from optimizing their reading skills for texts with a traditional layout, but it can prompt an intensive, accurate text-processing approach. On the other hand, nowadays many texts are read in a digital form, often from small devices. Although this development induces substantial challenges to readers, it also presents many opportunities to improve the reading experience and skills of children.

A fourth and final insight with implications for education is that both young low- and high-comprehending readers are sensitive to text genre and capable of adapting their processing approach according to genre, provided that they are stimulated to think out loud and presented with texts in a sentence-by-sentence text layout. Yet, low-comprehending readers in particular do not always adapt their processing approach in an effective manner, especially in the case of expository texts. Since the processing of expository texts demands more cognitive effort of the reader, an intensive and accurate reading style is appropriate. And as high-comprehending readers display a relatively stable processing approach across text genre when they silently read texts that are presented to them in their entirety, they are likely to benefit the most from interventions aimed at clarifying the differences between narrative and expository texts and stimulating a more intensive processing style for expository texts. Yet, it is doubtful whether low-comprehending readers are able to adopt a more effortful reading approach for expository texts when presented to them in their entirety and when they read them silently. In their case, rather than trying to adjust the global reading style of low-comprehending readers from a cursory to a more effortful style, it might be more useful to address the underlying cognitive and language deficits. Still, expository texts are an important learning tool. So, the during-reading interventions discussed at the beginning of this section are useful because they adjust the on-line text processing. And, when young readers do have to read expository texts independently a self-paced sentence-by-sentence presentation may enhance their comprehension.

Ideally, interventions are custom-made by varying the instructions in light of the processing behavior of the child in combination with the type of text he or she is reading and the reading goals in the educational setting. More research is needed to investigate the optimal presentation modes of different types of text for different types of readers.

S

Nederlandse Samenvatting

Verschillende lezers, verschillende teksten, verschillende leesprocessen: De effecten van lezers- en tekstkenmerken op de verwerking van teksten

Deze samenvatting is gedeeltelijk gebaseerd op
Helder, A.*, Kraal, A.*, & van den Broek, P. (2015). De ontwikkeling van begrijpend lezen: Oorzaken van succes en falen vanuit een cognitief perspectief. In D. Schram (Ed.), *Hoe maakbaar is de lezer?* (pp. 59-78). Stichting Lezen: Eburon.

**gedeeld eerste auteur*

Begrijpend lezen is een van de belangrijkste vaardigheden die kinderen leren op school. Kinderen moeten informatie in teksten kunnen begrijpen om te functioneren op school en in het dagelijks leven (*Organisation for Economic Co-operation and Development* (OECD), 2009; Slavin, Lake, Chambers, Cheung, & Davis, 2009). In zowel het basis- als het voortgezet onderwijs wordt veel van de leerstof overgedragen via teksten en daarom is begrijpend lezen voor bijna alle schoolvakken een belangrijke vaardigheid. Als kinderen niet in staat zijn om de teksten op school te begrijpen, zijn de gevolgen groot: het kan een belemmering zijn om de leerstof te verwerven, het kan het leiden tot slechte resultaten op toetsen, tot weinig vertrouwen in het eigen kunnen, en zelfs tot gedragsproblemen (Hall, 2004). In 2018 kon bijna een kwart (24%) van de 15-jarigen in Nederland niet op het gewenste niveau lezen (PISA-2018, 2019). Hun percentage is stijgende want in 2015 betrof dit bijna een vijfde (17,9%) van de 15-jarigen en dat was weer een stijging van 6,4% ten opzichte van 2003 (11,5%) (Feskens, Kuhlemeier, & Limpens, 2016). Het leesniveau van deze leerlingen is onvoldoende om volwaardig deel te kunnen nemen aan de maatschappij. Ze kunnen teksten niet goed begrijpen en zijn bijvoorbeeld niet in staat om een brief van hun school te begrijpen.

Begrijpend lezen is een complexe vaardigheid waarbij lezers verschillende cognitieve processen gebruiken. Voor succesvol lezen zijn zowel cognitieve processen voor basistaalvaardigheden als cognitieve processen voor begripsvaardigheden van belang (bv. Gough & Tunmer, 1986; Hoover & Gough, 1990; Kendeou, van den Broek, Helder, & Karlsson, 2014). Bij basistaalvaardigheden gaat het om processen die te maken hebben met het decoderen van tekst, zoals fonemisch bewustzijn en de koppeling van klanken aan tekens. Bij begripsvaardigheden gaat het om processen die te maken hebben met het begrijpen van de informatie uit de tekst. Voorbeelden van begripsvaardigheden zijn verbanden leggen (inferenties genereren), monitoren van begrip en kennis hebben van tekststructuren (bv. Cain & Oakhill, 2007; Helder, van den Broek, Van Leijenhorst, & Beker, 2013; van den Broek & Espin, 2012). Veel van deze begripsvaardigheden zijn niet alleen toepasbaar op geschreven tekst, maar spelen ook een rol bij bijvoorbeeld het luisteren naar een verhaal of het begrijpen van een presentatie of een film.

In de loop van de basisschool verandert de verhouding tussen de hoeveelheid aandacht die besteed wordt aan basistaalvaardigheden en begripsvaardigheden. In groep 1 en 2 wordt er aan basistaalvaardigheden ongeveer evenveel aandacht besteed als aan begripsvaardigheden, bijvoorbeeld in de vorm van luistervaardigheden. In groep 3 en 4 is er wel aandacht voor leesbegrip, maar de nadruk ligt op basistaalvaardigheden. Vanaf groep 5 is er juist meer aandacht voor begripsvaardigheden. Begrijpend lezen wordt een op zichzelf staand vak en er vindt vanaf groep 6 een omslag plaats van '*leren lezen* naar *lezen om te leren*' (Chall, 1996; Chall, Jacobs, & Baldwin, 1990). Tegelijkertijd is er een verschuiving van het gebruik van verhalende teksten naar het gebruik van informatieve teksten in het onderwijs. Deze tekstsoorten verschillen in de manier waarop ze zijn georganiseerd, de causale samenhang van informatie, het woordgebruik en de aanwezigheid van een centraal personage (Wolfe, 2005). Voor de meeste kinderen zijn informatieve teksten moeilijker te begrijpen dan verhalende teksten (Best, Floyd en McNamara, 2008). Adequaat begrip van informatieve teksten is echter cruciaal. In de bovenbouw van de basisschool wordt namelijk van leerlingen verwacht dat ze informatie uit teksten in onder andere geschiedenis-, aardrijkskunde- en biologieboeken leren en kunnen toepassen in andere contexten (Allington & Johnston, 2002). In de meeste vormen van het voortgezet onderwijs wordt dit ook van hen verwacht.

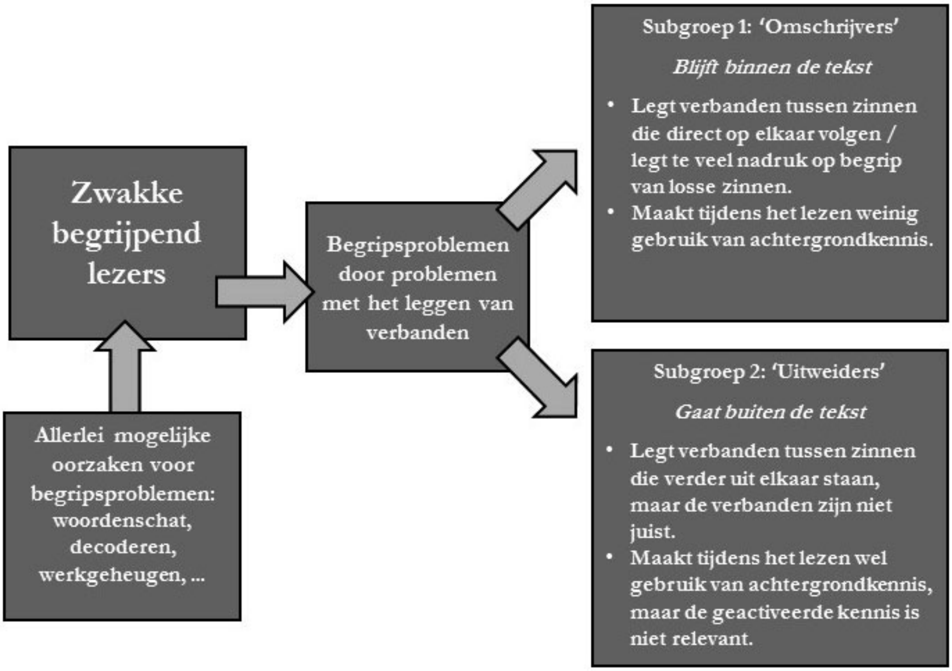
Het opbouwen van een samenhangende mentale representatie

Veel onderzoek naar begripsvaardigheden is gebaseerd op cognitieve theorieën over begrijpend lezen. Bij het merendeel van deze theorieën staat centraal dat lezers een *samenhangende mentale representatie van de betekenis van een tekst opbouwen* (voor een overzicht van theorieën zie McNamara & Magliano, 2009). Dit houdt in dat de lezer -- als alles goed gaat! -- onthoudt waar de tekst over gaat en de hoofdlijnen uit de tekst weet te halen, in plaats van te onthouden wat er letterlijk in de tekst staat. Wat er in een mentale representatie van een tekst wordt opgeslagen, is afhankelijk van de cognitieve processen die de lezer -- bewust of onbewust -- *tijdens* het lezen van een tekst gebruikt. *Dit betekent dat elke lezer een persoonlijke mentale representatie van een tekst opbouwt*.

Bij de opbouw van een samenhangende mentale representatie zijn veel verschillende cognitieve processen betrokken, zoals het leggen van verbanden, het sturen van de aandacht en het monitoren van begrip (Cain & Oakhill, 2007; Helder et al., 2013). Met betrekking tot het leggen van verbanden tijdens het lezen van een tekst is het belangrijk dat de lezer de juiste verbanden legt tussen delen van de tekst en dat de lezer op het juiste moment zijn/haar achtergrondkennis aanspreekt. Het opbouwen van een samenhangende mentale representatie van de betekenis van een tekst is essentieel voor succesvol leesbegrip.

Subgroepen lezers: omschrijvers *(paraphrasers)* en uitweiders *(elaborators)*

Binnen de populatie van zwakke begrijpend lezers is er een grof onderscheid te maken tussen een groep met een variëteit aan oorzaken voor hun begripsproblemen (bijvoorbeeld problemen met decoderen, werkgeheugen, woordenschat, et cetera) en een groep die specifieke problemen heeft met begripsvaardigheden (Cain & Oakhill, 2006), waaronder het leggen van verbanden. Onderzoeken naar de cognitieve processen van sterke, gemiddelde en zwakke begrijpend lezers hebben aangetoond dat er binnen de groep zwakke begrijpend lezers twee duidelijke subgroepen te onderscheiden zijn (McMaster et al., 2012; Rapp et al., 2007; van den Broek et al., 2006), zie Figuur 1.



Figuur 1. Subgroepen van zwakke begrijpend lezers.

Subgroep 1 is een groep zwakke begrijpend lezers die te veel nadruk legt op begrip van losse zinnen, of op het leggen van verbanden tussen zinnen die direct op elkaar volgen in de tekst. Ze herhalen vaak (letterlijk) wat er in de tekst staat en maken tijdens het lezen weinig gebruik van hun achtergrondkennis. Zwakke begrijpend lezers in subgroep 1 blijven dus heel erg 'binnen' de tekst en worden ook wel 'omschrijvers' (*paraphrasers*) genoemd. Subgroep 2 is een groep zwakke begrijpend lezers die wel verbanden legt tussen informatie die verder uit elkaar staat in de tekst en die hierbij wel de eigen achtergrondkennis betrekt, maar deze subgroep legt niet de juiste of niet de belangrijkste verbanden. Zwakke begrijpend lezers in subgroep 2 gaan dus juist 'buiten' de tekst en worden ook wel 'uitweiders' (*elaborators*) genoemd. Voor beide subgroepen geldt dat hun wijze van verbanden leggen niet leidt tot een samenhangende mentale representatie, wat resulteert in onvoldoende begrip van de tekst. En daarmee is hun basis voor leren en voor de toepassing van kennis ontoereikend. De twee subgroepen zwakke begrijpend lezers zijn niet te onderscheiden op basis van scores op gestandaardiseerde toetsen voor leesbegrip, waarbij kinderen vragen beantwoorden nadat ze een tekst hebben gelezen. Door inzicht te krijgen in wat kinderen *tijdens* het lezen doen zijn deze subgroepen wel te onderscheiden.

De ontwikkeling van basistaalvaardigheden en begripsvaardigheden

Zoals hiervoor is beschreven, zijn zowel basistaalvaardigheden als begripsvaardigheden belangrijk voor begrijpend lezen. Tijdens de eerste jaren van het basisonderwijs wordt er relatief veel aandacht besteed aan het automatiseren van basistaalvaardigheden. Als leerlingen net beginnen met leren lezen, vraagt het omzetten van tekens in klanken en woorden veel van hun beperkte cognitieve capaciteit. Gemiddeld genomen worden deze basistaalvaardigheden halverwege de basisschooljaren geautomatiseerd, waardoor er meer cognitieve capaciteit beschikbaar komt voor het toepassen van begripsvaardigheden (De Jong & Van der Leij, 2002; Kendeou, Papadopoulos, & Spanoudis, 2012; Perfetti & Hart, 2002). Tegelijkertijd neemt de cognitieve capaciteit van kinderen met name tijdens de basisschooltijd toe en deze blijft toenemen tot ver in de adolescentie (Huizinga, Dolan, & Van der Molen, 2006; Luna, Garve, Urban, Lazar, & Sweeney, 2004). De hoeveelheid beschikbare cognitieve capaciteit hangt samen met het begrijpend leesniveau (meer cognitieve capaciteit laat meer ruimte voor begrip), maar meer beschikbare capaciteit betekent niet per se dat correct gedecodeerde teksten ook daadwerkelijk goed worden begrepen. Hierbij spelen begripsvaardigheden een belangrijke rol.

Over de ontwikkeling van begripsvaardigheden is relatief minder bekend dan over de ontwikkeling van basistaalvaardigheden. Toch is er een aantal voor het onderwijs relevante conclusies te trekken, onder andere uit longitudinale studies waarbij bij een groep kinderen in opeenvolgende jaren dezelfde testen worden afgenomen (Kendeou, Bohn-Gettler, White, & van den Broek, 2008; Kendeou, van den Broek, White, & Lynch, 2009; Oakhill & Cain, 2011). Ten eerste blijkt dat de ontwikkeling van begripsvaardigheden al op jonge leeftijd begint. Al voordat kinderen formeel leesonderwijs krijgen, zijn zij in staat om verbanden te leggen tussen gebeurtenissen in verhaaltjes die aan hen verteld of vertoond worden. Ten tweede blijkt dat begripsvaardigheden zich relatief onafhankelijk van basistaalvaardigheden ontwikkelen. Dus als een kind niet goed is in het decoderen van een tekst, betekent dit niet per definitie dat het niet in staat is om de inhoud van de tekst te begrijpen. Ten derde blijkt dat individuele verschillen in begripsvaardigheden op jongere leeftijd het begrijpend leesniveau op latere leeftijd voorspellen, los van basistaalvaardigheden.

Daarnaast is vanuit onderzoek naar de ontwikkeling van begripsvaardigheden bekend dat tijdens de basisschooljaren en daarna zowel de kwantiteit als de kwaliteit van het leggen van verbanden verandert (van den Broek, 1997). Naarmate kinderen ouder worden, leggen ze *meer* verbanden en *andere* verbanden. Zo leggen kinderen in eerste instantie verbanden tussen tekstelementen binnen een alinea en later tussen tekstelementen van verschillende alinea's. Ook de kwaliteit van het leggen van verbanden ontwikkelt naarmate kinderen ouder worden.

Waarom informatieve teksten lastiger te begrijpen zijn dan verhalende teksten

Op school moeten kinderen in staat zijn om informatieve teksten te begrijpen en om informatie eruit te leren. Vergeleken met verhalende teksten zijn informatieve teksten vaak lastiger om te begrijpen. Daar zijn grofweg vier oorzaken voor (Lorch, 2017). Ten eerste zijn de leesdoelen en toepassingen van informatieve teksten gevarieerder. Als een lezer een verhalende tekst uitkiest, heeft hij/zij meestal een affectief doel (vermaakt worden) en een cognitief doel (het verhaal begrijpen). Een lezer kiest een informatieve tekst vaak niet zelf uit, maar krijgt de tekst van de leerkracht of moet de tekst lezen omdat de (schoolse) situatie daarom vraagt. Daar past geen affectief leesdoel bij, maar een leerdoel. Bij het algemene doel om te leren kunnen verschillende leesdoelen horen, bijvoorbeeld lezen ter voorbereiding op een toets, op een schrijfopdracht, of op een discussie-opdracht. De lezer moet zijn/haar doel hierop flexibel kunnen aanpassen en dit vergt metacognitieve vaardigheden. Een tweede oorzaak waardoor informatieve teksten lastiger te begrijpen zijn, is dat de onderwerpen die behandeld worden vaak minder bekend zijn voor de lezer en de situaties die beschreven worden vaak ingewikkelder. In allerlei theoretische modellen over tekstverwerking neemt de voorkennis van de lezer een centrale rol in. Zo stelt het *Landscape Model of Reading Comprehension* (van den Broek, Risden, Fletcher, & Thurlow, 1996) dat een eerste cognitieve reactie op het lezen van een zin betrekking heeft op het activeren van geassocieerde voorkennis in het geheugen van de lezer en op een proces dat de nieuwe informatie uit de tekst integreert in de mentale representatie die de lezer op dat punt in de tekst heeft opgebouwd. Alleen een titel van een tekst kan al veel voorkennis oproepen. Maar dan moet er wel voorkennis over het onderwerp aanwezig zijn en dat is bij informatieve teksten vaak niet het geval. En als de opgeroepen voorkennis niet relevant is of niet klopt (misconceptie), helpt dit niet om een goede mentale representatie van de tekst op te bouwen. Ten derde zijn informatieve teksten lastig om te begrijpen omdat hun tekststructuur ingewikkelder is en omdat de lezer minder bekend is met de tekststructuren van informatieve teksten. De globale structuur varieert tussen teksten en binnen teksten en is vaak complex, terwijl de structuur van verhalende teksten voorspelbaar is en min of meer gelijk is voor verschillende verhalen. Een informatieve tekst bestaat vaak uit verschillende deelonderwerpen. Lezen op een microniveau volstaat niet voor goed begrip van een informatieve tekst en veel lezers hebben moeite om op macroniveau te doorzien hoe de tekst opgebouwd en georganiseerd is. Ten vierde is het verwerken (*processing*) van informatieve teksten als gevolg van het voorgaande ingewikkelder. Als lezers tijdens het lezen van een informatieve tekst er telkens tegenaan lopen dat hun voorkennis ontoereikend is om hiaten in de tekst in te vullen (ze zijn dan niet in staat om inferenties op basis van voorkennis te maken), dan zullen ze vaak een 'gat' moeten dichten in de opgebouwde mentale representatie met het risico dat de representatie onsamenhangend of onjuist is (Lorch, 2017).

Effect van tekstopmaak op tekstverwerking

Hoe goed een lezer een tekst begrijpt, hangt niet alleen af van de kenmerken van de lezer of het tekstgenre. Tekstkenmerken – waaronder tekstopmaak -- hebben ook invloed op de leesaanpak van lezers en hun opbouw van een mentale representatie van de betekenis van de tekst. In tekstgerichte benaderingen wordt vaak aangenomen dat beginnende lezers baat hebben bij een eenvoudige tekst waarin woorden gemakkelijk worden herkend en gedecodeerd en zinnen gemakkelijk worden ontleed, omdat dit het opbouwen van een kwalitatief goede mentale representatie van de tekst zou moeten vergemakkelijken. Daarom worden teksten voor beginnende lezers vaak in een groot lettertype geschreven, met een grotere afstand tussen letters, woorden en regels (bv. Zorzi et al., 2012). Bovendien worden niet-frequente woorden en samengestelde zinnen met ondergeschikte bijzinnen vermeden en zijn zinnen over het algemeen kort. En om regelafbrekingen in het midden van een zin te voorkomen, worden teksten gepresenteerd in een gefragmenteerde opmaak waarin elke zin op een nieuwe regel wordt gepresenteerd (Land, 2009) . Het idee achter deze aanpassingen in de tekstopmaak is dat ze de oogbewegingen en basisdecoderingsprocessen tijdens het lezen optimaliseren en mogelijk cognitieve capaciteit vrijmaken voor hogere-orde-begripsprocessen, zoals het monitoren van begrip en het genereren van inferenties (zie Schneps, Thomson, Chen, et al., 2013; Schneps, Thomson, Chen, Sonnert, & Pomplun, 2013).

Onderzoeken van cognitieve processen van lezers

Aangezien de kwaliteit van de mentale representatie afhangt van de cognitieve processen die de lezer gebruikt, is het relevant om te onderzoeken wat er in het hoofd van de lezer gebeurt tijdens het lezen van een tekst. Voor zowel kinderen als volwassenen geldt dat hun cognitieve capaciteit beperkt is (bv. Cain, Oakhill, & Bryant, 2004; Just & Carpenter, 1992). Het is dus belangrijk om erachter te komen hoe deze capaciteit zo efficiënt mogelijk ingezet kan worden en om inzicht te krijgen in welke cognitieve processen op welk moment worden aangesproken. Sommige van deze processen zijn automatisch en onbewust, andere juist strategisch en bewust (bv. van den Broek, Rapp, & Kendeou, 2005; Gerrig & O'Brien, 2005; Graesser, Singer, & Trabasso, 1994; Van Kleeck, 2008). Tijdens het lezen kan er in het hoofd van de lezer van alles 'mis' gaan. Zwakke begrijpend lezers kunnen bijvoorbeeld moeite hebben om bepaalde verbanden in de tekst te doorzien, om op de juiste momenten relevante verbanden te leggen, of om de informatie in de tekst te integreren met zijn of haar achtergrondkennis (Perfetti, Landi, & Oakhill, 2005; Yuill & Oakhill, 1991). Dit leidt tot een minder goed samenhangende mentale tekstrepresentatie, hetgeen weer leidt tot oppervlakkige verwerking van de inhoud en minder goed begrip van de tekst (van den Broek et al., 2006; Rapp et al., 2007).

Cognitieve processen kunnen op verschillende manieren worden onderzocht met behulp van verschillende onderzoeksmethoden. Er is een onderscheid tussen methoden om te onderzoeken wat de lezer heeft opgeslagen in zijn/haar mentale representatie van de tekst *na* het lezen en methoden om te onderzoeken wat er in het hoofd van de lezer gebeurt *tijdens* het lezen. Na het lezen kunnen lezers bijvoorbeeld worden gevraagd naar de inhoud van de tekst -- het hoofdonderwerp en/of details -- of naar wat zij zich herinneren van de tekst. Dit zijn manieren om erachter te komen wat er is opgeslagen in de mentale representatie die de lezer heeft opgebouwd *na* het lezen van een tekst. *Tijdens* het lezen daarentegen kan een lezer worden gevraagd zijn/haar gedachten te uiten na het lezen van elke zin (hardopdenkmethode). Een andere, meer indirecte manier om de onderliggende cognitieve processen tijdens het lezen te onderzoeken, is het meten van leestijden en/of oogbewegingen.

Elke onderzoeksmethode heeft plus- en minpunten. Sommige methoden onthullen bijvoorbeeld alleen de bewuste gedachten van de lezer (bijvoorbeeld vragen stellen, hardopdenkmethode), terwijl andere methoden onbewuste processen meten die moeilijker te interpreteren zijn (bijvoorbeeld leestijden, oogbewegingen). Door een combinatie van onderzoekstechnieken te gebruiken, kunnen we verschillende soorten inzicht krijgen in hoe lezers begrijpen wat ze lezen.

De doelen en studies van dit proefschrift

Het hoofddoel van dit proefschrift is om aan de hand van verschillende onderzoeksmethoden inzicht te krijgen in de leesaanpakken van jonge, zwakke en goede begrijpend lezers bij het lezen van twee verschillende soorten teksten: verhalende en informatieve teksten. Een bijkomend doel is om inzicht te krijgen in verschillende leesprofielen van jonge, zwakke en goede begrijpend lezers. Een ander doel van dit proefschrift tot slot is om inzicht te krijgen in het effect van verschillende vormen van tekstopmaak op het tekstbegrip en de leessnelheid van jonge kinderen bij het lezen van verhalende en informatieve teksten.

Dit proefschrift bevat vier empirische onderzoeken (**Hoofdstuk 3 tot en met 6**). In de onderzoeken in *Hoofdstuk 3, 4* en *5* zijn zwakke begrijpend lezers gedefinieerd als lezers die moeite hebben met het begrijpen van verbonden tekst, ondanks een leeftijdsadequate technische leesvaardigheid (cf., Cain & Oakhill, 2007; Nation, 2005), met de aanvullingen dat hun intelligentie normaal ontwikkeld is en dat ze geen gediagnosticeerde gedragsproblemen hebben. In *Hoofdstuk 6* zijn twee Nederlandse gestandaardiseerde toetsen voor begrijpend lezen en decodeervaardigheid gebruikt als continue variabelen voor respectievelijk leesvaardigheid en woorddecoderingsvaardigheden.

Het doel van de studie beschreven in **Hoofdstuk 3** was om door middel van een **hardopdenkprotocol** de online begripsprocessen en het strategiegebruik van zwakke en goede begrijpend lezers in groep 4 te onderzoeken tijdens het lezen van verhalende en informatieve teksten. Een bijkomend doel was om te onderzoeken of het onderscheid van twee typen zwakke lezers, -- omschijvers (*paraphrasers*) en uitweiders (*elaborators*) (McMaster et al., 2012; Rapp et al., 2007) -- al op jonge leeftijd bestaat, en of dit onderscheid ook is van toepassing op goede begrijpend lezers. Een algemene conclusie van dit hardopdenkonderzoek is dat zwakke begrijpend lezers in groep 4 niet verschillen van goede begrijpend lezers in hun strategiegebruik. Deze kinderen hebben nog geen formeel onderwijs gehad in leesstrategieën, maar ze gebruiken een scala aan strategieën en maken op dezelfde manier onderscheid in tekstsoort: bij verhalende teksten maakten de zwakke en de goede begrijpend lezers meer elaboratieve (kennisgerelateerde) en voorspellende (tekstgerelateerde) inferenties, herhaalden ze of herformuleerden ze de gelezen zin vaker en verklaarden ze de gelezen zin vaker aan de hand van de voorgaande zin(en). Bij informatieve teksten gaven ze vaker commentaar, stelden ze meer vragen en maakten ze meer foutieve elaboratieve en voorspellende inferenties. Dit laatste was toe te schrijven aan de groep zwakke begrijpend lezers. Er was namelijk één significant verschil tussen de zwakke en de goede begrijpend lezers: bij informatieve teksten maakten de zwakke lezers meer foutieve elaboratieve en voorspellende inferenties. Dit soort foutieve inferenties is nadelig voor de kwaliteit van de mentale tekstrepresentatie.

Verder blijkt uit dit hardopdenkonderzoek dat zowel jonge zwakke als goede begrijpend lezers geclassificeerd kunnen worden als omschrijvers *(paraphrasers)* of uitweiders *(elaborators)*, met elk een verschillend, karakteristiek leesprofiel: omschrijvers maken een mentale tekstrepresentatie die voornamelijk de letterlijke betekenis van de tekst weergeeft, terwijl uitweiders hun mentale tekstrepresentatie proberen te verrijken door elaboratieve inferenties te genereren (cf., McMaster et al., 2012; Rapp et al., 2007).

In **Hoofdstuk 4** werd de online tekstverwerking van zwakke en goede begrijpend lezers in groep 4 onderzocht door hun **oogbewegingen** te volgen terwijl zij verhalende en informatieve teksten lazen. Een algemene conclusie van dit onderzoek is dat -- vergeleken met verhalende teksten -- zwakke begrijpend lezers anders omgaan met informatieve teksten dan goede begrijpend lezers. Het algemene patroon was dat verhalende teksten een langere, intensievere verwerking uitlokten voor zwakke begrijpend lezers dan voor goede begrijpend lezers. Bij verhalende teksten verschilden de zwakke begrijpend lezers van goede begrijpend lezers in hun oogbewegingspatronen op een manier waarop zwakke lezers in het algemeen verschillen van goede lezers: zwakke begrijpend lezers hadden langere leestijden en maakten kortere saccades (sprongen) met hun ogen. Dit verschil tussen zwakke en goede begrijpend lezers was minder bij informatieve teksten: de oogbewegingspatronen van zwakke begrijpend lezers leken bij informatieve teksten meer op die van goede begrijpend lezers. De resultaten suggereren dat zwakke begrijpend lezers een suboptimale leesaanpak aanwenden bij informatieve teksten: vergeleken met hun aanpak voor verhalende teksten passen ze hun leesaanpak niet aan of wenden ze een meer oppervlakkige aanpak aan bij het lezen van informatieve teksten. Beide aanpakken zijn suboptimaal voor zwakke lezers, omdat informatieve teksten vergeleken met verhalende teksten eerder meer dan minder cognitieve inzet van de lezer vergen (Williams, Hall, & Lauer 2004).

In **Hoofdstuk 5** hebben we onderzocht of de subgroepen van lezers die op basis van de in *Hoofdstuk 3* beschreven hardopdenkstudie als zwak en goed begrijpende omschrijvers en uitweiders werden gekenmerkt, ook werden gekenmerkt door verschillende oogbewegingspatronen. Hiertoe hebben we de data van het oogbewegingsonderzoek (*Hoofdstuk 4)* en het hardopdenkonderzoek (*Hoofdstuk 3*) in samenhang geanalyseerd. Daarnaast hebben we het effect van tekstgenre op de oogbewegingspatronen onderzocht. Tot slot hebben we onderzocht of de oogbewegingspatronen van omschrijvers en uitweiders overeenkomsten vertoonden met oogbewegingspatronen van subgroepen van lezers die worden onderscheiden in oogbewegingsonderzoeken van Koornneef en Mulders (2016), Olson, Kliegle, Davidson en Foltz (1985), Rayner, Castelhano en Yang (2009), en Rayner, Reichle, Stroud, Williams en Pollatsek (2006). Gebaseerd op deze onderzoeken naar subgroepen hebben we gekeken naar de waarschijnlijkheid dat lezers terugkijken (*first-pass regression probability)* en woorden overslaan (*first-pass word skipping probability*) tijdens het lezen.

Voor goede begrijpend lezers lieten de resultaten zien dat omschrijvers minder woorden oversloegen dan uitweiders, maar er was geen indicatie dat ze minder vaak terugkeken. Er was ook geen indicatie dat de subgroepen goede begrijpend lezers verschillende oogbewegingspatronen volgden voor verhalende en informatieve teksten en ook niet dat hun oogbewegingspatronen overeenkwamen met de patronen van subgroepen die in andere onderzoeken onderscheiden zijn. Algemene conclusies voor goede begrijpend lezers zijn dat de leesprofielen van omschrijvers en uitweiders deels gekenmerkt worden door verschillende oogbewegingspatronen en dat er geen aanwijzing is dat ze hun oogbewegingen aanpassen aan de tekstsoort (verhalend of informatief).

Voor zwakke begrijpend lezers lieten de resultaten zien dat omschrijvers en uitweiders dezelfde oogbewegingspatronen vertoonden met betrekking tot de maten die de waarschijnlijkheid aangeven dat lezers terugkijken (*first-pass regression probability)* en woorden overslaan (*first-pass word skipping probability*). Echter, de zwakke omschrijvers pasten hun oogbewegingen aan aan de tekstsoort, terwijl de uitweiders dit niet deden. Bij verhalende teksten keken omschrijvers vaker terug en sloegen minder woorden over dan bij informatieve teksten. Het lijkt er dus op dat de zwakke omschrijvers verhalende teksten nauwkeuriger lezen dan informatieve teksten. Dit lijkt een contraproductieve aanpassing: voor informatieve teksten is juist een nauwkeurigere leesstijl gewenst, aangezien dit soort teksten met name voor zwakke begrijpend lezers lastiger te verwerken is dan verhalende teksten (zie bijvoorbeeld Coté, Goldman, & Saul, 1998; Lorch, 2017; Oakhill, Cain, & Elbro, 2014; Williams, Hall, & Lauer, 2004). Verder waren er geen aanwijzingen dat de oogbewegingspatronen van de zwakke omschrijvers en uitweiders overeenkomen met de patronen die in andere studies zijn onderscheiden. Bovendien verschilden hun oogbewegingspatronen van die van goede omschrijvers en uitweiders. Algemene conclusies voor zwakke begrijpend lezers zijn dat de leesprofielen van omschrijvers en uitweiders niet gekenmerkt worden door verschillende oogbewegingspatronen en dat zwakke omschrijvers hun leesstijl aanpassen aan de tekstsoort, maar op een manier die onwenselijk is voor een goed begrip van informatieve teksten.

In **Hoofdstuk 6** hebben we onderzoek gedaan naar het **effect van verschillende tekstopmaken** op het tekstbegrip en de leessnelheid van lezers in groep 4 en 5. Door de opmaak van teksten te variëren, konden we onderzoeken of en waarom beginnende lezers kunnen profiteren van een specifieke opmaak. En door lezers met verschillende leesvaardigheden (decodeer- plus begripsvaardigheden) te onderzoeken, konden we onderzoeken of en hoe individuele verschillen in leesvaardigheden de effectiviteit van de opmaak van een tekst beperken. Een serie van vier leesexperimenten is uitgevoerd, waarin leerlingen uit groep 4 en 5 verhalende en informatieve teksten met verschillende tekstopmaken lazen. In de basisconditie liepen zinnen door op de regel tot het einde van de paginabreedte. In drie condities met een gesegmenteerde opmaak (1) werd iedere zin op een nieuwe regel gepresenteerd in een discontinue opmaak, (2) werden teksten zin voor zin gepresenteerd in een *Rapid Serial Visual Presentation* (RSVP; Young, 1984) waarbij de lezer het tempo bepaalt (*reader-paced*), en (3) werden teksten woord voor woord gepresenteerd in RSVP, waarbij de lezer ook weer het tempo bepaalde. In een vierde experiment werd de invloed op tekstbegrip van de zin-voor-zinopmaak en de woord-voor-woordopmaak vergeleken. Dit vierde experiment bevatte een conditie waarin de teksten werden aangeboden in een zogenaamde *moving window manner*. Hierbij verschijnen de woorden van een zin na elkaar in een venster (lezer bepaalt tempo), op de plek waarop ze in een zin zouden staan. Het eerste woord van een zin verschijnt dus aan de linkerkant in het venster en het laatste woord aan de rechterkant. Deze presentatiemodus vereist van lezers dat ze saccades plannen en uitvoeren. De resultaten van deze studie tonen aan dat een zin-voor-zin RSVP format waarbij de lezer het tempo bepaalt een goede manier is om teksten aan te bieden in de vroege stadia van lezen. Er werd geen algemeen begripsvoordeel waargenomen voor teksten waarin elke zin op een nieuwe regel van de pagina werd gepresenteerd (experiment 1), vergeleken met teksten met een doorlopende opmaak. Een robuust begripsvoordeel manifesteerde zich echter in de twee eigen tempo RSVP-opmaken waarin de teksten zin voor zin (experiment 2) of woord voor woord (experiment 3) werden gepresenteerd, ten koste van langere leestijden. Deze wisselwerking tussen snelheid en nauwkeurigheid was vooral prominent als de teksten woord voor woord werden gepresenteerd. Vertragingen in de leestijd waren veel minder extreem bij teksten die zin voor zin werden gepresenteerd (experimenten 2 en 4).

We hebben ook onderzocht waarom beginnende lezers profiteren van gesegmenteerde teksten. Het algehele patroon van resultaten gaf aan dat gesegmenteerde teksten tot een beter begrip van de hogere orde leiden door een meer accurate en intensieve verwerkingsaanpak op te wekken.

Ten slotte wilden we met dit onderzoek meer inzicht krijgen in de vraag of en hoe individuele verschillen in leesvaardigheid de effectiviteit van een tekstopmaak beperken. De analyses van de interactie van tekstopmaak en de leesvaardigheid van leerlingen waren verkennend van aard, maar laten vier algemene conclusies toe. Ten eerste zullen veel leerlingen in groep 4 en 5 baat hebben bij een gesegmenteerde presentatiemodus van teksten. Ten tweede wordt de effectiviteit van de presentatiemodus van een tekst bepaald door zowel de kenmerken van de lezer als het tekstgenre. Ten derde hebben zeer segmenterende teksten (woord voor woord) in sommige situaties een gunstige invloed op het begrip, zelfs voor betere lezers. Ten vierde zijn de potentiële voordelen van zeer gefragmenteerde teksten (woord-voor-woord-presentatiemodus) het meest relevant in de vroege stadia van het lezen; voor lezers in groep 5 lijken de voordelen minder prominent en dan is een zin-voor-zin-presentatiemodus van teksten geschikter voor de meeste lezers.

Al met al kunnen we stellen dat begrijpend lezen een belangrijke en complexe vaardigheid is waarbij verschillende cognitieve processen betrokken zijn. Begripsproblemen kunnen hun oorsprong vinden in verschillende cognitieve processen. Sommige problemen kunnen alleen gecompenseerd worden, andere kunnen worden opgelost. Zo heeft een lezer met een beperkte werkgeheugencapaciteit een ander probleem dan een lezer die niet in staat is om de juiste verbanden te leggen, en een ander probleem dan een lezer die moeite heeft met het decoderen van de tekst. Bij al deze lezers kan hun probleem leiden tot begripsmoeilijkheden waarvoor verschillende interventies ingezet zouden kunnen worden. Overigens is er bij zwakke lezers vaak sprake van combinaties van problemen (Cain & Oakhill, 2006). Dit bleek ook uit de resultaten van de verschillende testen die we in onze onderzoeken bij de proefpersonen hebben afgenomen. De uitdaging waar zwakke begrijpend lezers voor staan, is waarschijnlijk meervoudig van aard. Er moet aandacht besteed worden aan tekortkomingen in vaardigheden die nauw gerelateerd zijn aan begrijpend lezen – zoals verbanden leggen (inferenties genereren), monitoren van begrip en kennis hebben van tekststructuren -- om de begripsvaardigheden van lezers te verbeteren.

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Curriculum vitae

Astrid Kraal was born on November 12, 1968 in Capelle aan den IJssel, the Netherlands. She graduated from the Rijksscholengemeenschap Oud-Beijerland in 1987 and obtained her master's degree in General Arts with a specialization in Applied Linguistics in 1993 at the Faculty of Humanities at Utrecht University.

In 1991, Astrid started as an intern at the CED-Groep in Rotterdam as part of her study and continued to work there on all sorts of language-related projects relating to Dutch as a second language, content and language integrated learning, vocabulary, and reading comprehension. She is co-originator and -author of *Nieuwsbegrip*, a method for reading comprehension based on topical matters, and was project manager until 2012. Through her work, Astrid developed a strong interest in the development of reading comprehension skills and in potential causes of failure in comprehension of beginning readers. That is how she came in contact with (the work of) Prof. dr. Paul van den Broek.

In 2012, she got the opportunity to start a PhD project at the Department of Educational Studies at the Institute of Education and Child Studies of Leiden University under supervision of Prof. dr. Paul van den Broek, Dr. Arnout Koornneef, and Dr. Nadira Saab. The PhD project '*Texts that teach and readers that learn: The role of text characteristics and children's reading skills in comprehending and learning from informational texts*', with the CED-Groep as societal partner, was part of the NWO research programme *Begrijpelijke Taal*. In addition, Astrid was involved in various university teaching activities; e.g., teaching and supervising Bachelors, Master's and ACPA (Academic Teacher Training) students.

In 2017, Astrid returned to the CED-Groep as senior researcher. She is member of the Expertise Centre for Reading Comprehension (Kenniscentrum Begrijpend Lezen), an initiative of the CED-Groep and Sardes in cooperation with Leiden University and Utrecht University.

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